ICT and e-Business for an Innovative and Sustainable Economy

7th Synthesis Report of the Sectoral e-Business Watch (2010)

EUROPEAN COMMISSION

e-Business W@tch

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The Sectoral e-Business Watch

The Sectoral e-Business Watch studies the adoption, implications and impact of electronic business practices in different sectors of the economy. It continues activities of the preceding "e-Business W@tch", which was launched by the European Commission, DG Enterprise and Industry, in late 2001, to support industrial policy, notably in the fields of competitiveness and innovation. The Sectoral e-Business Watch is based on a Framework Contract between DG Enterprise and Industry and empirica GmbH, running until the end of 2010 (principal contact and coordination: Dr. Hasan Alkas).

As general purpose technologies, ICT goods and services are seen as important drivers of productivity growth and economic performance across all sectors. DG Enterprise and Industry therefore pursues a range of policies to enhance the use of ICT and the deployment of other key technology-enablers that advance the economy, create innovation and deliver sound competitiveness benefits. The services of the Sectoral e-Business Watch contribute to achieving these goals, by supporting informed policy decision-making in these fields.

The focus of the ICT and e-business studies conducted in 2009 was on the ICT potential for sustainable economic activity. This report summarises the main results. The full study reports, and further resources such as brochures, case studies and table reports with more detailed survey data, can be downloaded from the programme's website (http://www.ebusiness-watch.org).

Disclaimer

Imprint

This report has been prepared by empirica Gesellschaft für Kommunikations- und Technologieforschung mbH on behalf of the European Commission, Enterprise and Industry Directorate General, in cooperation with, DIW econ, IDC EMEA, Ipsos GmbH and GOPA-Cartermill.

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Copies can be requested, free of charge, from DG Enterprise and Industry (see contact details below). The report is also available in electronic format and can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

A great deal of additional information on the European Union is available on the internet. It can be accessed through the Europa server (http://ec.europa.eu).

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The Sectoral e-Business Watch studies of 2009 provide us with new insights about how information and communication technology (ICT) and electronic business can contribute to an innovative and sustainable economy. In particular, the findings improve our understanding of the role ICT and e-business can play in increasing energy efficiency and reducing greenhouse gas emissions.

A key objective of European enterprise policy is to facilitate the structural change towards the digital knowledge economy. Innovation is crucial in the course of this change and for ensuring competitiveness of European companies and industries. For both innovation and sustainability, the Sectoral e-Business Watch studies in 2009 confirmed that ICT and e-business are very important and need further analysis. The enabling role of ICT for innovation is supported by findings of representative surveys conducted in the energy supply industry and in the glass, ceramics and cement industry in March 2009. As regards sustainability, by means of an econometric analysis the e-Business Watch found a positive impact of ICT on greenhouse gas emissions in energy-intensive industries in Europe.

We need to make sure that European companies are among the leaders in using ICT for making products, services and processes smarter. However, the Sectoral e-Business Watch studies show that there are many challenges to be addressed. A recurrent theme is that small and medium-sized companies normally lag behind large enterprises in ICT and e-business use. A further recurrent theme is a lack of ICT interoperability; connectivity within and between European companies still needs to be improved. A lack of widely used standards, which is essential for increasing the benefits of a large European market, hampers the European-wide implementation of smart applications.

The studies about ICT-related industrial policy and e-skills remind us that the European Commission and the Member States need to join forces to establish powerful policy strategies and measures to sustain the manufacturing base in Europe. The analysis of the European Commission's Competitiveness Report 2009 confirms that if the crisis is used to trigger momentum for structural reforms it can become an opportunity to increase productivity growth and boost EU competitiveness. The outline for a more refined policy for such technologies has been laid down recently in a related Communication from the European Commission. Further activities in this direction can draw substantially from the studies of the Sectoral e-Business Watch in 2009.

Hasan Alkas
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E-Business is dead. It just died its second death. You don't believe? Do an internet search. You will find that e-business first died with the "dotcom" crash in 2001. What died was the false belief that e-commerce would change fundamental economic principles. e-Business has now died again, with the economic and climate crisis. What is fading away is a policy interest in ICT adoption. Other objectives take priority: innovation and sustainability. These were the main themes of the Sectoral e-Business Watch in 2009. Here are some appetisers from our findings:

Nearly 90% of the energy supply companies interviewed said that their new products or services have ICT components, and almost all said that their new processes are supported by ICT. This confirms that the energy industry is undergoing a profound change towards becoming an "intelligent utility". However, to make this change happen, significant standardisation efforts are required. The study on smart electricity grids and metering provides details on this issue.

Sectoral e-Business Watch studies of 2009 provide the first comprehensive economic analysis of the relationship between ICT investment and greenhouse gas emissions in European energy-intensive industries. There are high hopes of the ICT potential to reduce emissions, and the study confirms this potential. Another study confirms the potential of intelligent transport systems to reduce emissions. However, achieving reductions in greenhouse gas emissions using ICT was found to be expensive compared with other abatement technologies.

The study of the glass, ceramics and cement industry completes a series of sector studies about energy-intensive industries conducted over the past three years. While energy costs were, not surprisingly, found to be a major concern in this industry, the study also found, more surprisingly, that only 22% of firms have an ICT-enabled energy management system or a related process. There appears to be some potential to increase energy efficiency in this industry.

The study of "an economic assessment of ICT-related industrial policy" conducted an analysis based on economic theories, with a focus on game theory – a challenging endeavour with some counter-intuitive results. For example, while large-scale European joint research, development and innovation projects may be necessary to create critical mass of new knowledge, such joint activities may also lead to misuse of market power by the companies that win the race.

Finally, a study of demand for e-skills in manufacturing industries indicates that specific competences, for example in business processes, are not sufficiently developed among professionals or graduates.

ICT and e-business are alive and kicking. They will continue to be crucial for Europe's economic wellbeing. So let us recall what Peter Drucker said: "The best way to predict the future is to create it." In this sense, the study team would be pleased if our findings helped decision makers to foster innovation and sustainability in Europe.

Stefan Lilischkis
Sectoral e-Business Watch Project Manager
empirica GmbH

Executive Summary

Executive Summary

ICT, e-business and sustainable economic activity

This report summarises the results of **seven studies** conducted by the European Commission's "Sectoral e-Business Watch" in 2009. The Sectoral e-Business Watch was established in late 2001, with the mission to monitor ICT adoption trends in different sectors and to assess the business potential and impact of ICT for companies and sectors as a whole. A special focus and novelty of the research in 2009, as presented in this report, was to explore the **sustainability potential** of ICT. There are great expectations for ICT as an enabling technology in this domain: to increase the energy efficiency in production processes, to make road transport and logistics processes more efficient, and, as a result, to reduce the carbon footprint of industrial activity. Ultimately, the big question of our time is whether advanced economies can maintain their high standard of living, and emerging economies rise to this standard, without causing irreversible damage to our planet by over-exploiting non-renewable resources. This will only be possible if the global community finds a path to achieve either sustainable growth or, as a more radical and so far uncharted option, prosperity without growth.

The economic research presented in this report helps to understand the role of ICT in this context. In short, ICT was found to be an important and **useful tool**, but no "silver bullet" capable of solving the problem by itself. However, in the desperate fight to make economic activity around the globe more sustainable, any measurable contribution is welcome. Indeed, there is significant evidence that advances in ICT use are positively correlated with more sustainable production in energy-intensive manufacturing sectors and in the transport industry (see Chapter 2). However, the magnitude of ICT's impact on emissions appears to change according to levels of output and ICT capital stock. Although ICT consistently reduced emissions in the sectors analysed over the sample period (1995-2005), the absolute reductions decreased over time.

EXHIBIT 1: ICT IMPLICATIONS FOR ENERGY CONSUMPTION AND SUPPLY: KEY STUDY RESULTS OF 2009

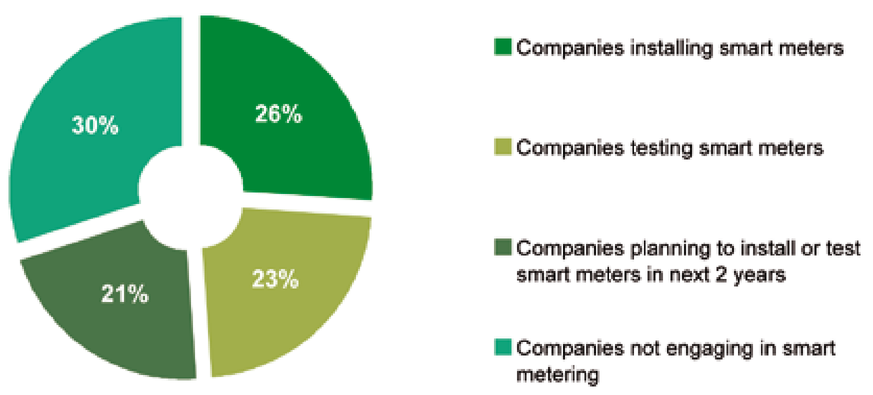
The ICT potential for sustainable production and transport	The role of ICT in the energy supply industry
ICT increases production sustainability: a greater share of ICT in a company's total capital is linked with greater production sustainability in energy-intensive industries. A one-percentage-point increase in ICT capital share is estimated to increase sustainable efficiency between 0.8 and 2.6 percentage points, depending on the sector. **Sectoral differences**: in absolute measures, the metals industry, transport services and the energy sector revealed the greatest scope for ICT-enabled efficiency increases in most countries. **Intelligent Transport Systems**: ITS, combined with Ambient Intelligence related technologies, show significant potential to make road transport more efficient. A major barrier to unlocking this potential is the absence of a common framework architecture for these systems.	**ICT is needed for "smart" energy distribution**: the energy supply sector is currently undergoing a transformation, in particular in distribution. Smart metering technologies are expected to play an important role in supporting sustainability, but the business case for their deployment is not yet sufficiently developed. **ICT-intensive sector**: Energy companies are well equipped with ICT systems supporting energy network automation and control. About half the companies surveyed were installing or testing smart meters in 2009, and about a fifth planned to do so in the next two years. **Standardisation and government support** are seen as critical success factors to realise the societal and environmental potential of ICT systems in the energy industry.

ICT systems have an impact not only on energy consumption (demand side impact), but also on the way energy is produced and distributed (supply side impact). The **energy supply sector** is expected to undergo transformation, in particular in terms of electricity distribution. Technological innovation, with ICT as one of the key enablers, is driving fundamental change in the power grid. The hope is that energy production will become "smarter", as the operation of all interconnected elements in the grid can be better coordinated. This would improve not only the security of energy supply, but also its environmental sustainability. The studies find that the transition towards a more climate-friendly energy supply sector is supported by a range of ICT solutions, which respond to changing regulatory, safety, and security requirements (see studies in Chapter 3). Although the sector is already an intensive user of ICT systems (compared to other industries), there is still scope for a much wider deployment of ICT solutions for monitoring and reducing its environmental impact.

A specific focus of the studies was to assess the deployment and importance of **smart metering** systems (see Exhibit 2). These are advanced electronic devices combined with modern two-way communication technologies. They collect and provide detailed information about consumption profiles. These data could have an important effect on both demand and supply, for instance by enabling innovative tariff schemes. The extent to which smart metering will be introduced is a subject of debate and will depend on the incentives introduced and the savings the technology can offer. The Sectoral e-Business Watch study found that about half of the companies were already installing or testing smart meters in 2009, and more than 20% had plans to do so within the next two years. No other application or technology attracted as much attention.

The studies also point to some **barriers** slowing down the deployment of smart metering systems. A general problem is that the business case for energy companies to drive smart metering is not yet clear. Another critical factor is standardisation. Insufficient international agreement on standards keeps companies from investing in the new technologies required for smart grids. The study concludes that only wide-scale organisations such as governments can accelerate and enforce the desired changes. They could set guidelines to decrease uncertainty, inform customers and provide financial incentives (e.g. for RTD on ICT systems which enable new energy technologies, and for investment in such systems).

EXHIBIT 2: DEPLOYMENT OF SMART METERING SYSTEMS IN 2009



Base (100%): Companies operating in the distribution and retail of energy and heating and cooling, in six EU countries (France, Germany, Italy, Poland, Spain, UK). N = 265.
Figures are weighted by employment. Reading example: "Companies representing 23% of employment in the energy sector were testing smart meters in 2009."

Removing barriers on the way towards advanced forms of electronic data exchange

The European e-Business Report 2008 observed a "trend towards digitally integrated value systems", with an increasing "importance of knowledge-intensive activities" within both the manufacturing and service sectors (p. 9f.). Even if the economic crisis has slowed the dynamics of this transformation, it has not come to an end or been reversed. ICT systems have become pervasive in business. In fact, "e-business" is probably no longer an adequate term to capture the general trend of applying ICT systems in commercial exchanges. In advanced companies, most business processes are ICT supported in one way or the other; a distinction between "e-business" and "traditional business" is no longer possible. However, even if the concept is being mainstreamed, some important issues remain to be addressed. These include technical and legal challenges for electronic data exchanges between companies, which limit the scope of the network effects and the resulting productivity gains.

With the study on the glass, ceramics and cement industry (see Section 2.2), the Sectoral e-Business Watch completed its series on e-business in energy-intensive sectors (pulp and paper, 2006; chemical, steel and transport services, 2008). The second sector study of 2009 analysed e-business activities in the energy supply industry (see Section 2.3). The studies confirmed the general trends outlined above. Even in the **glass, ceramics and cement** industry, a traditional manufacturing sector where SMEs account for more than 50% of employment, more than two thirds of the companies said that they conducted at least some of their business processes electronically in 2009. About 15% saw themselves as intensive users. However, many companies use ICT mainly for optimising their internal processes rather than for data exchanges with suppliers and customers. Although the **energy supply industry** is a completely different sector, basic business objectives - such as the efficiency and productivity of operations and the return on assets - are the same. Energy companies make intensive use of a broad range of ICT solutions to reach these objectives. Solutions range from general corporate ICT systems (such as ERP) to sector-specific ICT solutions for various activities covering the full value chain: energy generation, transmission, distribution, metering and retail. All in all, the sector is an advanced user of ICT systems; nearly 90% of the energy companies said they conducted at least some of their processes electronically in 2009.

EXHIBIT 3: E-BUSINESS TRENDS AND CHALLENGES IN 2009/2010

ICT & e-business trends observed in 2009	Challenges to be addressed to advance e-business in Europe
Impact of the crisis: many large companies have reduced their ICT budgets and downsized or cancelled projects. Companies have refocused their e-business activities on cost saving. This is a reverse trend compared to the economic growth period of 2004-2007, when companies began to invest more in marketing and improving customer services.	**Supporting SMEs in taking informed decisions**: the digital divide is a major barrier for wider use of e-business, limiting the network effects. A challenge for many small firms is to take informed decisions on ICT adoption (or non-adoption), as they are not familiar with ICT concepts and the business opportunities they offer.
ICT to improve the transparency of internal processes: increasing the efficiency of internal processes remains a key objective of ICT use. Case studies demonstrate the potential of ICT in this regard, both for large companies and for SMEs. The cases also show that gains in efficiency tend to go hand in hand with more transparency in business processes. This facilitates planning and decision making.	**Creating an optimal framework for advanced electronic data exchanges**: some business processes, such as invoicing, are well suited to be digitised. However, there are still complex issues to be solved. The EC's Expert Group on e-Invoicing made comprehensive recommendations on how the framework conditions could be improved (2009); these should be followed up.
e-Business as part of the strategy and business model: in large companies and in some SMEs, e-business is deeply integrated with the company's overall strategy. It supports the strategy, and can even become a part of it. This includes decisions on which parts of the value chain to cover, on product portfolios, distribution channels and cooperation strategies.	**Broader agreements on standards for e-business within value chains**: the scope for expansion in advanced e-business with suppliers and customers remains significant in many sectors. Agreement among the players on standards for data exchanges is a key success factor in driving adoption.

Strategic responses for policy and industry: towards a European strategy for Key Enabling Technologies

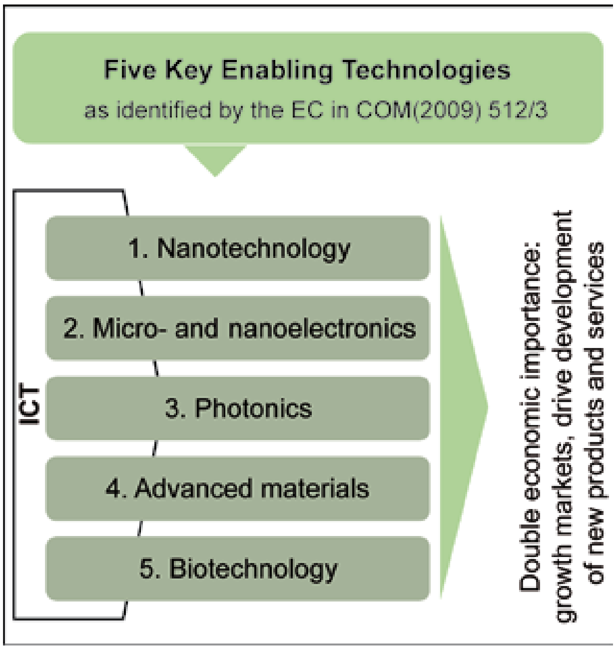
ICT as a general purpose technology

ICT is a so-called general-purpose technology with three far-reaching characteristics: it is pervasive as it spreads to all economic sectors; it improves over time and hence keeps lowering the costs for users; and it spawns innovation, i.e. it facilitates research, development and market introduction of new products, services or processes. This last property can be termed the "enabling role of ICT for innovation". The Sectoral e-Business Watch studies of 2009 confirmed the importance of ICT for product and service innovation as well as for process innovation. This holds true for innovation in the energy supply industry (see Sections 3.1 and 3.2), in road transport (see Section 2.3) and even in traditional manufacturing sectors (see Section 2.2). The development of new products, services and processes could be further enhanced by the "Future Internet", comprising the "Internet of Things" (i.e. networks of objects and sensors which are interconnected through wireless devices or the internet) and the "Internet of Services" (online networking and collaboration tools).

ICT can support innovation in key enabling technologies

In a Communication published in September 2009, the European Commission introduced a focus on "key enabling technologies" (KETs), i.e. technologies that will be of crucial importance for the development of new products and services over the next five to ten years. The EC identified five KETs: nanotechnology, micro- and nanoelectronics (including semiconductors), photonics, advanced materials, and biotechnology. These technologies are seen as crucial to ensure the competitiveness of European industries in the knowledge economy.

EXHIBIT 4: ICT AND THE NEW KEY ENABLING TECHNOLOGIES



ICT is still relevant for all of these KETs, not only because it is embedded in almost all high-tech applications. Micro- and nanoelectronics are by definition ICT, as they are basic components of hardware; and photonics, the technical application of light, has large overlaps with ICT. Furthermore ICT may, in its general purpose, help exploit the innovative potential of nanotechnology, advanced materials, and biotechnology. Another condition for successfully establishing these industries and using their applications is a functioning high-speed (broadband) network. The European Commission and Member States are well advised to closely intertwine their KET activities and strategies with those related to ICT.

Policy responses: focusing on commercialisation, applying game theoretical considerations in policy design

A principal problem of European innovation performance is, as the KET Communication states, that "the EU has very good research and development capacities in some key enabling technology areas; however it is not as successful in commercialising research results through manufactured goods and services" (p. 3). Innovation policy will thus have to focus on the **commercialisation** of results from KET R&D. To this end, the European Commission suggests, among other things, increasing the focus on joint strategic programming and demonstration projects in order to reach sufficient critical mass and overcome fragmentation of European R&D. The European Commission also suggests reviewing possibilities to spur innovation through state aid.

The Sectoral e-Business Watch study about ICT-related industrial policy shows how considerations and concepts based on **game theory** can help design effective policies. For instance, policy makers should be aware of the possible downsides of joint European technology programmes and state aid, such as inefficient collusion of firms involved and free-rider behaviour of companies and countries (see Section 4.1).

ICT and e-business for an innovative and sustainable economy: synopsis of the main study results

ICT and e-business for an innovative and sustainable economy: synopsis of the main study results

ICT impacts in three domains

ICT use in business is not only becoming more pervasive, it is also progressing towards more advanced and sophisticated applications. From this perspective, ICT still has the characteristics of a "**general purpose technology**" or an "**enabling technology**". These terms refer to technologies which are widely used (or embedded) in different domains, and which have a profound effect on the entire economy, in particular because they enable incremental or even disruptive innovation.

The potential and the resulting economic impacts of ICT can be observed and analysed in different domains. These include, in particular, the role of ICT for innovation, for competitiveness and for sustainability (see Exhibit 1-1). The three domains are strongly interrelated. For example, if a company increases its energy efficiency ("sustainability"), it reduces costs and becomes more competitive. However, there can also be conflicts of interests between these domains: investments in innovative green technology may increase the environmental sustainability, but not pay off for the company, at least in the short term. Therefore it makes sense to evaluate ICT impacts from these different domain perspectives.

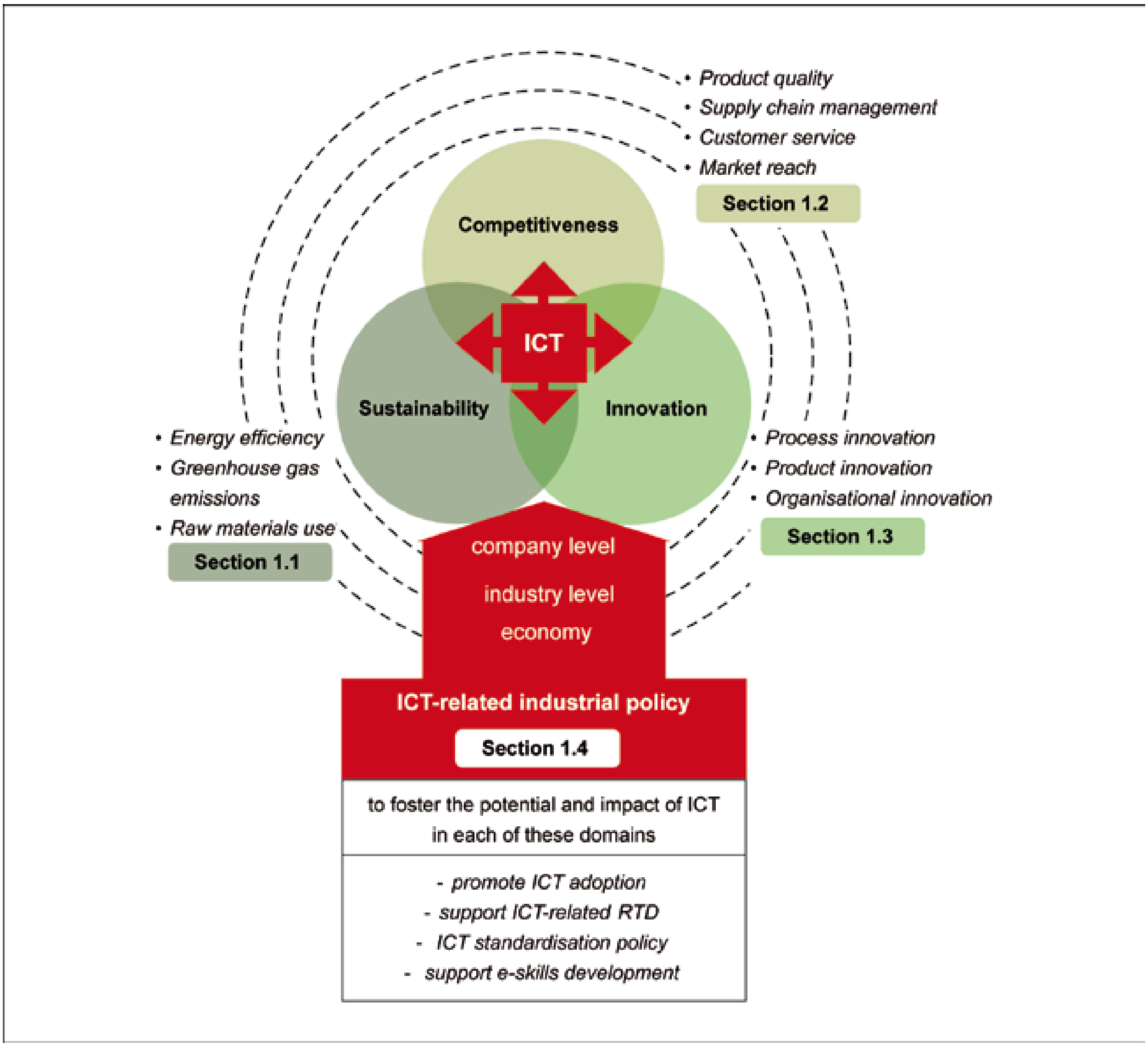
Sustainability refers to efforts in using energy and non-renewable resources as efficiently as possible, and to keep the emission of greenhouse gases at the lowest possible level. Few economic studies have so far been conducted on the potential of ICT in this field. The pilot studies of the Sectoral e-Business Watch contribute to this body of literature. The main results are summarised in Section 1.1.

Competitiveness is very much linked with e-business activities in the narrow sense and covers objectives such as reducing procurement costs, optimising the supply chain, improving products and customer service, reaching new customers or increasing the market share. Connected ICT systems enable automated data flows within and between companies. Advanced forms of e-business are now being widely practiced by large companies across all sectors, but the digital divide with smaller companies is still hampering their full deployment. The Sectoral e-Business Watch has analysed related issues for many years. The main current issues to be considered, based on the latest series of studies (2009), are summarised in Section 1.2.

Innovation: finally, technological progress in ICT has enabled a host of innovations in business, leading to improved products, more efficient processes and new organisational structures (see Section 1.3). The capability for innovation is considered to be extremely important for European companies in order to keep their position in market segments with higher added value, as they cannot compete with emerging economies in labour costs.

All three domains of ICT impact – sustainability, competitiveness and innovation – are relevant at different levels: at the **micro level** of the individual company, the **meso level** of the industry and the macro level of the economy as a whole. Because of the meso and **macro effects**, industrial and innovation **policy** in advanced economies has for many years been paying close attention to ICT. Section 1.4 summarises strategic responses for an ICT-related industrial policy recommended by the Sectoral e-Business Watch studies of 2009.

EXHIBIT 1-1: THE ECONOMIC IMPACT OF ICT AS A GENERAL PURPOSE TECHNOLOGY



1.1 ICT and sustainability: the "green" potential

Main conclusions

ICT enables production sustainability: a greater share of ICT in a company's total capital is linked with greater production sustainability in energy-intensive industries. Increases in production volumes can be delinked from an increase in greenhouse gas emissions. However, achieving emissions reductions through ICT is expensive compared to other abatement technologies.

Largest ICT potential in metals and transport industries: The two sectors that revealed the largest scope for efficiency changes from a greater emphasis on ICT capital were the metal and transport services sectors.

Combining Intelligent Transport Systems with Ambient Intelligence: Intelligent Transport Systems (ITS) show significant potential to reduce road transport emissions, but, so far, little quantitative evidence for this has been gathered. To unlock this potential, ITS will have to be combined with Ambient Intelligence related technologies (such as ubiquitous computing and sensor network systems).

ICT is needed for "smart" energy distribution: The energy supply sector is currently undergoing a transformation, in particular in distribution. Smart metering technology is expected to play an important role in supporting sustainability, but the business case for utilities to deploy smart meters is not yet sufficiently developed. Standardisation and government support will be important to achieve societal and environmental objectives.

"Green ICT" to reduce the sector's own carbon footprint: About 2% of greenhouse gas emissions are caused by the production and use of ICT. Therefore, in parallel to unlocking the indirect green potential of ICT, it is also important to address the direct ecological footprint of ICT in the design, manufacture, use and disposal of ICT products.

ICT as a key enabling technology for environmental objectives

In the past few years, a new aspect of ICT use has emerged and become a focal point of attention: the "green" potential of ICT, in particular the use of ICT to **become more energy-efficient** and, as a result, **reduce greenhouse gas emissions**. There is much hope that ICT can be a major part of the solution in tackling climate change and related environmental challenges. In its Communication "Mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy"[1], the Commission has made recommendations to the ICT industry and to Member States on how to achieve related objectives.

To reinforce the (scarce) empirical evidence in this field, a special focus of the research conducted by the Sectoral e-Business Watch in recent years has been to explore the "green potential" of ICT. An economic pilot study in 2007/08 analysed the links between ICT adoption and energy efficiency. One of the main results was that an increased use of communications devices had a positive impact on the electricity efficiency of the sectors studied, while the IT part of ICT (computers and software) had the reverse effect, but a positive impact on the productive efficiency. In 2009, a new study analysed the relationship between ICT and greenhouse gas emissions in European energy-intensive industries and found a significant impact in some sectors (see Section 1.1.1). Both studies are amongst the first comprehensive economic analyses in this field. A sector study on ICT use in the energy supply industry explored the role of ICT from the supply-side perspective and concluded that ICT is enabling a far-reaching transformation of the whole sector (Section 1.1.2). A bibliographic survey of the implications of Intelligent Transport Systems for road transport concluded that they have a significant potential to reduce emissions (Section 1.1.3). Finally, for a comprehensive assessment of the "green potential" of ICT, the sector's direct ecological footprint must also be considered. Section 1.1.4 points to some trends in this regard.

1.1.1 ICT AND ENVIRONMENT-FRIENDLY PRODUCTION PROCESSES

Industrial activities account for more than half of global greenhouse gas emissions. **Energy-intensive sectors** such as metals, chemicals, paper, glass, ceramics and cement manufacturing, and the transport services industry, are responsible for a disproportionate share of emissions. There is strong evidence that greenhouse gases (GHG) have an impact on the climate, commonly referred to as global warming. Today, the great majority of experts take these links for granted, with only few still contesting that global warming is (at least partly) caused by industrial civilization. In the past five years, international efforts to reduce (GHG)

[1] COM(2009) 7604, 09.10.2009.

EXHIBIT 1.1-1: ICT IMPACT ON GHG EMISSIONS IN EUROPEAN ENERGY-INTENSIVE INDUSTRIES (1995-2005)

	Basic and fabricated metals	Chemicals, rubber, plastic	Glass, ceramics and cement	Transport and storage
Increase in sustainable efficiency due to a 1 percentage pt. increase in ICT capital share	• 0.79 to 0.89 percentage pts.	• • • 2.64 percentage pts.	• • • 2.58 percentage pts.	• • • 1.24 to 1.72 percentage pts.
Equivalent increase in gross output without additional increase in emissions (1995 euros)	• €330 million	• • • €1370 million	• €280 million	• • €750 million
Equivalent absolute reduction in GHG emissions at constant output levels	• 0.13 million t	(2)	(2)	• • • 1.2 million t
% change in emissions per output due to 1% increase in ICT capital intensity	• -0.12%°°	(2)	• -0.15 to -0.20%°	• -0.12%°°
Equivalent absolute reduction in GHG emis-sions	• • • 26,400 to 74,000 t	• • 15,000 tonnes°°	(2)	• • • 27,200 to 34,800 t
Cost in ICT fixed capital stock of a 1 tonne reduction in GHG emissions (1995 euros)	• • €170 to € 440	• • • € 1,350 (1)	(2)	• • € 420 to € 540

(1) = not robust to exclusion of certain countries from the data set
(2) = results not reported for lack of significance or interpretability
Source: DIW econ 2009.

emissions have gained significant support and momentum. Europe is committed to take a lead in this field.

A Sectoral e-Business Watch study by DIW econ explored to what extent ICT can help to mitigate the environmental footprint of energy-intensive industries (see Section 2.1). The study focused on the period 1995-2005. Results for the analysed sectors and countries varied considerably, reflecting different industry structures and different available technologies. Thus, the relationship between ICT and GHG emissions in European energy-intensive industries is not straightforward. With all due caution, however, the econometric analysis (based on two different approaches conducted in parallel) did find statistically significant evidence (except for the paper industry) that a greater share of **ICT** capital in total capital **contributes to sustainable production**. In other words, ICT can help increase output at constant emission levels. In four out of the five sectors analysed, a one-percentage-point increase in ICT capital share (e.g. fixed ICT capital stock increases from 2% to 3% of total capital) is estimated to increase sustainable efficiency by between 0.79 and 2.64 percentage points. Thus, greater intensity of ICT capital in production processes can reduce emissions per output; however, the magnitude of the impact on emissions changes with levels of output and ICT capital stock.

The two sectors that revealed the greatest scope for efficiency changes (in absolute measures) as a result of greater emphasis on ICT capital were the metal industry and, in particular, the **transport services** sector (see Exhibit 1.1-1). In the transport industry, non-ICT capital was also found to be significantly emissions-increasing (but not in the metal sector).

The study also found that the impact on emissions of greater ICT capital per output was more conclusive for older EU

Member States. It concluded that the potential had not yet been realised in the new Member States in the period analysed, reflecting older production technology. In fact, to counteract rising energy costs, energy-intensive industries in advanced economies have already made major efforts to become more energy efficient in production. The glass industry, for example, has significantly increased its energy efficiency, i.e. the amount of energy needed to produce a tonne of glass, by 50-70% since the 1970s.[2] There is scope for further improvement, but most probably not of the same magnitude.

1.1.2 ICT AND THE ORGANISATION OF ENERGY SUPPLY

ICT is an important enabler of innovation not only in energy-consuming industries, but also in the energy supply sector. Supplying energy requires a series of complex interactions between **generation, transmission, distribution and retail** facilities. A Sectoral e-Business Watch study documents the important role of ICT in facilitating these interactions (see Section 3.1). The study concludes that ICT can contribute towards the EU objectives related to the security of energy supply and its environmental sustainability.

The energy supply sector is currently undergoing a transformation, in particular in distribution. Traditionally, electricity grids have been seen as passive distribution grids. They were characterised by a hierarchical and unidirectional energy flow structure, from higher to lower voltage levels. Technological innovation is driving fundamental change in the electricity grid. The popularity of small-scale distributed generation units is growing. The former hierarchical and unidirectional system is turning into an active distribution grid with bi-directional energy flows. A modernisation of the electricity delivery system, the so-called **smart grid**, has therefore been proposed. Its aim is to integrate, monitor, protect and automatically optimise the operation of all interconnected elements in the grid.

[2] According to industry statistics published by British and German sector associations.

To enable demand-side management, smart metering technology is necessary. The basic components of a smart meter include large storage capacity, programmable devices and a digital display. Innovative smart meters are advanced electronic devices combined with modern two-way communication technologies. They can provide a wide range of useful information, including more accurately measured data on households' electricity consumption and billing, load profiles, time-based electricity pricing and tariffs. Smart meters can make such information available not only to utilities but also to consumers.

The extent to which smart metering will be introduced is still unclear, and depends heavily on customer acceptance and on agreement on standards for communication and data management. A Sectoral e-Business Watch study on this topic (see Section 3.2) concludes that **standardisation** is one of the most crucial steps in this context to speed up developments. Another important factor is **governmental support** from all levels. Great benefits may accrue on a societal level, i.e. to the environment and in terms of power supply reliability. The e-Business Watch survey among energy supply companies found that about half of all energy companies (by their share of employment) were either installing or testing smart meters in 2009. About 20% had plans to do so in the next two years. However, the business case for utilities to spontaneously invest in the deployment of smart meters is still weak. Governments may have to enforce changes in today's electricity distribution system in order to realise the potential benefits for the environment and society. Possible changes in business models to support adoption include tariff schemes with time-of-use pricing.

1.1.3 ICT AND THE EFFICIENCY OF ROAD TRANSPORT

Transport and logistics related emissions are responsible for a significant share of environmental pollution and greenhouse gas emissions in the European Union and worldwide. Furthermore, the sector has increased absolute emissions over the past 15 years, while emissions in energy-intensive manufacturing sectors have decreased due to more efficient production technologies. Transport and logistics remains one of the fastest growing energy demand sectors, particularly in the new EU Member States. Its share in energy demand (more than 20%) is expected to rise even further. Within the sector, road transport accounts for 72% of CO_2 emissions in the EU, which increased by 32% from 1990 to 2005. As the majority of goods are already carried on Europe's roads, further increases in volume will present a major challenge in respect of traffic congestion, road safety and the environment. Against this background, any improvement in the efficiency of road transport (e.g. through smart logistics) can have a significant impact on GHG emissions levels.

A Sectoral e-Business Watch study of 2009 found that **Intelligent Transport Systems** (ITS), although not explicitly designed for environmental purposes, show significant potential to reduce road transport emissions (see Section 2.3). However, this is mostly a qualitative assessment; there is hardly any quantitative empirical evidence available yet. Therefore, focussed research efforts to measure the scope of possible impacts are recommended, for instance through pilot projects in the RTD Framework Programmes of the EU.

ITS tools are a major enabler for the management of logistics chains, notably in maintaining a paperless information trail in the management of the physical flow of goods ("eFreight").

A major barrier to unlocking the environmental potential of ITS is the lack of a **common framework architecture** for these systems. The impact can only be maximised if different systems can operate with each other. To date, a diverse range of ITS have been deployed throughout transportation networks. They have often developed piecemeal with each system tailored for its application-specific purpose. EU policy would be well advised to promote the development of a common ITS framework architecture and establish interoperability guidelines, e.g. by supporting relevant research projects.

Another important success factor will be to combine **Ambient Intelligence** related technologies (such as ubiquitous computing and sensor network systems) with the existing infrastructure and deployment of ITS technologies. While ITS technologies increase the level of intelligence in the infrastructure, Ambient Intelligence increases the sensing, processing and communications capabilities of both vehicles and travellers. In a long-term scenario, the integration of ITS and Ambient Intelligence technologies could lead to a completely new paradigm of transport network management, control and operation.

1.1.4 "GREEN ICT" – MAKING ICT SYSTEMS MORE ENERGY EFFICIENT

The above sections discussed the "green potential" of ICT as an instrument to make industrial production processes and road transport more environmentally sustainable. They did not consider the environmental footprint of the ICT systems themselves. By contrast, the frequently used terms "green computing" or "green ICT" usually refer to the **direct footprint of the ICT industry** and their products rather than to their indirect impacts. "Green ICT" attempts to minimise the environmental impact of manufacturing, using and disposing hardware (including computers, networks and peripheral devices such as printers). Green ICT concepts have not yet been analysed by Sectoral e-Business Watch studies. A complete picture of the environmental impact of ICT should consider both sides, however: the direct footprint of ICT (the "debit"), and the indirect footprint from ICT-enabled efficiency gains (the "credit").

On the debit side, Green ICT recognises that ICT systems have become a major consumer of energy. The use of ICT equipment and services are estimated to account for about 8% of electrical power consumption in the EU and about 1.75% of carbon emissions. A further 0.25% of emissions come from the production of ICT equipment.[3] If no measures are taken to significantly improve the energy efficiency in computing and networking, a dramatic further increase in energy demand is inevitable. There are two major drivers for ICT related emissions: the enormous growth of ICT use in emerging economies, and the rapid technological progress, resulting in qualitative growth (more computing power available at a given price). CO2 emissions caused by ICT production and use in Germany are expected to increase by 60% until 2020 if no progress towards more energy-efficient systems can be achieved.[4] The share of electricity consumption by ICT products and services may grow from 8% to 10.5% by 2020.

To counteract the increasing energy demand of ICT, the industry has made enormous efforts to make their products and services more sustainable and energy-efficient along their entire life cycle, including during design, manufacture, use and disposal. New technological development such as virtualisation (the hosting of applications or other computing processes on one single, powerful system) could enhance green ICT concepts.

1.1.5 OUTLOOK

As discussed in the introduction, the environmental objectives of ICT use are closely linked with other business objectives. The key incentive for companies to increase the energy efficiency of their production processes is to save on energy costs. In energy-intensive sectors such as the cement industry, energy costs can amount to more than 30% of total production costs. However, the environmental dimension of ICT use goes beyond cutting costs. There are at least two further aspects where companies are forced to act and where ICT could have a role as a facilitating technology: the **compliance with legal requirements** regarding the monitoring and reporting of emissions, and considerations regarding the **image of the company**

[3] Smart 2020 report and Bio Intelligence study, both quoted in the EC Communications COM(2009) 7604 final, 09.10.2009, and COM(2009) 111 final, 12.03.2009.
[4] "Von Green-IT zu Green Business - CO2-Reduktion innerhalb und außerhalb des Rechenzentrums" (2008). Study by A.T. Kearney, quoted in: "White Paper Green ICT. Der Weg zum Grünen Business." Published by T-Systems (2009).

in terms of being innovative and environmentally responsible.

In the short and medium term, the main pressure on companies to act will come from rising energy costs and from **emissions regulation**. Industrial activities account for more than half of global GHG emissions. Energy-intensive sectors such as the chemical, metals, paper and mineral products industries, inevitably, cause a disproportionate share of emissions. International efforts to reduce GHG have gained significant support and momentum. Europe is committed to take a lead in this field and has implemented the EU Emissions Trading System in 2005, the largest multi-country, multi-sector agreement to control GHG emissions in the world. As a long-term trend, it can be expected that, with the possible exception of legal requirements, customers will become the key force in reducing GHG emissions, as they become more demanding not only concerning the quality and price of products, but in terms of their impact on the environment. Eco-labels and certificates documenting the ecological footprint of products, such as scales on electrical products indicating their energy efficiency (e.g. from A-E), will become more widespread and constitute a product quality feature. It can therefore be expected that the "green potential" of ICT will gain even more attention in the future.

1.2 ICT and competitiveness: the business potential

Main conclusions

e-Business as a strategic issue: Decisions on the e-business strategy need to be aligned with a company's overall strategy and business model and should not be seen as an "add-on".

Unequal distribution of benefits: Large companies in all sectors are paving the way towards advanced forms of e-business and are profiting from their benefits. However, the business case for many of the smaller companies is not as straightforward. This implies a conflict between micro and macro objectives: the potential network effects cannot be fully realised because the benefits are not equally distributed between companies.

Focus on cutting costs: many companies currently focus on the cost-cutting potential of ICT (efficient processes, e-procurement), due to the difficult economic environment. When the economy recovers, the strategic focus could shift towards marketing and growth objectives (e-commerce, customer service).

Aggregate ICT impact on productivity growth: the existing literature indicates that ICT-induced productivity effects are less pronounced in capital intensive, mature manufacturing industries (such as the glass, ceramics, cement or chemicals industry).

Implications for future research: experience of the Sectoral e-Business Watch shows that a thorough assessment of e-business impacts on the competitiveness of enterprises should combine different approaches, including both qualitative and quantitative analysis based on micro and macro data.

1.2.1 THE STRATEGIC DIMENSION OF E-BUSINESS

e-Business is part of a company's business model

e-Business is not primarily about technology (even if the part technology plays in ICT is anything but trivial), but about optimally managing internal processes, and relationships with suppliers, customers and business partners in a complex and often global competitive environment. It is part of a company’s business strategy; the way a company uses e-business is essentially part of its business model. For instance, the decision whether or not to offer products online is part of the distribution strategy, and the use of e-procurement systems must be embedded in the overall procurement strategy of a company. The sector studies of the Sectoral e-Business Watch have repeatedly shown that such an integrated view of ICT use and e-business is essential to comprehend the implications for the competitiveness of individual companies, for sectors, and for the economy as a whole.

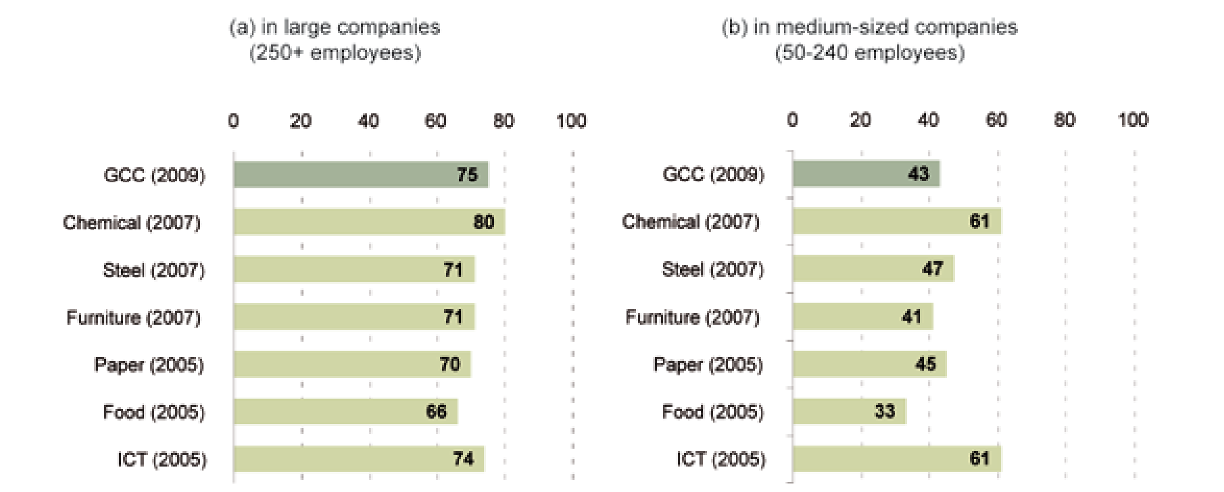
Two main objectives of ICT use: reducing costs, increasing revenues

Companies use ICT and e-business for two basic objectives: to reduce costs, and to increase their markets and revenues. The focus and priorities differs between sectors, but can also change depending on the company strategy and the business environment. The glass, ceramics and cement industry is an example of a sector where reducing costs by making internal processes more efficient is clearly the dominant objective (see summary in Section 2.2). This orientation towards the cost-saving potential of ICT has been reinforced by the economic crisis. By contrast, an earlier sector study on the chemical, rubber and plastics industry (2008) found that companies were increasingly turning their attention to the growth-supporting potential of ICT and the opportunities it offers for improving customer service. It is noted that these observations were made during a period of strong economic growth.

1.2.2 THE DIFFICULT ROAD TOWARDS ADVANCED ELECTRONIC DATA EXCHANGES

Companies use ICT for many purposes and with different levels of sophistication. The e-Business Watch sector studies conducted in the past five years provide comprehensive evidence of this. At a very basic level, applications such as e-mail and using the web do not have major implications for the existing business. They support existing processes without changing them. To use more effectively advanced forms of e-business, such as the exchange of standardised data with business partners, companies often have to implement significant organisational changes in parallel. In some sectors (such as tourism), the rise of e-business has not only had an impact on internal processes, but is transforming the entire business model of companies or the sector as a whole.

EXHIBIT 1.2-1: ADOPTION OF ERP SYSTEMS IN DIFFERENT MANUFACTURING SECTORS (2005-2009, IN % OF COMPANIES)



Source: e-Business Surveys 2005 / 2007 / 2009

Level 1: Basic ICT use – little organisational impact

ICT use has become commonplace in modern business. Nearly all companies use **e-mail**. Many have a **website**, and some of them offer basic **e-commerce** services on their website. These basic ICT applications do not have a significant impact on how the company operates, i.e. on its processes or business model. Many SMEs in manufacturing sectors, notably in the more traditional industries, use ICT on this level. The gains in process efficiency and cost savings are limited; on the other hand, investments in the technology are low as well. For many small companies, this use of ICT may be optimal, provided that they are not forced by large buyers to upgrade their e-business capabilities.

Level 2: Advanced e-business activity – significant impact on business processes

"Advanced" e-business means that companies can exchange data electronically with suppliers or customers based on **e-business standards**. This is the precondition that ICT systems can then automatically process the data (without having to manually key them into the system). Taking the step from basic to advanced e-business must, however, be well planned and is not without challenges. For most companies, this innovation has significant organisational and financial implications. They may need new, **advanced ICT systems** such as ERP and SCM systems (see Exhibit 1.2-1); they have to decide which standards to use and organise their business data (e.g. product catalogues) accordingly; and they have to make sure that the new systems are aligned with their actual business processes. The large companies in manufacturing sectors such as the glass, ceramics and cement industry (see sector study summary in Section 2.2) are in this situation.

Level 3: e-Business transformation – new business models and value chains

ICT has affected some sectors more than others, in particular the ICT services industry, tourism, financial services, publishing and the logistics industry. In these industries, the role of ICT and e-business goes far beyond improving process efficiency. ICT, and in particular the internet, have had a profound **impact on value chains**, including the emergence of new players. Many companies have to **adapt their business model** in order to stay in business. In tourism, for example, the internet makes it possible for service providers to interact directly with tourism customers, which puts enormous pressure on traditional market

EXHIBIT 1.2-2: THE IMPACT OF ICT AND E-BUSINESS IN DIFFERENT SECTORS

Level 1 Basic ICT use – with little impact on business processes	Level 2 Advanced e-business activity – sector-wide exchange of standardised data	Level 3 Sectors undergoing a major transformation due to e-business
• Most SMEs in process manufacturing sectors (e.g. paper, chemical, basic metals, glass, ceramics, cement) • SMEs in manufacturing sectors such as food, furniture • Construction SMEs	• Automotive industry • Electronics industry • Pharmaceutical industry • Large companies in other manufacturing sectors (e.g. chemicals, paper) • Large retail chains	• ICT services • Tourism • Financial services • Knowledge-intensive business services • Publishing • Logistics

intermediaries (travel agencies and tour operators). At the same time, the internet facilitates market entry, as players can operate exclusively online. In publishing, the advertising and sales revenues of newspaper publishers are decreasing as many young people of the "internet-generation" do not subscribe to a printed newspaper. Convergence of services, multi-channel publishing and the offer of mobile services are some of the catchwords that attempt to give a concrete character to future developments in this sector.

1.2.3 INDUSTRY PRODUCTIVITY GROWTH THROUGH ICT

Econometric analysis of aggregate impacts

ICT-based innovation in business is a major source of productivity growth. This is widely acknowledged and has also been found in studies of the Sectoral e-Business Watch. There is abundant (if mostly qualitative) evidence from case studies that supports this assertion. However, quantifying the impacts of ICT on the aggregate level is proving difficult. The debate on productivity impacts dates back to the productivity growth resurgence in the USA and a simultaneous diffusion of ICT products in the 1990s. It was assumed that a significant part of this increased productivity growth was attributable to increased ICT investments.

In response, a lot of research has been conducted to better understand the importance of ICT for competitiveness, productivity and growth. Unsurprisingly for such a complex topic, the research results cannot easily be summarised into simple conclusions. Studies revealed that only some countries and specific sectors (notably services and the ICT industry itself) have seen a clear surge in productivity resulting from ICT investment. These diverse results imply that the "productivity paradox"[5] is still valid. Despite ICT being pervasively used in all sectors and business functions, it is difficult to prove the direct impact on productivity and growth through macro-economic analyses.

The Sectoral e-Business Watch contributed to this debate. A study conducted in 2008, covering five sectors, found only moderate direct effects of ICT capital on labour productivity growth. Instead, the intensity of intermediate inputs was identified as the main driver of productivity growth. An econometric analysis of the aggregate impact of ICT in the glass, ceramics and cement industry (2009) confirmed this result. On the whole, there was no convincing evidence for substantial productivity or growth effects of ICT capital in this sector for the period 1995-2005. The empirical evidence was not fully conclusive, however; for instance, ICT capital was closely correlated with labour productivity growth, but investments in ICT were not. In short, the existing literature indicates that **ICT-induced productivity effects** vary significantly between sectors and that they **are less pronounced in capital intensive, mature manufacturing industries** (such as glass, ceramics, cement or chemicals).

Although the glass, ceramics and cement industries are not an ICT-intensive sector, the result is somewhat counterintuitive. The technological progress in production and supply-chain processes in these industries during this period is beyond doubt, and ICT components have certainly contributed to this innovation. The big question is whether data on ICT capital reflect the pervasive function of software systems adequately. What happens, for example, if these are embedded in production technologies?

Research implications for the impact assessment of e-business activities

A thorough assessment of e-business impacts on the competitiveness of enterprises requires the combination of different research approaches, such as micro and macro data analysis, qualitative and quantitative analysis. Each approach has its strengths, but also its limitations. Case studies of single companies, for example, are rich in information about current e-business practices and the related opportunities and risks, but they may not be representative. In order to avoid drawing invalid conclusions, case studies should therefore be compared with representative data about ICT adoption and use, as obtained from company surveys, such as those conducted by Eurostat and the Sectoral e-Business Watch. Macro-economic analysis of ICT impacts can assess aggregate effects (on sectors or the economy as a whole); however, the high level of aggregation of the variables used in these models can fail to recognise important issues, which are hidden in the accounts. The combination of all these instruments in the studies of the Sectoral e-Business Watch, in particular in those of the past three years, has been a unique feature in its research and a key factor for the interest that the studies have attracted.

[5] "Computers are everywhere but in the productivity numbers." (Robert Solow, 1987). The "productivity paradox" (or "Solow computer paradox") refers to the discrepancy between measures of IT investment and measures of output, in studies using growth accounting methods to explain the contribution of different inputs. The paradox was common in studies of the late 1980s and early 1990s, while later studies found more evidence of ICT-induced productivity effects.

1.3 ICT and innovation: the enabling potential

Main conclusions

ICT enables innovation as a general purpose technology (GPT): ICT has all the basic characteristics of a GPT: it is pervasive as it spreads to all sectors of the economy; it improves over time as it drives costs down for users; and it spawns innovation.

Process innovation is closely linked with ICT use: When companies introduce new business processes, this innovation activity is in most cases supported or enabled by specific software solutions. Vice versa, the introduction of new ICT systems often goes hand in hand with major organisational changes and constitutes a process innovation in itself. The latest surveys in the energy supply industry and the glass, ceramics and cement industries confirmed this for the entire research, development and innovation stream.

Innovation through cooperation: many companies involve external experts and cooperate with business partners in their innovation activities. The concepts of "joint innovation" and "open innovation" are gaining momentum, and ICT is facilitating this trend. Ideally, a more open and cooperative approach to innovation reduces costs and risks for companies, in particular in pre-competitive R&D activities. Advanced innovation policies are taking these trends into account.

1.3.1 ICT AS A KEY ENABLING TECHNOLOGY

ICT has far-reaching properties. It is a so-called general-purpose technology, or "key enabling technology", with three basic characteristics: it is pervasive as it spreads to most sectors of the economy; it improves over time and hence keeps lowering costs for users; and it spawns innovation, as it facilitates research, development and market introduction of new products, services or processes. This last property can be termed the "enabling role of ICT for innovation". For example, in the energy supply industry, "smart metering" and "smart grids", two technologies that will potentially transform European energy provision, are ICT-enabled.

The European Commission is currently focussing on key enabling technologies, including ICT, because they are the main driving force behind the development of new products and services. Such technologies may be crucial to ensure the competitiveness of European industries in the knowledge economy, as set out in a September 2009 Communication.[6] More specifically, the Communication states that "the EU has very good research and development capacities in some key enabling technology areas; however, it is not as successful in commercialising research results through manufactured goods and services" (p. 3).

1.3.2 ICT-ENABLED INNOVATION IN 18 INDUSTRIES

In the e-Business Watch surveys in 2006, 2007 and 2009, the innovativeness and the importance of ICT for innovation was examined across 18 industries: 13 manufacturing industries and five service industries. While the questions asked in 2009 differed slightly from 2007 and 2006, and while there may have been subtle changes in innovation behaviour from 2006 to 2009, the data provide an insightful overview. Exhibit 1.3-1 shows general product and service innovation activity as well as the role of ICT for product and service innovation by industry.

Product and service innovation

The overview reveals that telecommunications services, consumer electronics manufacturing, chemicals-rubber-plastics manufacturing, ICT manufacturing and energy supply were the most **innovative industries** among those covered by Sectoral e-Business Watch surveys since 2006. In these five industries, more than 50% of the companies said they had introduced new products or services in the twelve months prior to the interview. It is notable that three of the five top innovating industries are ICT producing or service industries. In the ICT industry, international competitiveness and the necessity to innovate are very high. At the other end of the scale, shipbuilding and repair as well as construction were found to be the industries with the lowest share of companies introducing new products and services. It is also notable that three of the five service industries included are located at the bottom: tourism, retail as well as transport and logistics.

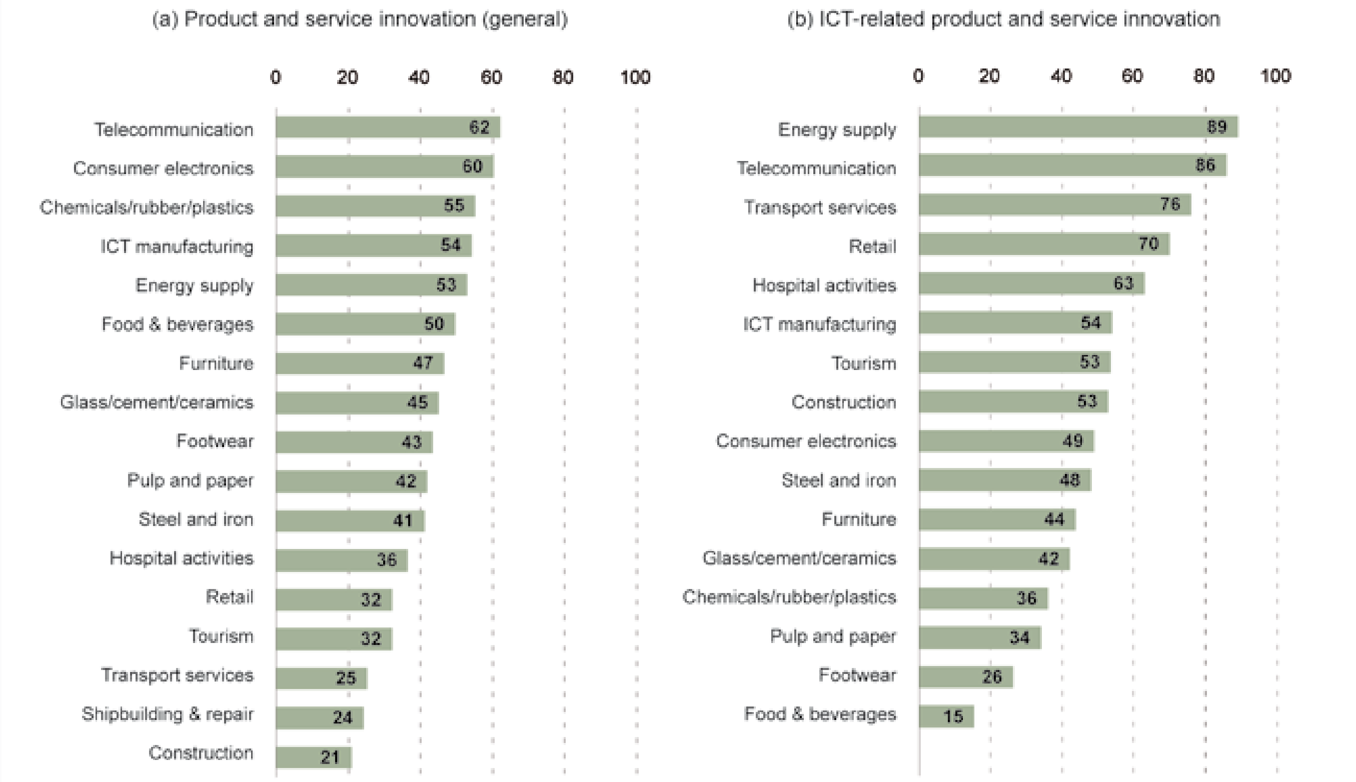
The picture changes when **ICT-related product and service innovation**[7] is considered. Companies that

[6] See the related Communication from the European Commission "Preparing for our future: Developing a common strategy for key enabling technologies in the EU", COM(2009)512, issued in September 2009.
[7] For the shipbuilding and repair industry, no data are available about ICT-related innovation because the number of cases was too small.

confirmed they launched new or substantially improved products or services were further asked whether these innovations had been directly related to, or enabled by ICT. Two industries stand out in this respect: energy supply (89%) and telecommunications services (86%). Their leading position may reflect the fact that these industries were liberalised in recent years and that they are realising their innovative potential as they are exposed to competition. With some distance, three industries follow in which more than 60% of the companies stated that their product and service innovations were ICT-related: transport and logistics services (76%), retail (70%) and hospitals (63%). All these three industries were found to be not particularly innovative in general, but if they innovate, ICT apparently has a crucial role. It is also notable that the five service industries included are among the largest seven industries in Europe's economy. This indicates a particularly high importance of ICT for service innovation.

The industries with the smallest importance of ICT in product or service innovation were found to be footwear production (26%) and food and beverages production (15%) – two industries characterised by craft production in small and micro companies, for which investment in ICT may not be profitable.

EXHIBIT 1.3-1: PRODUCT AND SERVICE INNOVATION ACTIVITY BY INDUSTRY – GENERAL AND ICT-RELATED



Figures are weighted by employment. Reading example: In the telecommunication services industry, companies representing 62% of employment stated that they introduced new or substantially improved products or services in the past twelve months prior to the interview.

Source: e-Business Watch Surveys 2006, 2007, 2009

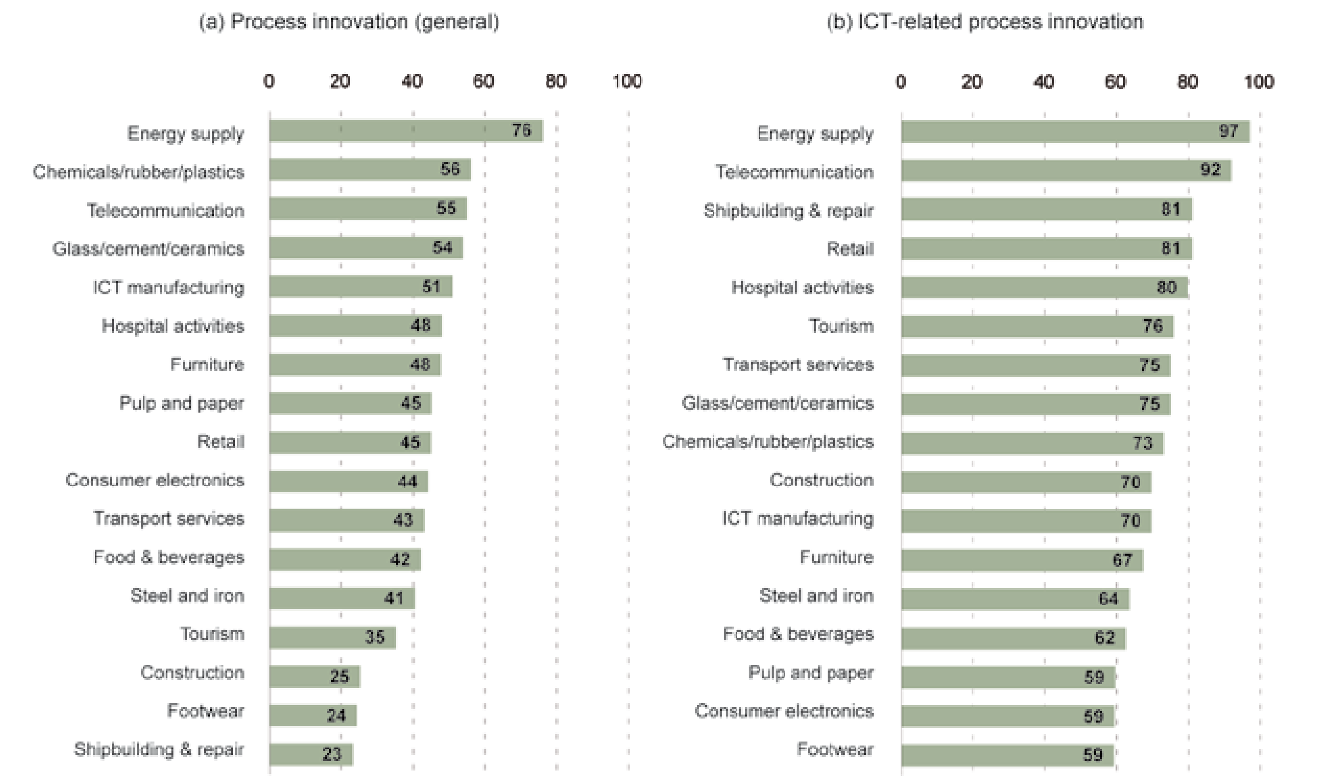
Process innovation

The energy supply industry was found to lead the way in terms of process innovation, with 76% of its companies classed as innovative. Runners-up are far behind: chemicals-rubber-plastics (56%), telecommunications (55%), glass-ceramics-cement (54%) and ICT manufacturing (51%). At the other end are construction (25%), footwear (24%) and shipbuilding (23%).

Energy supply was also found to lead in ICT-related innovation. Out of those companies that indicated general process innovation, almost all energy supply companies (97%) said these innovations were ICT-related. The following industries are telecommunications (92%), retail (81%), hospitals (80%) and tourism (76%). Again, the five service industries are among the seven most innovative industries with regard to ICT-related process innovation.

Unlike product and service innovation, both general and ICT-related, and also unlike general process innovation, the share of companies stating that their process innovation were ICT-related was distributed more evenly across industries. The lowest share of companies stating that their process innovations were related to, or enabled by, ICT was 59% - found in pulp and paper manufacturing, consumer electronics and footwear. This indicates that ICT is of very

EXHIBIT 1.3-2: PROCESS INNOVATION ACTIVITY BY INDUSTRY – GENERAL AND ICT-RELATED



Figures are weighted by employment. Reading example: In the energy supply industry, companies representing 76% of employment stated that they introduced new or substantially improved processes in the past twelve months prior to the interview.

Source: e-Business Watch Surveys 2006, 2007, 2009 high importance for process innovation in any industry. Exhibit 1.3-2 shows general process innovation activity and the role of ICT for process innovation.

1.3.3 INNOVATION IN ENERGY SUPPLY AND GLASS-CERAMICS-CEMENT

ICT importance for product, service and process innovation

In 2009, the Sectoral e-Business Watch conducted company surveys in two industries: energy supply and glass-ceramics-cement manufacturing. According to these surveys, companies representing 53% of the energy supply industry's employment said they introduced new products or services in the past twelve months, and 76% introduced new processes. In glass, ceramics and cement, companies representing 45% of employment introduced new products or services and 54% new processes. These companies were then asked about the role of ICT in their innovation activities.

The vast majority of innovators in both industries stated that ICT played a crucial role for innovating. In energy supply,

EXHIBIT 1.3-3: ROLE OF ICT IN INNOVATION IN THE ENERGY SUPPLY INDUSTRY 2009

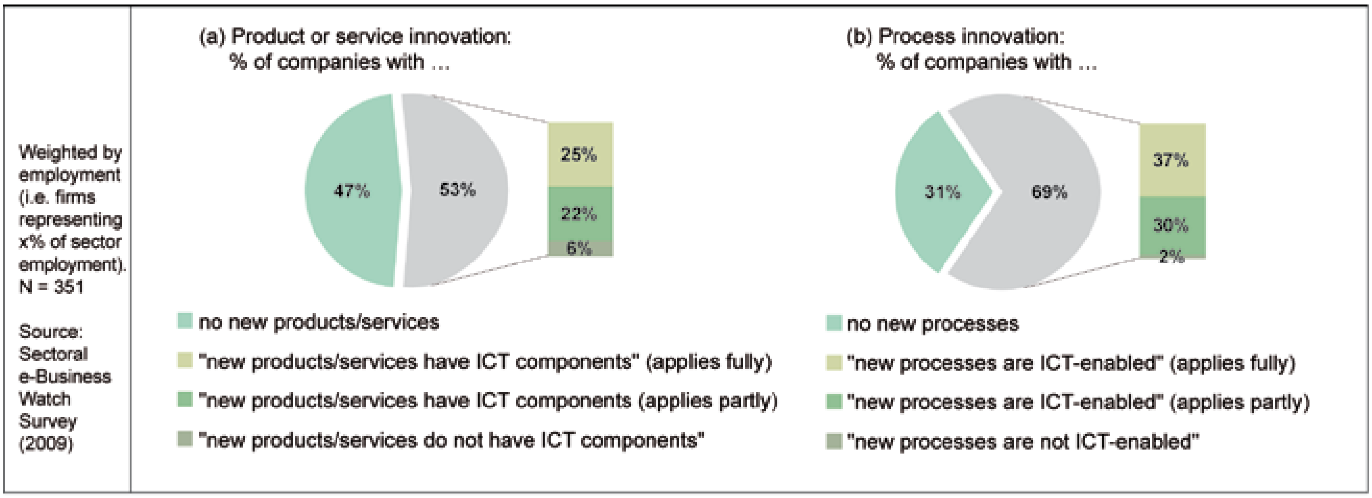
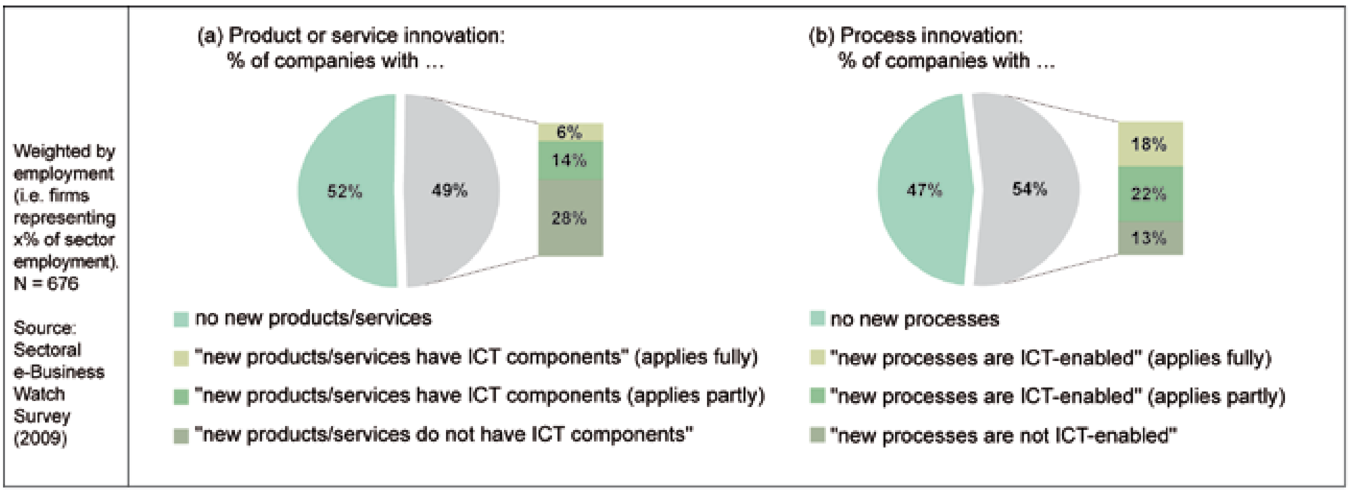


EXHIBIT 1.3-4: ROLE OF ICT FOR INNOVATION IN THE GLASS, CERAMICS AND CEMENT INDUSTRY 2009



nearly 90% said that the new products or services had ICT components (48% said this applied "fully", 41% "partly"), and nearly all companies said that their new processes were at least to some extent supported by ICT. These are the highest values for ICT-enabled innovation that the e-Business Watch has ever found in an industry. In glass, ceramics and cement, the percentage of companies saying that the new products or services had ICT components was lower; only 13% said it applied fully, and 29% said it was "partly" the case. This reflects the nature of the products being made in this industry. However, 75% of the process innovators said that their new processes were supported by ICT (see Exhibits 1.3-3 and 1.3-4).

ICT is also important for R&D and market launch

In both industries, ICT was also found to play an important role in R&D processes leading to innovation, as well as in market launch or implementation. In energy supply, 71% of companies (employment-weighted) stated that ICT was important for market launch and R&D leading to product and service innovation, and more than 90% stated it was important for process innovation. In the glass, ceramics and cement industry, the role of ICT is apparently smaller: 56% of the companies reported that ICT was important for R&D, 54% said that ICT was important for market launch, and close to 70% said it was important for process innovation. This more detailed view shows that ICT has multi-faceted functions in the innovation stream, which also supports the case for the "enabling role" of ICT.

Joint innovation is prevalent

The surveys also showed that a large proportion of companies collaborated with business partners or external experts in developing the new product, service or process. This type of "joint innovation" may be beneficial for companies in that it expands the scope of new knowledge involved, reduces costs and also reduces risks – particularly in pre-competitive R&D. Companies may, for instance, work with universities. More than 80% of the innovative companies in the energy supply industry and more than 50% in the glass, ceramics and cement industry said that they involved external experts or business partners in product, service or process innovation. This finding underlines how much innovation in both industries relies on expertise from outside the company.

Larger share of innovators among large companies

In both energy supply and glass-ceramics-cement, the share of innovating companies increases with company size. In energy supply, only about a quarter of the small companies (10-49 employees) reported having introduced new or substantially improved products or services in the past twelve months. Among medium-sized companies, more than 40% had done so, as had more than half of the large companies. The ratios for process innovation are higher: about half the small companies, 60% of the medium-sized ones and nearly 80% of the large ones had adopted new processes over the same period. In the glass, ceramics and cement industries, 33% of the small companies reported product or service innovation; the share was 41% in medium-sized companies and 47% in large companies. Again, the same ranking applies to process innovation (small companies: 33%, medium-sized companies: 51%, large companies: 61%). However, this does not necessarily mean that SMEs are less innovative than large firms. Innovation is more likely to be found somewhere in the many business units and markets of large companies than in SMEs simply because of their scale. With a view to ICT, the results suggest that, in both industries, ICT is more important for product, service and process innovation in large companies than in SMEs.

Conclusions

The results confirm the crucial importance of ICT for innovation in many industries. ICT should thus continue to play a prominent role in the European Commission's economic and innovation policies, particularly with regard to policies for fostering R&D&I of key enabling technologies. Links between ICT policy and innovation policy should be recognised. The following section elaborates on the implications of these results for ICT-related industrial policies.

1.4 Strategic responses for policy and industry

Main conclusions

The common denominator of the Sectoral e-Business Watch studies in 2009 is the **enabling role of ICT and e-business for innovation**. This has implications for ICT-related industrial policy and for the industries concerned. The recommendations, which these studies make to policy and industry, reflect the enabling role of ICT, and can be grouped into four main objectives:

Enhancing competitiveness through ICT: economies that are innovation leaders and have a strong industrial base in key enabling technologies (KETs) are expected to have a competitive advantage. Advanced ICT systems should still be considered as KETs.

Promoting ICT and e-business standards: ICT-related standards play an essential role for interoperability of applications and for data privacy and accessibility of services.

Supporting the development of e-skills, notably among SMEs: many SMEs do not have enough knowledge about e-business to judge whether ICT could be useful for their company and take informed decisions whether to invest or not. There is a risk of opportunity costs.

Fostering ICT and e-business impact: innovation policy should include measures to accelerate ICT and e-business adoption, such as showcasing innovative applications and examples of good practice, in order to enhance network effects at the sector and economy levels.

Overview of policy objectives and measures proposed

The thematic scope of the studies presented in this report is very broad. Therefore, it is difficult to condense the strategic responses which these studies propose to industry and policy into general points. A common denominator of the various studies is that they analyse the ICT potential for enabling innovation, or the framework conditions that are necessary so that ICT can realize its potential. The strategic responses can be grouped into **four overarching policy objectives**. These objectives are directly related to key issues addressed by Unit D4 "ICT for Competitiveness and Innovation" of DG Enterprise and Industry: competitiveness, standardisation, e-skills and ICT impact. Exhibit 1.4-1 provides an overview of the policy objectives, possible policy approaches, and specific measures that could be considered. The specific measures would have to be developed and implemented by policy makers, stakeholders in the industries concerned (such as industry associations and federations) and intermediaries (such as business support networks, knowledge transfer centres and regional development organisations).

1.4.1 ENHANCING ICT COMPETITIVENESS

In its Communication "Preparing for our future: Developing a common strategy for key enabling technologies in the EU",[8] the European Commission stresses the importance of a coherent strategy on how these technologies can be better brought to industrial deployment in Europe. Key enabling technologies (KETs), such as nanotechnology and photonics, will drive the development of future goods and services and are essential to manage the shift towards a low carbon, knowledge-based economy. Economies which are innovation leaders and have a strong industrial base in KETs are expected to benefit from significant competitive advantages. Although ICT are not explicitly listed among the main emerging KETs,[9] advanced ICT systems can certainly be considered as KETs in the wider sense.

From this perspective, DG Enterprise and Industry aims to promote the competitiveness of ICT production and services in Europe and to support the take-up of ICT and e-business practices by European companies. Research, development and innovation (R&D&I), and the broad cooperation of stakeholders, will be crucial to ensure that Europe can develop and sustain a strong position in the emerging high-tech markets. Studies presented in this report provide empirical evidence for the importance of advanced ICT systems as a backbone for innovation, for example in the energy supply industry. The studies propose strategic responses for industry and policy and discuss challenges that need to be addressed.

Research, development and innovation (R&D&I)

The study on ICT-related industrial policy (see Section 4.1) points out that the problem companies experience in terms of appropriating the returns from newly generated knowledge is a general argument in favour of public support of R&D&I in companies. This implies that

[8] COM(2009) 512, 30 September 2009.
[9] The Commission considers advanced materials, nanotechnology, micro- and nano-electronics, industrial biotech and photonics as the five principal emerging KETs.

EXHIBIT 1.4-1: STRATEGIC POLICY RESPONSES SUGGESTED IN THE STUDIES OF 2009

Policy objective	Approaches	Possible specific measures
Enhance competitive-ness through ICT	Encourage research, development and innovation	• Energy supply: support innovation in ICT for energy efficiency in the energy supply value chain to drive behavioural changes of energy users. • Energy use: R&D&I for furthering energy and emissions management systems and intelligent transport systems. • Overarching: rethink the percentage of public contribution to commercialisation costs, at least for SMEs.
	Strengthen cooperation between industry and research	• In the energy supply sector: development and implementation of smart applications can be successful only with close cooperation among all the players involved. • In energy-using sectors: cooperation with research to support the development of ICT-based energy and emissions-management systems (EMS).
Promote ICT and e-business standards development	ICT-related standardisation policy	• In the energy supply sector: agreement on specific standards for smart grids and smart metering is urgently needed to support investment and further development. • In energy-using sectors: standards for monitoring and reporting company-level greenhouse gas emissions as well as a common ITS framework architecture and interoperability guidelines are needed. • Foster ICT standards development.
	Industry-led e-business initiatives	• Launch initiatives to agree on standards for electronic data exchange within the sector and with major customer sectors, to promote e-business uptake. • Support sectoral e-business projects to develop common framework architectures for e-business.
Support e-skills development	Strengthen ICT training to avoid a shortage of ICT practitioners	• Develop innovative curricula in cooperation with prospective employers from the industry. • Tackle the e-skills gap in energy supply industry. • Recognise the importance of complementary skills in ICT training, in particular communication and presentation skills. • Education and training programmes combining ICT skills and business / management skills.
	Enhance e-business skills in SMEs	• Adopt measures to raise awareness, including showcasing best practices to SMEs. • Provide targeted information to SMEs.
Leverage the ICT impact	Pilot projects and best practice dissemination	• Promote demonstration projects for innovative technology such as virtual power plants. • Disseminate best practices about intelligent energy supply and emissions management.
	Optimise legal framework conditions	• Address and remove legal uncertainties (e.g. in cross border e-invoicing) to leverage the impact of e-business.

policy makers must **rethink the percentage of public contribution to commercialisation costs**. Considering the high commercialisation costs and relatively low R&D costs related to innovative ICT products, it could be worthwhile to increase the maximum percentage of public contributions to commercialisation costs of ICT-producing companies. As large firms were found to have advantages over small and medium-sized enterprises (SMEs) with regard to ICT product innovation, the percentage of contributions to commercialisation costs could at least be higher for ICT-producing SMEs. The other sector and topic reports provide suggestions for concrete R&D&I support.

In the **energy supply industry**, support for R&D&I of ICT may be needed to develop new key enabling energy technologies. Most innovative and commercially immature energy technologies, including the virtual power plant concept, may benefit from EU co-funding. Market forces may not deliver solutions in time for the EU to reach its energy policy targets. In particular, specific actions could support innovation in ICT for energy efficiency both in the energy supply value chain and to drive behavioural changes of energy users in industry and private households. The study on smart grids (see Section 3.2) suggests specific research in the field of digital measurement technology, automated calibration procedures and remote calibration with add-on devices.

As regards **energy use**, support for R&D&I of energy and emissions-management ICT systems may be advisable. In particular, small firms do not have the R&D&I power of large innovators examined in the case studies related to greenhouse gas emissions in energy-intensive industries (see Section 2.1). Support could be targeted at R&D&I that furthers the cross-sectoral scope and implementation flexibility of current and new ICT-based energy and emissions management systems. Targeted research may also be required to exploit the potential of intelligent transport systems to reduce greenhouse gas emissions (see Section 2.3). To date hardly any targeted research aimed at analysing the relationship between greenhouse gas emissions and intelligent transport systems has been conducted. Such research would be needed to set priorities for further R&D investment into ITS.

Foster cooperation for ICT-enabled innovation

In the energy supply industry as well as in energy-intensive industries, policy has a role to promote and coordinate the cooperation of stakeholders. In energy supply the development and implementation of **smart applications can be successful only with close cooperation of all the players involved**, not just along the energy supply value chain, but also with other stakeholders and other industries. It would therefore be important to identify and disseminate the opportunities of agreements and cooperation and to establish measures to get relevant stakeholders involved. This could encourage the development of better solutions. Local governments, under the umbrella of EU sustainability policies and targets, may play an important role in pioneer projects, establishing frameworks that can be replicated on a larger scale. The Austin Energy case study shows the importance of city authorities in the successful roll-out of smart meters and smart grids, and similar initiatives at EU level are emerging (e.g. Amsterdam Smart City, Malaga Smart City - see Section 3.1).

In energy-intensive industries, it could prove beneficial to promote increased industry and cross-sectoral **cooperation for the development of energy and emissions-management ICT systems**. Fostering collaborative innovation among firms within a sector and even cross-sector (or with academic entities) specifically with regard to emissions-reducing ICT systems may accelerate the reduction of emissions per output. The case study of the Maersk company's cooperation with a university for the development of a highly customised ICT system (see Section 2.1) is a good example of cooperation between industry and research.

1.4.2 PROMOTING ICT AND E-BUSINESS STANDARDS

ICT standards play an essential role in interoperability of applications and in data privacy and accessibility of services. Hence, issues of **interoperability, standardisation and standards adoption** have been a recurrent theme of the Sectoral e-Business Watch. The European Commission considers standardisation as a voluntary cooperation for the development of technical specifications based on consensus among stakeholders. However, the EC may support standardisation organisations and standards adoption in selected industries. With the exception of studies about the glass, ceramics and cement industry, and about e-skills, all studies in 2009 included policy implications related to standards, as summarised in the following.

Standards in the energy supply industry

The studies of the energy supply industry and of smart electricity metering and grids found that a **lack of standards and interoperability is hampering innovation, particularly regarding the roll-out of the smart grid and smart metering**. Agreement on what specific standards are implemented is urgently needed to support investment and further development. Two kinds of public policy activities related to standards can be suggested. First, standardisation of interfaces between different players such as generation units, transmission and distribution service operators, traders, and customers must be achieved to facilitate data exchange across the entire value chain. Second, interoperability standards between various devices of different vendors may facilitate, for instance, supplier switch and the deployment of smart metering in the EU. It appears that the market and the energy supply industry itself are encountering difficulties in setting the basis for related standards, considering above all the following issues: complexity of the energy industry's value chain, a high level of regulation, and a high level of risk related to the innovations necessary to fulfil the objectives of the EC's energy policies.

To overcome these barriers, there is a need for policy to define at pan-European level the key functionalities to be implemented by Member States with regard to smart grids initiatives. For instance, in order to successfully develop smart meters in Europe, it is necessary to define the key mandatory functionalities of a smart meter. The EU, the US and some European governments have started developing standards for smart meters. Some standards have already been announced and final standards can be expected to reach a European level within the next two years.

Standards in energy-using industries

A further issue is interoperability and standards to reduce greenhouse gas emissions. The study on the ICT impact on emissions in energy-intensive industries substantiates a need for smart metering facilities from the perspective of energy-using industries (see Section 2.1). The study concludes that **standards for monitoring and reporting firm-level greenhouse gas emissions are needed**. More specifically, the study of intelligent transport systems (ITS) points out that interoperability of ITS systems is a key to maximising the impact of ITS in road transport, including its impact on reducing greenhouse gas emissions. EU policy should support the creation of a common ITS framework architecture and interoperability guidelines, for example in European collaborative research projects.

Foster standards development

Sectors and companies that are faster in climbing the e-maturity ladder towards more advanced forms of electronic data exchanges have a competitive advantage. The study on the glass, ceramics and cement industries (see Section 2.2) found that e-business with suppliers and customers was not as widespread as in other sectors. In contrast to other manufacturing sectors - such as the chemical, paper and steel industries - the glass, ceramics, cement sector has reached no agreement on standards for electronic data exchange that might lead to **coordinated initiatives to facilitate e-business**. The study proposes that the industry should consider initiatives either to promote the use of existing e-business standards among its companies, or to copy initiatives taken up by other sectors to facilitate e-business specifically in their industry.

Finally, the study about ICT-related industrial policy suggests some overarching implications (see Section 4.1). The study suggests **e-business standards should not be adopted but developed**. Policies for standards adoption should be aware of the hidden intentions of companies involved. Public policy would do better to foster institutions like standardisation committees that do not rely on direct payments. Furthermore, the European Commission should seek to coordinate the adoption of e-business standards on a European level in order to prevent competing national standards that may reduce incentives of ICT-using companies to invest into e-business systems.

1.4.3 SUPPORTING THE DEVELOPMENT OF E-SKILLS – NOTABLY IN SMES

A shortage of labour force with the ICT-related qualifications ("e-skills") required by companies, whether in ICT-producing or in ICT-using industries, threatens economic development. This shortage can be quantitative, in terms of the number of people trained in ICT, or a competence shortfall between current and needed competence levels of (employed) personnel. e-Skills comprise ICT practitioner skills, ICT user skills and e-business management skills. The growth potential of the ICT industry may not be optimally exploited if demand for its products and services surpasses capacity (due to unfilled vacancies). In ICT-using industries, innovation processes can be slowed down, with negative implications for productivity growth and competitiveness. A key challenge for policy is that there are no easy fixes to adjust demand and supply through ad-hoc short-term measures, because of the cyclic and long-term nature of the issue. DG Enterprise and Industry has therefore stressed the importance of a coherent e-skills policy framework with a longer-term policy strategy.

ICT skills shortage affects the energy supply industry

The study on ICT and e-business in the energy supply industry (see Section 3.1) highlights that ICT solutions to support energy efficiency and to reduce emissions require complex solutions and organisational changes within energy supply firms. These solutions and changes rely on qualified skills. However, the study indicates an **ICT skills gap in the energy supply industry**. A large share of energy supply companies are experiencing difficulties recruiting e-skilled personnel and they stated that the computer skills of employees are insufficient. This skills shortage may hamper the full exploitation of the ICT potential in this industry. There appears to be a need for support to ICT education and training, especially in areas where ICT can improve energy efficiency.

Importance of complementary competencies

The study on e-skills demand trends (see Section 4.2) found the main shortcoming interviewees perceived in ICT practitioners today was usually not the core ICT skills themselves, but rather complementary skills and competencies which are needed to apply their ICT skills in an effective and efficient way. The following competencies were mentioned as particularly important: communication and presentation skills, project management skills, and a thorough understanding of business processes. This has implications for initiatives in the field of ICT training. These should not only aim at increasing the quantitative output of practitioners, but also strengthen these topics in the curricula of training programmes.

e-Skills are key for successful e-business adoption

The study of ICT-related industrial policy (see Section 4.1) suggests that from a game theory point of view, the readiness of companies to engage in employee training and change management may be an indicator for how seriously they intend to improve their e-business practices, and not merely seek public funding. Employee training about e-skills and management change could thus be made obligatory components in publicly funded e-business adoption projects.

Improve e-business skills for SMEs

Many of the sector studies conducted by the Sectoral e-Business Watch in recent years discussed the implications of the "digital divide" between large and small companies in e-business practices, notably when it comes to advanced forms of data exchange. This hampers the network effect of e-business and reduces the potential of productivity gains. In the glass, ceramics and cement industries, the digital divide is even more significant than in other sectors. Many small companies do not use any ICT systems other than e-mail. The sector study (see Section 2.2) acknowledges that from an economic perspective, it may make sense for individual companies not to make investments in ICT and e-business. However, **the challenge for many small firms is to make an informed decision**. SMEs often do not have the means to consider ICT-related issues and therefore cannot judge whether and how ICT could be useful for their company. The study recommends that industry and policy should consider actions to improve the e-business skills of SMEs, through measures such as awareness raising and the targeted provision of information about ICT solutions for SMEs. The suggestion addresses in particular industry associations, SME support organisations, knowledge-transfer centres and regional development agencies.

1.4.4 INCREASE ICT AND E-BUSINESS IMPACT – DISSEMINATE GOOD PRACTICE

European enterprise policy seeks to facilitate the structural change towards the knowledge economy in Europe by creating a favourable environment for ICT and e-business use. The collection and dissemination of good practices is a promising instrument for public policy makers to help maximise the impact of ICT and e-business.

Showcase most innovative technology for energy supply

As regards energy-related issues, knowledge about good practices may help both the supply and the demand side. The study about ICT use in the energy supply industry points out that for some innovative ICT implementations, including virtual power plants and smart metering, a positive business case is not easy to prove. Therefore, **demonstration projects** may be helpful for generating and disseminating knowledge about the economic implications of the most innovative technologies (see Section 3.1). The findings of this study support the launch of initiatives like the DG Research and DG Transport and Energy joint call for proposals, as part of the 7th Framework Programme, aimed at large-scale demonstration of smart electricity distribution networks with distributed generation and active customer participation. On the demand side, **consumer acceptance** of smart meters is necessary. Political support may be crucial, not only by introducing a legal framework requiring the use of smart metering, as done by the EC, but also by informing consumers on a national or local level. This way some burden and possible mistrust is removed from utilities, ensuring further good relationships and augmented consumer acceptance on a broad basis.

Document and publicise good practice in emissions management

Public policy can also play a role with regard to documentation and publication of **good practices in emission management ICT systems**. Collection and distribution of best practices and lessons from the implementation of ICT systems can accelerate the adoption process, especially for smaller firms, leading to lower emissions per output for the aggregate sector. The case studies presented in the study on the potential of ICT to reduce emissions in energy-intensive industries (see Section 2.1) show that there are many ways to use ICT to this end. Such firm-specific knowledge and experience could be gathered and shared across the industry in order to foster industry-wide emission reductions.

Sector studies: ICT & e-business in energy-intensive industries

2.1 ICT impact on greenhouse gas emissions in energy-intensive industries

A study by DIW econ. Study authors: Ferdinand Pavel, Katja Frank, Madeleine Evans

There is much hope that ICT will help increase energy efficiency and reduce greenhouse gas (GHG) emissions. This study provides the first comprehensive economic analysis of the relationship between ICT and GHG emissions in European energy-intensive industries.

Econometric analysis finds significant but limited impact of ICT

Against the confounding presence of structural differences and structural change, the study identifies a limited but significant impact of ICT on GHG emissions and production sustainability of European energy-intensive industries.[1] Increasing the share of ICT in a company's total capital leads to greater production sustainability. Increases in a company's production volumes can be delinked from an increase in GHG emissions. The impact of ICT on GHG emissions is less clear, with the most significant results suggesting it diminishes "carbon returns" in the metal and transport sectors. In general, achieving GHG reductions through ICT appears to be expensive compared to other abatement technologies.

Case studies and surveys highlight weak diffusion but receptiveness to market and policy incentives

The eight company case studies conducted provide more evidence that ICT plays an important role in increasing sector sustainability, particularly by using ICT to optimise production, oversee energy usage, and manage emissions. The industry surveys highlighted weak diffusion of these systems (especially for emissions management), with adoption increasing in accordance with market or policy incentives. These accounts provide anecdotal support for efficiency gains from ICT while underlining the necessity of substantial production changes in order for ICT to achieve reductions in GHG emissions.

Policy implications

The study cautions against focussing support on ICT as an abatement technology in view of the limited evidence of its ability to reduce GHG emissions. Structure largely determines industry emissions per output. As can be inferred from both the decreasing trend in GHG reductions that transpires from the econometric analysis and from the opinions of industry experts, the carbon reductions that might be achieved through ICT are limited. Policies should focus on other paths toward GHG reductions, such as imposing sufficiently high prices on carbon through emission caps under the EU Emissions Trading System (ETS). Nevertheless, ICT-based energy- and emissions-management systems have been observed to reduce costs and allow for less emissions-intensive production, particularly in the transport sector. This provides a target for indirect policy support in the form of R&D and implementation incentives. Policy support for ICT in new Eastern European member states is of particular interest as these countries have so far made little use of the GHG-reducing effect of ICT. Finally, standardised emissions accounting and reporting systems are essential to harmonise reduction incentives to provide broader and more comparable data for analysis.

[1] Structural changes hidden by aggregation in available data precluded a robust analysis of the paper sector.

2.1.1 STUDY OBJECTIVES AND APPROACH

The study focuses on the role of information and communications technology (ICT) in reducing GHG emissions in energy-intensive industries. It provides empirical evidence of the role that ICT can play in minimising GHG emissions through sustainable production technologies. It also describes how companies in these sectors use ICT to reduce GHG emissions, and points at possible implications for policy. The analysis is based on economic literature and data retrieved specifically for the analysis. Further results are drawn from company case studies as well as from the findings of two surveys. These include a telephone survey among decision-makers in European companies from the glass, ceramic and cement industry, which was conducted in the context of a separate study, and a telephone and online survey among corporate managers and industry experts from Europe's energy-intensive industries.

Focus

The focus of the study is threefold. First, we quantified how ICT has historically contributed to reducing GHG emissions in energy-intensive industries. Second, we investigated how ICT can contribute to emissions reductions and sustainable production in the future. Third, we provided policy recommendations in order to realise ICT's potential. The following topics and questions are treated in detail in this study:

ICT impact on emissions and sustainability: to what extent does ICT enable firms in energy-intensive sectors to reduce the GHG emissions from their industries? What direct and indirect effects may ICT have in this respect? How can this impact be quantified and how does it differ across sectors?

ICT uses and development status: how important is ICT for reducing GHG emissions relative to other technologies? What specific ICT options are currently available to reduce GHG emissions, and what other technologies are being developed for prospective future use? To what extent can the use of ICT help firms mitigate the negative consequences of the EU ETS? To what extent does ICT help firms to better plan their response to emissions regulation?

ICT diffusion and adoption barriers: how far has the GHG-reducing potential of ICT diffused in energy-intensive industries? What are the barriers to adopting these tools or to using them more effectively? Has emissions regulation such as the EU ETS stimulated adoption of ICT in order to reduce GHG emissions?

Policy implications: how can public policy best promote the effective use of ICT to reduce GHG emissions in energy-intensive industries? Are there any implications of ICT use for the EU ETS and its further development? Can policy contribute to developing relevant ICT?

Combining descriptive, empirical and analytical approaches

The study is exploratory, descriptive and explanatory. It applied a series of investigative approaches. An empirical econometric analysis on the impact of ICT on GHG emissions and efficiency was completed and then combined with qualitative case studies and quantitative survey data. This threefold approach produced an in-depth understanding of current ICT use in European energy-intensive industries with regard to GHG emissions. Results from these different approaches are self-contained pieces of research and cross-referenced for better comprehension. Information was collected from the following sources:

Applied econometric analysis: econometric methods were used to evaluate historical data for a statistically significant impact of ICT capital growth on GHG emissions. The detailed structure of this economic analysis is presented in chapter 1.1.2.

Pilot survey: the glass, cement and ceramic sector is one of two sectors covered by the SeBW Survey 2009. The SeBW Survey is an additional source for analysing ICT impact on GHG emissions.

Delphi-style survey: an online and telephone-based Delphi-style survey was conducted among selected industry experts, including company managers and experts from industry organisations. Two rounds of the survey were performed with the same experts. In the second round, participants were asked to evaluate their responses in light of survey results from the first round.

Case studies: eight case studies were conducted to describe the ICT and e-business strategy of companies from European energy-intensive industries. The companies were selected to match the focus of this study, seeking a balanced coverage of countries, business activities (sub-sectors) and company size-bands.

Interviews: interviews were conducted with company representatives as part of the case study work. In addition, further in-depth interviews with company representatives and industry experts, including the Advisory Board members, were conducted for this report.

Need for sector-level analysis

The impact of ICT on a specific firm depends in part on the extent to which ICT applications have spread among other companies within the same industry. A single firm can of course derive direct benefits from the use of ICT; but high levels of ICT usage in one firm may lead to widespread positive externalities at the sector level. Moreover, industry-specific factors determine the speed of ICT diffusion, the type of applications being adopted, and the benefits that can be obtained in the short and the longer term. Sectoral characteristics influence the intensity of ICT use and the intensity of GHG emitted in production, calling for a sectoral level of analysis. The study focuses on the following five European energy-intensive industries:

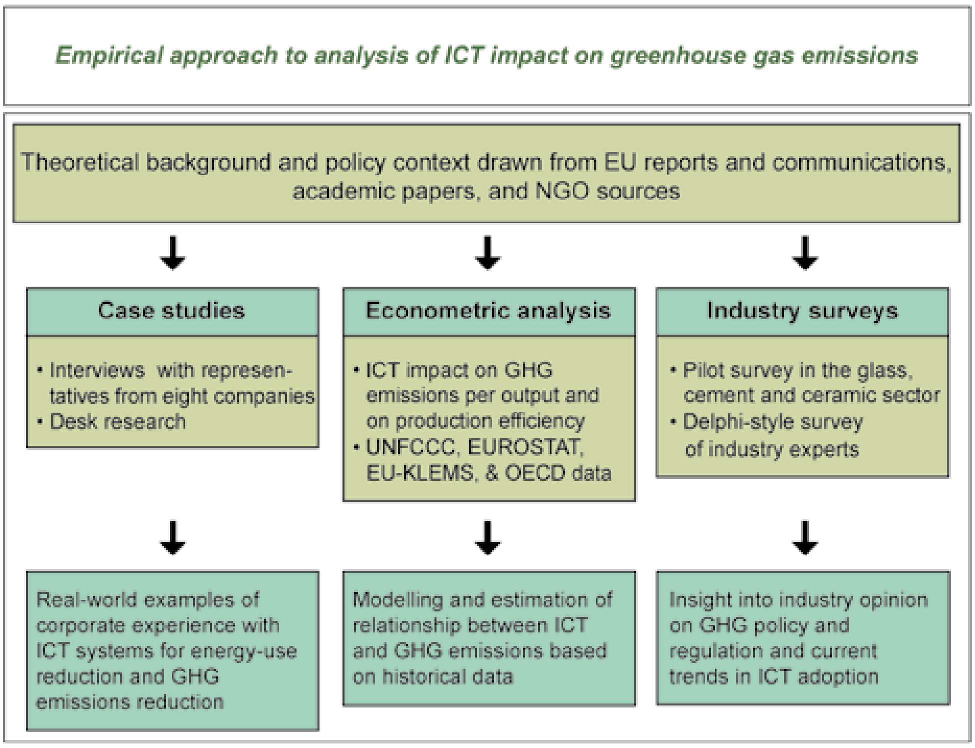
- Basic metal and fabricated metal (NACE Rev. 1.1, Divisions 27 and 28).
- Chemicals, rubber, plastics and coke (NACE Rev. 1.1, Divisions 23 to 25);
- Pulp, paper, printing and paper products (NACE Rev. 1.1, Divisions 21 and 22);
- Glass, cement and ceramic (NACE Rev. 1.1, Division 26);
- Transport and storage services (NACE Rev. 1.1, Divisions 60 to 63);

For a long time, most of these sectors remained free to emit GHG with no specific regulations. Only Finland, Sweden, Denmark (all since the early 1990s) and the UK (since 2001) imposed taxes on their emissions. Since 2005, the GHG emissions of the paper, basic metal, and glass-cement-ceramic sectors have been subject to the EU ETS. For these industries, GHG emissions are costly and provide an extra incentive to reduce GHG emissions.

2.1.2 ECONOMETRIC ANALYSIS

While ICT is often cited as a promising approach to reduce GHG emissions, no empirical evidence from the econometric literature has so far established the relationship between ICT and GHG reductions. Few surveys even document the exact reduction of GHG emissions that can be attributed to ICT programmes, although promising results are provided by those that do. However, a more complete body of literature

EXHIBIT 2.1-1: STUDY APPROACH



Source: DIW econ 2009.

studying the connection between ICT and energy use offers important insights. On the one hand, increased diffusion of ICT leads to higher levels of electricity consumption (income effect). On the other hand, improved process optimisation from the use of ICT leads to better energy efficiency and thus lower consumption at given output levels (substitution effect). The net impact of ICT on energy consumption, and thus on emissions, is ambiguous and requires empirical analysis.

Two analytical approaches, parametric regressions and semi-parametric analyses, are used, each with the ability to provide unique insights into the effect of ICT on the GHG emissions and efficiency levels of European energy-intensive industries. These methods are separately applied to each energy-intensive sector. The use of two complementary econometric methods, based on the two most relevant strands of empirical literature on ICT and emissions, improves the robustness of the results presented in this study.

Data considerations and analytical limitations

Both approaches use historical data from the five selected industries in eleven EU member states[2] on GHG emissions, gross output, fixed ICT capital stock, fixed non-ICT capital stock, and energy prices from 1995-2005, sourced from EUROSTAT, EU KLEMS, the UNFCCC, and the OECD.

It is important to understand the limitations imposed by the available data. Changes in the ICT sphere or in GHG emissions regulation since 2005 will not be reflected in the econometric analysis. It must be borne in mind that the effect of ICT may change as market incentives to reduce emissions kick in under EU ETS. In addition, our production and emission data are available only at the industry or sector level, which obscures important structural changes over time within a given industry, and could bias the results.

First approach: parametric regressions

The explicit link between ICT capital and GHG emissions in energy-intensive industries has not been comprehensively studied in economic literature. Since a well-defined model is not available, our first approach utilises three different regression specifications – a linear, log-linear, and non-linear model – to test for and estimate the direct effects of ICT capital on GHG emissions. The models also separate the effects of non-ICT capital stock, energy price changes, and trends in an industry over time from the true impact of ICT capital. Each model is designed to account for static differences such as industry structure, geography, and/or policy environment across member states,[3] such that the estimated effect of ICT on GHG emissions should be interpreted as the effect of increasing ICT within a given country-sector over time.

Linear model: Our linear model comprises a linear relationship between ICT capital (taken as the independent variable) and GHG emissions (taken as the dependent variable). This model allows the impact of ICT on emissions to be tested at constant rates of change. Previous econometric studies that decompose emission production by input mix were taken as the foundation for this model.[4] This model estimates the change in GHG emissions attributed to an increase in ICT capital stock.

Log-linear model: This study also considers ICT as an "input" to emissions through a Cobb-Douglas production function. All variables in the linear model are transformed with natural logs in the estimable form of this model. The interpretation of the results is slightly different from the linear model: as ICT capital changes by one percent, GHG emissions change at a constant percentage level.

Non-linear model: In this model, the assumption of a simple linear relationship between GHG emissions and ICT capital is relaxed. The area of environmental economics that investigates the environmental Kuznets curve (EKC) relationship between economic activity and pollution provides theoretical grounding and support. The EKC hypothesis presumes that pollution levels initially increase with economic development – typically measured by income – and subsequently decrease after development and income have reached a certain threshold. It is postulated that this relationship derives from a variety of effects that occur as economic activity increases, as follows:[5]

- Scale effect: emissions increase with a larger scale of economic activity;
- Output effect: the emissions-producing entities switch the structure of output from basic manufacturing to more sophisticated value-added activities, reducing emissions per unit of output;
- Input effect: the emissions-producing entities switch the structure of inputs from more to less environmentally-damaging inputs (e.g. substituting natural gas for coal), reducing emissions per output (at a constant level of input per output);
- Technology effect: the emissions-producing entities reduce emissions per output due to innovations which

[2] The eleven member states (Germany, Denmark, Italy, the Netherlands, the United Kingdom, Portugal, Sweden, Austria, Finland, Czech Republic, Slovenia) were selected on the criteria of complete data availability for the designated time period, industries, and variables of interest.
[3] The random effects (GMM) estimator was chosen over OLS and fixed-effects estimators as a result of standard statistical tests.
[4] Especially Stern (2002)'s econometric decomposition of national sulphur emissions into national output mix, input mix, and productivity.
[5] Aslanidis (2009) and Stern (2004).

increase energy efficiency or allow for changes in production processes.

According to the EKC hypothesis, this leads to an inverted parabolic or U-shaped relationship between the two variables as the output, input, and technology effects overwhelm the scale effect in later stages of economic development. In this study, we assume the way an industry uses ICT changes as part of the growth process, such that an EKC-type curve could exist between GHG emissions and ICT capital.[6] The regression specification thus resembles the linear model, but also includes a squared term for ICT, which allows for a parabolic relationship between increasing ICT capital and GHG emissions.

Initially, ICT contributes to company expansion and thus greater emissions through the "scale effect". This ICT could be heavy in computers and software, which have been shown to increase emissions. Once this basic ICT capital is in place, marginal ICT could go to optimise production processes, increasing energy efficiency and reducing emission intensity through the technology effect. The input and output effects are also possible within a sector, if ICT capital enables the use of cleaner inputs or the production of more ICT-based output. For instance, publication companies classified in the paper sector could shift toward online instead of print media, utilising ICT to produce output that is service-based and cleaner than newspaper printing.

Explanatory variables: The variables are the same in the three basic models.

GHG emissions are modelled using emission intensity, which is measured in million tonnes of CO2 equivalent emissions per gross output in million euros.[7] Emission intensity provides firms and policy makers with a quantity that incorporates both environmental benefits of new measures and the burden they place on economic output. Modelling emission intensity as the dependent variable is also convenient for making comparisons across countries, creating a "level playing field" by scaling absolute emissions by gross output. Furthermore, the use of an intensity measure is strongly supported in the literature on both the effect of ICT on energy use and on emission decomposition and EKC analysis.[8]
ICT capital is also modelled as ICT capital intensity, with ICT capital stock (aggregate of computers, software, and communication devices) scaled by gross output in million euros. Only current effects on emissions are included in the model. The aggregated nature of the available ICT measure requires consideration. Fixed ICT capital stock, the indicator used for the level and value of firm ICT deployment, does not precisely reflect the total ICT a firm might employ to reduce emissions (especially not ICT embedded in capital stock). However, the value of ICT capital stock remains a useful proxy for the extent to which a sector deploys ICT for efficiency gains and GHG emissions reductions.
Non-ICT capital intensity, defined by fixed non-ICT capital stock scaled by gross output in million euros, is added to account for the remaining capital-based sources of GHG emissions in production.
Energy price is also accounted for in the regressions, since the assumption that energy use determines a large part of emissions would suggest that variations in energy prices are also responsible for variations in emission intensity.
Lastly, a time trend is included to account for exogenous effects on emission intensity of changes in technique and productivity in a given sector. Together, ICT capital, non-ICT capital and energy prices are assumed to govern energy use in production and thus represent the largest sources of emissions in the analysed industries, while time and structural effects account for other non-static and static influences on the level of emission intensity in each sector.

Model selection: The most statistically significant and theoretically appropriate sectoral model is selected through an iterative process that can produce different outcomes for each sector.

- Check for the validity of the whole model: The first step in assessing the models is to determine their overall significance. Any model that is not significant will not be considered as an appropriate model.
- The choice between the linear and non-linear model: The non-linear model represents a more complex version of the linear model, with a quadratic effect of ICT included. Since this study is primarily concerned with modelling the effect of ICT capital intensity on GHG emission intensity, the non-linear model is preferred over the linear model when the quadratic effect is significant.
- General goodness-of-fit measures: R squared, which identifies the proportion of variability in the dependent variable that can be explained by a particular model, is used as the final comparison tool. A higher value of R squared implies that the model explains more of the variation in the dependent variable.

[6] Further explanation and references that support this assumption can be found in the full study report.
[7] All variables measured by value are reported in Euros, 1995 prices.
[8] In literature on the ICT impact on energy, see Cho et al. (2007), Collard et al. (2005), Bernstein and Madlener (2008), and Ang and Zhang (2000). Freeman et al. (1997) further specify that a value measure of gross output is better than a volume-based measure when more aggregated data are used (cited in Cho et al., 2007). Stern (2002) and EKC analyses use an intensity measure as well, but the measure is emissions per capita.

While statistical tests are necessary in choosing a valid model, the selected model must be consistent with the sector's particular structure, industrial processes, and ICT use.

Second approach: Semi-parametric analysis

Recent research in production theory offers guidance for our second econometric approach. Production studies focus on the processes that convert inputs into outputs, with particular interest in production efficiency. The entity that produces the same outputs from fewer inputs (or, equivalently, more outputs from the same inputs) is generally more efficient.

In this study, the entity in question is a given sector within a sample member state. We examine relative technical efficiency, which is determined by those entities (country-sectors) that produce the largest amount or value of output by using the same input, forming the efficiency frontier which approximates the state-of-the-art technology. The technical efficiency of all other country-sectors can be measured relative to this efficiency frontier in the form of an efficiency score expressed in percentage points (equalling 100% for fully efficient country-sectors and lower values for all remaining ones).

Estimating efficiency scores:

We use a non-parametric estimation method called Data Envelopment Analysis (DEA) to estimate the relationship between outputs and inputs and empirically measure efficiency as a relationship between inputs and outputs. However, this study is concerned not just with efficiency in regard to conventional outputs and inputs, but also with GHG emissions produced during production. Recent empirical analyses have demonstrated that GHG emissions act as undesirable output in the efficiency analysis,[9] but GHG emissions can also be incorporated into the analysis as an additional input since they are often costly for companies. We address both possibilities, estimating two versions of "sustainable efficiency" using input-oriented and output-oriented DEA. The input-oriented version treats GHG emissions as an input, along with capital and labour. The output-oriented version incorporates GHG emissions as an output, and is structured in such a way that more inefficient firms produce more GHG emissions for a given quantity of inputs. Here, DEA has the further advantage of requiring very few assumptions about production technology, which are difficult to make in this case of a "black box" relationship between production inputs (like ICT capital) and the emissions produced (or in the input-oriented case, the relationship between output and the cost burden of the related GHG emissions).

For each sector, the output-oriented DEA includes two different inputs plus a desirable and an undesirable output. These variables are defined as follows:

- The first input is Labour: number of hours worked by persons engaged in the sector.
- The second input is Capital: total fixed capital stock including ICT and non-ICT capital.
- The desirable output is Gross output, reported in millions of euros.
- The undesirable output is GHG emissions in million tonnes equivalent.

We assume constant returns to scale in the production process when estimating efficiency, in order to allow efficiency scores for country-sectors of heterogeneous size to be fully comparable within a year. However, the frontier formed by the most efficient countries is likely to change over time due to structural change, technological progress etc., such that efficiency scores cannot be compared over time.

It is also important to note that these "sustainable" efficiency measures can be compared to "conventional" efficiency measures that simply analyse the relationship between traditional inputs and outputs of the production process. Thus in addition to estimating sustainable efficiency scores, we also estimate conventional efficiency scores using DEA in a similar manner.

Efficiency and ICT capital:

Once conventional and sustainable efficiency scores have been estimated, a parametric regression model is estimated to assess the impact of the share of ICT in total capital stock on conventional and sustainable efficiency scores. Similar to the parametric regressions in the first approach, these regressions are estimated separately for each sector in the eleven countries covered over the period from 1995 to 2005. Because the efficiency scores are defined as relative measures, we use an estimation technique incorporating a model that accounts for relevant data characteristics.[10] Using this technique, the impact of a change in ICT capital share on efficiency (marginal effect) is calculated as the mean of ICT capital share. The impact on GHG emissions can be identified by comparing the impact of ICT capital on sustainable efficiency with the impact of ICT on the conventional efficiency scores.

[9] See, for example, Zhou and Ang (2008).
[10] A Tobit model is used, as data are truncated between zero and one.

As expected, the results for each defined sector vary considerably, reflecting different industry structures and different available technologies. Results also sometimes differ according to the countries included in the sample. Two new Eastern European member states were at times omitted from our sample as they altered results. Below, some context on the observed trends in each industry and some notable results are presented.

Basic metal and fabricated metal sector ("metal sector"):
Despite being a major producer of GHG emissions in our sample countries, the sector reduced its aggregate emission intensity by 18% from 1995 to 2005. The results of the econometric analysis in this sector are highly encouraging with respect to the role of ICT in achieving emission reductions. In the parametric regressions from the first approach, the relationship between ICT capital and emissions is found to be highly significant and robust with respect to model specification. Overall, greater use of ICT is predicted to reduce the level of emissions per output, but with diminishing impact – both the log-linear and non-linear models have explanatory value, and the quadratic term on ICT is significant. Structural effects are also highly significant in every model, signalling that the base level of emissions per output in the metals sector is significantly different in each of the member states in our sample. In contrast, levels of non-ICT capital, energy prices, and a time trend do not conclusively contribute to explaining the emission levels of the metal sector in Europe, although the models as a whole explain around two-thirds of the variation in emission intensity in the sector.

The results from the non-parametric DEA analysis, the second approach, support these results. The estimations find that ICT capital does not seem to have a significant impact on conventional efficiency when only labour and aggregate capital stocks are considered as inputs. The higher the level of ICT capital share, the greater the ability of the metal sector to produce more output at constant emissions, with a given value of total labour and capital inputs. Thus the use of more ICT relative to total capital stock improves the sustainable efficiency of the metals sector, with an impact of slightly less than one-to-one.

Chemicals, rubber, plastic and coke sector ("chemicals sector"):
The linear model provides informative results about the effect of ICT capital intensity on emissions per output in the chemical sector. However, the variations in effect significance and model R squares when different data sets are used indicate that the true relationship between ICT and emissions is not the same in all EU member states. The new Eastern European member states, in particular, make it difficult to describe the effect of ICT capital in the chemicals sector using simple models, due to their high emissions and ICT data variance. Among older EU member states, some countries (for instance, the Netherlands[11]) seem to experience completely different effects of ICT. Based on the available data, a simple model of the effect of ICT on capital intensity in the chemical sector appears unobtainable. Nevertheless, a linear emissions-reducing effect of ICT is significant for the majority of sample countries.

The semi-parametric analysis, in contrast, does produce robust results across all countries regarding the impact of ICT capital share on the output-oriented measure of sustainable efficiency. ICT plays a significant role in enabling the industry to grow while maintaining GHG emissions constant. The results for this sector highlight the advantage of using different methodological approaches in this analysis. Further research should investigate how ICT interplays with different output structures and whether non-linear effects of ICT on emissions can be robustly estimated across all EU member states.

Pulp, paper, printing and paper products sector ("paper sector"):
As discussed in the section on data limitations, structural differences within a sector can confound our econometric estimations. While this problem of incomparability generally affects all sectors to some extent, it appears to be of particular importance in the paper sector for the eleven sample countries. For example, Finnish industry has a much stronger focus on the production of raw materials (pulp) with a low value per ton, while the German industry concentrates on final paper products with a higher value per ton. These differences make efficiency estimates incomparable across country-sectors, even within a given year, and thus the semi-parametric analysis is not meaningful. Furthermore, results from the parametric regressions are highly dependent on the countries sampled. We refrain from including these results, which seem biased by different structural changes over time in different countries.

Glass, cement and ceramic sector ("GCC sector"):
With inconsistent results across old and new EU member states, conclusions cannot be reached on the effect of ICT capital intensity on emissions per output in the GCC

[11] Data from Italy may also appear to mimic the characteristics of data from the Netherlands, but estimations are robust to the exclusion of Italy.

sector. However, where the effect of ICT capital intensity is insignificant, non-ICT capital intensity plays a significant role in determining emissions per output in older EU member states. Emissions per output increase significantly with non-ICT capital intensity in the sector for older EU member states, and the same relationship is suggested for new member states as well, but not found to be significant.

The semi-parametric analysis offers fresh insight into the role of ICT in the GCC sector in Europe, revealing consistent effects of ICT for the sector across all sample countries where the parametric analysis did not. The semi-parametric analysis clearly shows that countries with higher ICT capital share are more capable of increasing output at constant levels of emissions. When only older EU member states are considered, higher ICT capital relative to total capital also appears to help countries reduce emissions at constant levels of output and improve conventional production efficiency.

Transport and storage sector ("transport sector"):
The transport sector comprises a large part of the total GHG emissions from the eleven countries sampled, averaging, from 1995 to 2005, 18.5% of their total emissions. Together, the semi-parametric and parametric analyses demonstrate that ICT capital can improve the sustainability of the transport sector.

Only when the newest and lowest income member states are excluded, do the parametric estimations produce significant results. For older and higher-income EU member states, greater ICT capital intensity is found to reduce emission intensity in the transport sector. This influence of ICT capital is expected to have diminishing returns. Newer and lower-income member states may also find ICT to be emission-reducing, but at higher levels of ICT capital to gross output that have not yet been reached in the sector. No conclusion can be reached on the effect of non-ICT capital in these states.

When looking at ICT share in total capital, as opposed to ICT relative to gross output, ICT is found to significantly improve efficiency for the transport sector in EU member states regardless of member status or GDP. From the parametric analysis, however, we know that in the interests of finding results that can be credibly extended to a unified Europe, there should be further examination of differences in the structure of the transport sector and patterns of ICT use in new and older member states, or in high- and low-income member states.

Key findings across sectors
As the results above demonstrate, the relationship between ICT and GHG emissions in European energy-intensive industries is not straightforward. This section aims to synthesise and summarise the main findings of the semi-parametric and parametric analyses, and the central conclusions that can be drawn from them. However, in light of the potential problems introduced by aggregated data, care should be exercised in quantifying the effects of ICT. We caution that the "ICT capital cost of GHG emissions reductions" should be used as a reference point for comparison among sectors, rather than as an exact value on which to make policy or business decisions.

Structural differences and structural change limit the scope of meaningful analysis on the basis of the data available

With different production processes and different trends in capital investment and emissions in each sector, it was clear from the beginning that each sector would need to be studied separately. Further structural differences within the five sectors – especially between old and new EU member states – make it necessary for conclusions based on econometric methods to be narrowed to particular sets of countries in most sectors. In the paper sector, differences in output composition within the sector and a lack of detailed data make it impossible to draw robust conclusions. With the limited data available (or inconsistencies across countries and sectors), the chances of discovering robust effects of ICT on emissions were limited from the outset of the econometric analysis. Despite analytical challenges, however, the combination of two different econometric approaches within the empirical analysis does reveal certain promising, yet limited, avenues in which ICT can improve the sustainability of European energy-intensive sectors.

Greater share of ICT capital in total capital contributes to sustainable industry development

Setting aside the paper sector, the semi-parametric analysis consistently finds ICT to have a positive impact on our measure of "output-oriented" sustainable efficiency in European energy-intensive industries. In other words, ICT can help to allow output to increase at constant emission levels. Across four industries, a one-percentage-point-increase in ICT capital share (e.g., fixed ICT capital stock increases from 2% to 3% of total capital) is estimated to increase sustainable efficiency by between 0.79 and 2.64 percentage points. Row (a) in Exhibit 2.1-2 summarises these results, which indicate that ICT has a more than one-to-one impact on efficiency in most energy-intensive sectors. Again, excluding the paper industry, the effect of ICT on sustainable efficiency can be quantified. As row (b) in Exhibit 2.1-2 shows, a one-percentage-point-increase in ICT capital share can help industry increase gross output – at constant levels of emissions and capital and labour inputs – by between €280 million and €1,370 million. This analysis demonstrates that the quality of total capital is important for the sustainable production growth of energy-intensive sectors in Europe.

For the metal and transport sectors, the effect of ICT capital share on a different measure of sustainable efficiency – the ability of the sector to reduce emissions at given output levels – was also found to be significant. We quantify the effect of a one-percentage-point-increase in ICT capital, in this case, as equivalent to a 0.13 million tonne reduction in CO_2 emissions in the metal sector and a 1.2 million tonne reduction in CO_2 emissions in the transport and storage sector. In these two sectors, shifts in overall capital composition from non-ICT to ICT-based capital would allow the sector to reduce the carbon intensity of current production and actually reduce environmental degradation rather than simply expanding production with the same environmental impact. These two measures combine to provide strong evidence that ICT furthers the sustainability of these two sectors, even with existing production processes.

The range of absolute measures in columns (b) and (c) is to be expected for two reasons. First, production processes across industries will naturally respond differently to changes in capital composition, with some processes being more flexible than others. Secondly, the way in which the efficiency scores are constructed means that the corresponding change in gross output or emissions must be calculated as a relative change against some reference value. The absolute changes reported in Exhibit 2.1-2 are calculated against mean output values, which differ considerably across sectors. For example, with a much greater average aggregate emissions level in the transport sector, the greater estimated change in absolute GHG terms in relation to the metal sector is further magnified. The elasticity of gross output and emissions will also change over time, as mean values grow or shrink. Furthermore, as mentioned at the beginning of this chapter, the use of an aggregated ICT capital stock measure in general means that the quantification of estimated effects will be slightly biased. The measure may capture some ICT that has no use for sustainability, and in turn not all ICT capital stock value with an emissions-reducing potential is included. With these points in mind, the estimated numbers in Exhibit 2.1-2 are best used as heuristics for planning purposes rather than as exact figures.

Greater intensity of ICT capital in production processes can reduce emissions per output, but the magnitude of the impact on emissions changes with levels of output and ICT capital stock

When we investigate the form and magnitude of the effect of ICT on GHG emissions directly (i.e. when we use the parametric approach), the two sectors that reveal the largest scope of efficiency changes as a result of a greater emphasis on ICT capital – the metal and transport sectors – are the same sectors in which ICT delivers the greatest and most significant impact on emissions per output. When the five energy-intensive sectors are viewed as a whole, the effect of ICT on emissions per output is still promising, but not always clear. The quantified impact differs depending on the group of countries treated in the analysis and, of course, on the sector. However, when ICT has a significant effect on emissions per output, it is almost always beneficial.

The impact of ICT is most visible in the metal sector. In this sector, an increase in ICT capital per output is estimated to reduce emissions per output by slightly less than a one-to-one ratio for all European countries analysed. At average levels, a 1% increase in ICT capital intensity is specifically estimated to reduce GHG emissions per output by between 0.18% and 0.52%, depending on the model used (row (d) in Exhibit 2.1-2). In fact, two basic models of the relationship between ICT and emissions in the metals sector were found to be significant, a model that treats emissions as proportional to ICT capital (i.e., the log-linear model), and a model that views ICT to have a non-linear impact on emissions – both of which suggest that ICT is emissions-reducing, although offering significantly diminishing returns. In other words, these two models indicate that, while ICT has consistently reduced emissions over the sample period in the sector, the absolute reductions in emissions achieved by increases in ICT capital will dwindle over time.

In the transport sector, similar dynamics are observed. Increased ICT capital, relative both to total capital and to

EXHIBIT 2.1-2: SUMMARY TABLE OF EFFECTS OF ICT IN EUROPEAN ENERGY-INTENSIVE INDUSTRIES

Basic metal and fabricated metal	Chemicals, rubber, plastic and coke	Glass, ceramics and cement	Transport and storage
(a) Increase in sustainable efficiency due to a 1 percentage pt. increase in ICT capital share			
0.79 to 0.89 percentage pts.	2.64 percentage pts.	2.58 percentage pts.	1.24 to 1.72 percentage pts.
(b) Equivalent increase in gross output without additional increase in emissions (1995 euros)			
€ 330 million	€ 1370 million	€ 280 million	€ 750 million
(c) Equivalent absolute reduction in GHG emissions at constant output levels			
0.13 million tonnes	°°°	°°°	1.2 million tonnes
(d) % Change in emissions per output due to 1% increase in ICT capital intensity			
-0.18% to -0.52%	-0.12%°°	°°°	-0.15% to -0.20%°
(e) Equivalent absolute reduction in GHG emissions			
26,400 to 74,000 tonnes	15,000 tonnes°°	°°°	27,200 to 34,800 tonnes
(f) Cost in ICT fixed capital stock of a 1 tonne reduction in GHG emissions (1995 euros)			
€170 to € 440	€ 1,350 °°	°°°	€ 420 to € 540

Notes:

Part 1: ° = only applies to old EU member states

Part 2: °° = not robust to exclusion of certain countries from the data set

Part 3: °°° = results not reported for lack of significance or interpretability

Please refer to the methodology explanation in section in the full version of the final report for the exact definitions of the variables referred to here. Explanations as to why results from the paper sector were omitted can be found above.

Source: DIW econ 2009.

gross output, is estimated to decrease emissions per output with diminishing impact. However, these predictions apply only to older, higher-income EU member states, as results regarding the impact of ICT were inconclusive for the other sample countries.

In the other three energy-intensive sectors analysed, the results regarding the environmental impact of ICT obtained from the parametric regressions are much weaker and narrower in scope. In the chemical sector, we find a 1% increase in ICT capital intensity to reduce emissions per output by 0.12%, an order of magnitude lower than in the metal and transport sectors. Unlike the metal and transport sectors, the relationship between ICT and emissions is assumed to be linear in the most significant model, initially suggesting no boundary to the use of ICT capital for emissions reductions. However, this result is not robust to the exclusion of new Eastern European member states from the analysis. Thus, while ICT may yet be emissions-reducing across the aggregate European chemical sector, the effect of increased ICT capital is likely to be complex and non-linear, and may also differ significantly between old and new member states. The parametric regressions for the GCC sector add no further conclusions to the semi-parametric results. As for the paper sector, evaluation of the parametric results is not possible given the particular way in which the data is aggregated in the context of substantial sectoral changes over the sample period, as previously mentioned.

Changes in the ICT and non-ICT capital structure of the transport sector can reduce the impact of Europe's energy-intensive industries on the climate

Observations of energy expenditure and emissions data trends show that the transport sector is responsible for the greatest share in total emissions in the eleven sample countries out of the five energy-intensive industries. Furthermore, the sector has increased absolute emissions over the period, while emissions have decreased in other sectors. Econometric results confirm that increases in ICT capital stock in the transport sector are particularly important for reducing the aggregate emissions of European energy-intensive industries.

The emissions-reducing impact of increasing the share of ICT capital in total capital is by far the most pronounced in the transport sector, given historical average output and emissions levels. In addition, non-ICT capital is significantly emissions-increasing[12] in the transport sector, but not in the metal sector. Simultaneously decreasing the non-ICT capital stock necessary for production therefore boosts the emissions-reducing effectiveness of augmented ICT stock in the transport sector. Furthermore, we recall that the impact of greater ICT capital per output on emissions is conclusive only for older member states, and the excluded countries[13] are particularly large contributors to the aggregate emissions of the sector. With these results in mind, it seems that increasing the share of ICT stock in total capital, particularly in the new member states of Slovenia and the Czech Republic, is an effective way to reduce GHG emissions in the European transport sector.

2.1.3 CASE STUDIES

This section provides summaries of case studies that were conducted for this study. The complete case studies are included in the study report, available on the Sectoral e-Business Watch website.

Siemens' energy optimisation services

Siemens, a German-based supplier of equipment for industry, energy and healthcare, offers an integrated approach to increase energy efficiency and decrease GHG emissions. ICT is used to assess awareness of energy efficiency matters based on interviews conducted with the help of the software "One-2-Five Energy". Furthermore, ICT in the form of the standard Microsoft Excel software is used to calculate the impacts of different production optimisation measures. An ICT-enabled knowledge management system amasses information on comparable optimisation measures implemented in plants worldwide.

In Siemens' experience with customers, energy-saving applications based on ICT can lead to significant reductions in energy consumption. On average, these applications reduce energy use by 10-20%, with reductions of up to 30% having been observed, depending on project-specific conditions. Siemens estimates that chemical companies typically reach a 20% decrease in energy use, whereas paper or steel producers typically achieve smaller reductions of about 10%.

Siemens emphasises that industry consciousness of sustainable production is a recent development and is often driven principally by marketing considerations. This bias increases with the proximity to consumers. The ETS has not yet had a significant effect on the demand for information about energy consumption, according to Siemens. In addition to internal factors, the regulatory framework plays an important role in stimulating further advances in energy efficiency.

Deutsche Post World Net's Intelligent Transport System and Carbon-Accounting

Deutsche Post World Net is a world-leading logistics company, offering its services under the brands of Deutsche Post and DHL. Its commitment to sustainable development is characterised by its target to reduce GHG emissions by 30% on its 2007 levels by the year 2020. The case study presents two elements that play an important role toward the achievement of this goal. Deutsche Post World Net is currently implementing an Intelligent Transport System, called SmartTruck, aimed at reducing certain delivery characteristics such as kilometres per hour and the number of stops per hour.

One of the elements introduced by SmartTruck is a permanent dialogue between vehicles and a central optimisation system that, among other features, takes current traffic data and new incoming orders into account, leading to a more efficient delivery process in terms of fuel consumption and GHG emissions. Furthermore, an ICT-based Carbon-Accounting scheme is in the implementation phase and will be finalised in 2010.

[12] At higher levels of non-ICT capital per output, the dynamics of the effect of non-ICT capital on emissions per output change significantly.
[13] In this sector, the Czech Republic, Slovenia, and Portugal are excluded from the sample.

The Carbon-Management system manages the production of carbon credits arising from internal and external projects and allows customers to offset the emissions caused by their deliveries. The use of ICT also holds great potential for the reduction of GHG emissions, especially in the SmartTruck project.

Corus Rail's approach to increase energy efficiency

This case study focuses on a plant in Hayange, France, operated by Corus Rail, which is part of the Corus Group and Tata Steel. The plant produces a wide range of rails for the French, European and world market. Among these are special rails for high-speed tracks or urban transport. The production is characterised by the conversion of purchased blooms into rails. To increase energy efficiency in production, several ICT-based systems were applied to the process of reheating the blooms in a natural-gas-fired furnace. These systems include a database, which is used to document the optimal temperatures of the bloom and the furnace for different products, an automation package to ensure an optimal air to gas ratio for the furnace, and a computer system to optimise the temperature in different areas of the furnace.

Together, these measures resulted in an 11% drop in energy consumption over the last four years, and a decrease of more than 10% in the number of defects due to uneven heating of the blooms. Scope for further improvement is limited and would involve a new furnace or major changes in the plant's physical structure.

Self-developed logistic software of Due Torri S.p.A.

The Italian logistics company Due Torri S.p.A. offers many kinds of logistics services. It is located close to Bologna (Italy) and has 20 permanent employees. In 2007, it implemented a logistics software that helps conduct shipping orders more efficiently. The system was developed internally over six months.

The effect of the implemented system was a decrease in gas consumption. For example, a shipping order from Bologna to Milan now demands about 25% less fuel. The effects on GHG emissions are equivalent. Productivity also rose about 20%, as the procedures are much more efficient. Due Torri is very satisfied with the system and plans to improve it further.

A.P. Moller – Maersk's approach to make shipping more efficient

A.P. Moller–Maersk Group is the world's largest liner shipping company, operating about 550 self-owned and chartered vessels and more than 1,900,000 20-foot-long containers, of which 200,000 are reefers in which the load can be cooled. Maersk is currently working on sustainable and environmentally friendly solutions in many projects to reduce the environmental "footprint" of its transport business.

This case study focuses on two of these initiatives. The first example presented is QUEST, a method of decreasing the energy needed to cool reefers by 50%, which is based solely on ICT. The second example is VES, a system that enables a vessel's crew to choose fuel-efficient routes and propeller revolution speeds and has resulted in a 1% drop in fuel consumption (121,000 tonnes) in 2008.

In addition to the implementation of these two programmes to increase the company's sustainability, Maersk supports the formation of a global approach to regulate GHG emissions.

Eka Chemicals' strategy for reducing energy consumption

The Swedish company Eka Chemicals, a business unit of Akzo Nobel, develops and produces chemicals for the pulp and paper industry. Eka Chemicals faces tough price-competition. Energy costs are an increasingly important factor in this context. The company therefore has a strong interest in increasing its energy efficiency.

In the 1990s, a standardised Production Information System from GE Fanuc was introduced in many production processes. This system constantly monitors and analyses the energy consumption of a process and compares it to the historical energy demand of this specific process. In case of unusual increases in energy use, an alarm is triggered. The problem is then addressed and solved, either manually or automatically, depending on the complexity of the production process.

The energy reduction that resulted from using this system is estimated to be about 1% of the energy consumption of the previous year. The system is constantly improved, but further significant energy reductions are seen to be attainable only through new technologies.

Solvay: The changing role of ICT in production processes

Solvay is a Belgian company that produces pharmaceuticals, chemicals and plastics, and is a world leader in some of its product areas. Solvay believes the role of ICT has diminished in recent years. This observation is based in particular on characteristics of the chemical industry, which is very much limited in its production by underlying physical and chemical considerations. According to Solvay, the only way to increase energy efficiency is to reduce the standard deviation of optimal production parameters.

It has worked on this issue for about 20 years now, and Solvay sees little hope for further improvements by means of ICT. Solvay maintains that additional costs of GHG emissions imposed by related policies would ultimately reduce the firm's competitiveness, because the increase in production costs cannot be compensated for through higher efficiency. Solvay is currently considering relocating production facilities to non-EU countries if additional levies on GHG emissions are introduced in the chemical industry in Europe.

Oracle Transport Management

Oracle Corporation is the world's largest business software company. Oracle's product range includes databases, middleware and application solutions and services. This case study focuses on the "Oracle Transport Management" (OTM) solution.

OTM is a complex software package consisting of several products, one of which is the Oracle "Fusion Transportation Intelligence" (FTI). This system transforms transportation data into logistics information, which makes it possible to trace an optimal route for complex shipping orders. The case study demonstrates the potential of FTI by focusing on one user company: Kraft Foods, a food manufacturer with an enormous shipping demand, which implemented the system in 2007. Since Kraft foods started using the system, it has reduced its shipping costs by 3-5%. As these costs mainly cover gas, the savings can be directly translated into a decrease in CO2 emissions. With rising awareness of GHG emissions, OTM is seen as a product of increasing importance.

2.1.4 INDUSTRY SURVEYS

The econometric analysis in this report is grounded in the case studies presented above, which illustrate the experiences with ICT of eight companies in Europe's energy-intensive industries. However, further knowledge of industry attitudes toward GHG emissions and reactions to environmental and emission regulation is necessary in order to fully take advantage of the previous chapters' lessons for environmental policy purposes.

In order to provide up-to-date insights into the interaction between environmental policy and industry business practices, and to understand the extent to which ICT has been implemented to reduce emissions in energy-intensive industries, the findings of two surveys are presented in this chapter.

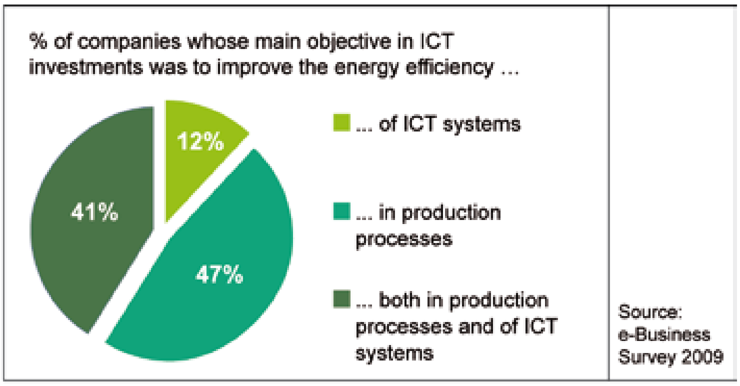
- A pilot survey among companies from the glass, cement, and ceramic industries examines the use of ICT for saving energy and monitoring GHG emissions.
- A Delphi-style survey poses questions about the potential of ICT for reducing GHG emissions to experts in relevant companies, industry associations and research institutions. The survey also investigates the perceived effect of environmental policy on European energy-intensive industries.

Pilot survey in glass, ceramics and cement sector

The Pilot survey covered 676 companies in the glass, cement and ceramic sector (GCC) in six European countries.[14] It explored the extent to which companies in this industry use ICT systems for managing and reducing energy consumption and emissions, as well as the potential companies see in ICT. The interviews were conducted through computer assisted telephone interviews (CATI method) in March 2009 with ICT decision makers in the companies. The general trend in the usage and assessment of ICT for energy and emissions management in the GCC sector is expected to be indicative for other energy-intensive sectors as well.

Rising energy costs are a business concern in all energy-intensive industries, as the cost of energy impacts competitiveness. If energy costs are significantly higher in one region, local companies face a competitive

EXHIBIT 2.1-3: ENERGY EFFICIENCY AS AN OBJECTIVE FOR ICT INVESTMENTS



[14] Germany, France, Italy, Poland, Spain and UK.

disadvantage. This certainly holds true for the GCC sector. In the cement industry, for example, energy costs account for more than 30% of total production costs.[15] Each tonne of cement produced requires about 105 kWh of electricity.[16] Energy costs are unsurprisingly perceived as a relevant issue by almost 80% of all companies. To counteract rising energy costs, the industry has made enormous efforts to achieve more energy efficient production. The technological progress in production procedures has also led to reduced CO2 emissions in relation to output. Innovation in ICT systems for monitoring and analysing energy consumption are expected to enable companies to further increase their energy efficiency, i.e. to reduce their energy consumption at given output or to increase production with the same amount of energy. Examples of such systems are ICT-enabled tools that monitor, control and optimise the performance of the generation and transmission system, so called "energy management systems" (EMS).

In the pilot survey, companies were asked to report their use of these EMS. Companies that said they had used an EMS for at least one year were then asked for an assessment of the system's effectiveness. About one in five believed that the energy efficiency of their company had "significantly improved" due to the system in place and about a third of the companies said the efficiency had "somewhat improved". The fact that almost half of these companies did not perceive any improvement can be interpreted in two ways. First, energy efficiency is often only an indirect objective, as EMS are usually implemented to control and overview energy flows with a focus on safety and quality of the final product. Second, it might take some time until information gained through EMS is evaluated and processes are adjusted.

Some questions in the survey explored how relevant energy-related aspects are for ICT investment decisions in general. In total, about a fifth of the interviewed IT decision-makers from the GCC sector said that energy efficiency has been a relevant objective in their ICT investments in recent years. These companies were then asked whether the focus was on improving the energy efficiency of production processes or of the ICT systems themselves. Exhibit 2.1-3 confirms the role of ICT as a general-purpose technology in this respect: nearly half the companies with an energy focus in their investments said that their main goal was to reduce energy demand indirectly by improving production processes through ICT.

Despite a moderate-to-strong use of EMS in the sector, the pilot survey indicates that specific systems or modules for monitoring and measuring GHG emissions are not yet widely diffused. In the GCC industry, less than 10% of the companies interviewed said they had an ICT-enabled application to systematically monitor GHG emissions. A further 3% said they did not have an ICT solution for this purpose but had implemented a dedicated non-ICT process for systematically monitoring and analysing their emissions. This leaves close to 90% of the companies surveyed which apparently have no systematic approach to emissions management. Although ICT is the preferred option for emissions-management systems, the uptake of these systems is extremely slow. Evaluating the usefulness of ICT emissions-monitoring systems will have to rely on anecdotal evidence until there is wider implementation.

Delphi-style survey among industry experts

In order to provide further context for the results from the econometric analysis, a Delphi-style survey of experts in the five analysed energy-intensive industries was conducted. To find relevant interview subjects, three pools of experts were considered: representatives from companies, representatives from industry organisations, and representatives from research institutions that specialise in these industries. The assembled group of twenty-three respondents were intended to be indicative of energy-intensive industry rather than statistically representative, with seventeen representatives from companies, five from industry organisations, and one from a research institution. At least four representatives from each industry were presented with the questions in this survey. Six representatives came from the metal sector and five from the transport sector. The respondents came from companies of various sizes, with representatives from the largest players (based on output) specifically sought out and utilised when possible. Representatives came from nine countries within the EU-15 and from the Czech Republic.

The survey consisted of six questions that addressed the following areas of intersection between ICT and emissions in energy-intensive industries: the perceived impact of emissions regulation on industry business practices; the use of GHG emissions monitoring systems; and the potential for ICT to reduce GHG emissions. In the first round, survey questions were posed through an online questionnaire or in a telephone conversation, according to the preference of the respondent. In the second round, questions were posed

[15] Ibdz: "Themes: Energy intensity and energy efficiency", http://www.bdzement.de/75.html?&lang (March 2009).
[16] CEMBUREAU: "Main characteristics of the cement industry." www.cembureau.be (March 2009).

through e-mail versions of the online questionnaire, with the results from the first round attached in graphic form. Participants were asked to respond with any changes to their opinion based on knowledge of the attached results, thus inducing a Delphi-style survey effect. In each round of questions, respondents were also given the opportunity to make any further comments, in writing or orally. The answers of respondents from the second round accorded with those from the first round, indicating either clarity of opinion or a lack of impetus to reflect more deeply on the topic.

The Delphi-style survey provides a broader perspective on the opinion of experts from energy-intensive industries regarding ICT and its effectiveness for reducing GHG emissions. In contrast to the responses from the survey of the glass, cement, and ceramic sector presented above, the experts questioned in the Delphi-style were emphatic about the strong impact that both the EU ETS and general emissions regulation have on business practices in their five industries. Interviewees revealed that large capital investments in renewable energy technologies as well as investments in ICT-based emission monitoring systems had been made as a result of these emissions regulations.

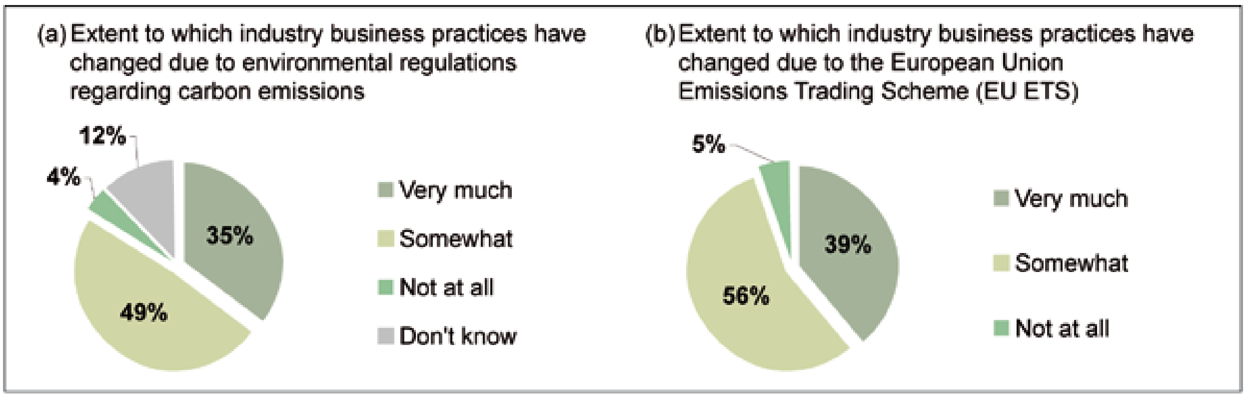
Carbon-emission monitoring systems were found to be relatively common. Only 5% of systems were reported to be non-ICT based, with almost three times as many companies implementing these systems over the whole company (or even group) as opposed to specific business units. The motivation for the implementation of such systems and the decision regarding their scope are based on a cost-benefit analysis that is strongly influenced by the framework of emission regulation. 39% of survey participants stated that industry business practices have changed "very much" due to general environmental regulation regarding carbon emissions (see Exhibit 2.1-4a). When asked specifically about the EU ETS, 35% gave the same response (see Exhibit 2.1-4b).

The system of rebates in the UK was reported to be particularly comprehensive, while at least one respondent complained that benefits for energy-reducing investments were not sufficient under the current EU ETS. Lastly, the opinion of industry experts regarding the potential of ICT systems seems to be split. ICT systems are reported to be integral to emissions monitoring systems, but achieving actual reductions seems to require a more comprehensive production overhaul.

2.1.5 CONCLUSIONS AND POLICY IMPLICATIONS

With the goal of discovering the impact of ICT on GHG emissions in energy-intensive industries, this report has employed a combination of econometric estimation techniques, case studies, and surveys. In the first section of this chapter, we provide an integrated review of the main results

EXHIBIT 2.1-4: POLICY IMPACT ON BUSINESS PRACTICES



Source: DIW econ, 2009.

and discuss the implications for the role of ICT in improving the sustainability of European energy-intensive industries. In the second section, we provide policy suggestions in order to assist European policymakers in putting the results in this report to good use.

Putting econometric results in context

Our most robust econometric conclusion is that increased ICT share in total capital allows increased aggregate production without emissions increasing at the same rate.[17] As all case studies demonstrate, ICT-based production optimisation systems are at the heart of these efficiency gains. ICT is used for improving the time and fuel-efficiency of transport routes and optimising furnace temperatures in steel processing, for example.[18] Various quality and service improvements as a result of the implementation of ICT-based optimisation systems are also worth noting. In turn, these company-level observations on the usefulness of ICT to achieve efficiency and sustainability gains provide support for our econometric estimations, despite concerns about the aggregated nature of the ICT measure used.

Both surveys indicate the necessity of using ICT in order to build an effective emissions-monitoring system. Monitoring is the first step toward achieving reductions. The Deutsche Post/DHL case study provides the consummate example of how ICT can be extensively employed to enable a spectrum of emissions monitoring systems. ICT capital investments for emissions-monitoring also permit Deutsche Post/DHL to offer monitoring services and carbon offset opportunities to its customers, creating a multiplier effect. This cross-sectoral link between ICT capital and emissions reductions was not directly captured by the economic analysis. Furthermore, the case studies indicate that the most significant realisation of efficiency benefits and emissions reductions through ICT within energy-intensive industries took place after 2005, which is beyond the range of the data set. The spread of ICT-based emissions-monitoring systems has also been particularly weak within the period covered by available data. The estimated effects in this study (which are based on the period from 1995 to 2005) should thus be taken as descriptive of historical trends.

Wider implementation of ICT-enabled energy-efficiency and emissions-monitoring systems is likely to strengthen the direct link between ICT and emissions intensity that may be revealed by econometric methods in the coming years. Our estimations may well be the lower boundary of the true effect of ICT on sustainability in energy-intensive industries, especially when an ICT investment has the dual effect of reducing emissions through production efficiency and "enabling" further reductions through its monitoring and feedback function. However, the future dynamics of returns to ICT capital growth cannot be expressly concluded with available data and the applied methods.

Monitoring and feedback systems can enable reductions in GHG emissions that have not yet been captured by the econometric analysis

Across all econometric analyses, structural effects – such as static differences in policy, geography, the regulatory framework and culture – are highly important determinants of emissions intensity. Industry opinions confirm a strong influence of climate change policies and regulation on industry business practices. Industry investments in energy efficiency and emissions monitoring systems were also reported to be a direct result of national or international incentives. These incentives differ considerably between the countries in our econometric sample, partially explaining the significance of structural effects in the econometric results. Some countries have imposed a cost on emissions through carbon tax regimes, others have implemented incentive systems to support renewable energies, and others lack climate change policies altogether. Furthermore, the Siemens case study shows that industry demand for ICT-based monitoring technologies increases with the environmental consciousness of the industry's customers. Varying levels of concern for sustainability in European countries, both on the part of end users and manufacturers, translate into significantly different patterns of ICT adoption and GHG emissions per output. All in all, the policy and culture of the country in which an industry operates constitute a highly varied and complex structure which can hinder or enhance the deployment of ICT for marginal reductions in emissions.

Specific policy and structural environments in each country are important determinants of the emissions intensity of production, and can make or break the effect of ICT

The significant relationships between ICT capital and emissions per output discovered by our econometric analysis are also significantly non-linear, especially when it comes to the diminishing impact of emissions-reducing ICT. Diminishing returns to ICT investment for companies in

[17] We refer to the output-oriented measure of sustainable efficiency in the semi-parametric analysis.
[18] See case studies for Deutsche Post World Net and Corus Rail.

the chemical sector are supported by the Solvay case study. To be sure, an established company with knowledge of all available ICT technologies is likely to see diminishing returns on ICT investment. As a company nears optimal efficiency, reductions in emissions become increasingly tied to input composition, and the environmental impact of further ICT solutions diminishes. However, company-level dynamics are different from sector-level dynamics, and our econometric methods are unlikely to capture the full dynamics of the effect o ICT deployment on GHG emissions.

When firms in a sector quickly adopt new technology, our econometric analysis is more likely to capture a significant and diminishing link between ICT and emissions at the sector level. However, this link has been observed only in the metal sector, and for older, higher-income EU member states in the transport sector. A sector-wide analysis of the impact of ICT is complicated by the fact that the opinions of individual companies rarely reflect sector-level data. Indeed the visibility of ICT impact depends to a large extent on whether each company is among "early adopters" of ICT or lags behind.

Energy experts at Siemens observe that, for most energy-intensive industries, concerns over energy-efficiency and demand for production optimisation technologies have become important only in the past two to three years. Awareness of energy efficiency also differs according to each industry. This helps explain the strongly varied econometric results in this study. The steel industry, cited as an early-adopter of energy-management technology by Siemens, is also the sector in which we find the most conclusive link between increased ICT and lower emissions intensity. An emissions-reducing impact of ICT that is not statistically significant at the sector level (as in the chemical sector, for example) could be a result of weak sector-level adoption of ICT rather than evidence against the potential for these technologies to improve the sector's sustainability. Indeed, Siemens finds that awareness of ICT-based efficiency systems has only recently increased in the chemical sector and estimates large potential savings from ICT systems, while the early-adopter Solvay entertains a more pessimistic view.

Improvements in awareness and changes in the type of marginal ICT investment are crucial in further reducing the sector's impact on the climate

Structural homogeneity (within a sector and across sectors) is also likely to determine whether the econometric analysis finds significant evidence for an emissions-reducing effect of ICT. A larger set of homogenous firms increases demand for a particular ICT solution within a sector, making it more likely that this service is developed and implemented – and subsequently magnifying the emissions reductions generated by industry ICT capital stock. Homogeneity in processes among sectors (such as use of a standard electricity generation technology) similarly enables increased investment in ICT capital that increases efficiency and reduces emissions. This increases the likelihood that econometric analysis will find a consistent and meaningful relationship between ICT and emissions in all sectors.

When currently available technologies prove capable of significant reductions in emissions, but are not adopted industry-wide (for reasons of low awareness, low economic returns or because of structural/technical considerations), the industry econometric analysis will not find significant emissions-reducing effects of ICT. As marginal increases in ICT capital stock at the industry level consist more of investments in process optimisation and emissions monitoring systems, future econometric analyses will probably confirm a more significant role for ICT in all energy-intensive sectors. In the case where ICT has truly reached its potential for improving efficiency (this is more likely for a particular firm than for the sector as a whole), the only way to continue reducing GHG emissions is to revamp production processes and non-ICT capital structures, and to implement ICT-based emissions monitoring systems.

Policy implications

While ICT can be significantly emissions-reducing, it is not the "silver bullet" for GHG emissions abatement. With a range of different technologies that can reduce emissions at varying costs, the most efficient way to identify the cheapest technologies for reducing GHG emissions is a cap-and-trade system which imposes a cap on total emissions while leaving the choice of specific abatement technologies to the market. With the EU ETS, such a scheme was introduced in Europe in 2005. For this system to work effectively, the cap must be set so that the price for carbon emissions is sufficiently high. A high cost on emissions will induce the implementation of various technologies to monitor, manage and reduce emission levels.

1. Allow the market to determine the most efficient technology for achieving GHG emissions reductions through a sufficiently high price for carbon emissions

In conjunction with a strengthened EU ETS and better incentives for the development and implementation of ICT-based energy- and emissions-management systems, completely standardised regulations regarding the monitoring and reporting of company-level GHG emissions are needed. Emissions costs can be correctly allocated only if all firms are reporting direct GHG emissions according to the same procedures. Furthermore, life-cycle carbon-accounting systems, such as those implemented by Deutsche Post World Net, need to be standardised. Comprehensive standardisation of carbon tracking procedures will have myriad benefits.

2. Harmonised guidelines for recording and reporting emissions in all sectors

The EC has identified, in COM (2009) 111, the role of ICT systems as "quantifiers" and "enablers" in reducing GHG emissions through energy-efficiency. In other words, ICT systems quantify how efficiently a production process is executed, and enable management to make appropriate changes to these processes. These two major roles for ICT are manifested in energy-management systems, as illustrated in our case studies and surveys, and apply to emissions-management systems as well. ICT emissions-management systems have been adopted for marketing and reputational reasons, out of the concern of individual managers about the climate, and to profit from providing related carbon management services to customers. The adoption of these systems has historically been weak and has picked up only recently, indicating the need for targeted policy support to encourage faster adoption of ICT systems that combat climate change.

With the EU ETS functioning efficiently in all EU countries, direct support for specific technologies that reduce emissions at company-level will not be needed. However, budding market incentives can be encouraged by indirect policy support measures specifically for ICT-based energy and emissions management systems without distorting the market. These measures can come in many forms, as listed in Exhibit 2.1-5.

3. Foster ICT-based process optimisation systems that integrate energy and emissions management systems through indirect policy support

In all energy-intensive sectors analysed, we find significantly different relationships between ICT and GHG emissions when Eastern European member states are excluded from the analyses. Bearing in mind the relatively recent economic transitions of these countries, these results suggest the new member states do not yet take advantage of emissions-reducing ICT innovations in the way older member states have. These states are likely to benefit from specific policy to guide marginal increases in ICT capital stock toward investments in ICT-based energy- and emissions-management systems.

Furthermore, a special focus on wider implementation of ICT-based optimisation systems in the transport sector in new European member states is strongly advised. Where the EC has confirmed the importance of furthering ICT-based energy-efficiency gains for carbon emissions reductions in the transport sector in general, these policies can be enhanced by a special focus on new member states. Case studies demonstrate that ICT-based systems significantly increase efficiency and reduce emissions in the transport sector, but the econometric analysis finds a historical emissions-reducing effect of ICT in the transport sector only for old, higher-income European member states.

4. Focus policy support on new European Union member states and the transport sector

Various gaps or undesirable characteristics in the data available for this analysis limit the conclusions that can be drawn from our econometric studies. With a truncated production data set from EU-KLEMS, the effects of important developments in the ICT sphere and of the implementation of the EU Emissions Trading System are not incorporated in the econometric estimations. In order to ensure that future structural evolutions can be analysed, we recommend that EU KLEMS continue to collect and publish the range of production data used in this report.

The limitations to analysis do not just stem from the length of the data set, however. In order to reduce bias in the estimated effect of increases in ICT capital on GHG emissions (and on other important measures such as productivity), we recommend that a wider range of metrics regarding ICT be collected. These metrics should attempt to capture both the composition of ICT capital stock through disaggregated

EXHIBIT 2.1-5: SUGGESTED INDIRECT POLICY SUPPORT FOR ICT SYSTEMS

Policy Support	Foundation and Implications
Foster increased industry and cross-sectoral cooperation for development of energy- and emissions-management ICT systems	Fostering collaborative innovation among firms within a sector and even cross-sector (or with academic entities) specifically with regards to emissions-reducing ICT systems will accelerate the reduction of emissions per output in all energy-intensive sectors. Maersk's cooperation with a university to develop influential ICT systems exemplifies the benefits that cooperation can bring.
Documentation and publication of best practices regarding energy- and emissions-management ICT systems	Along with providing greater support in the form of financing and incentives for the implementation of ICT-based optimisation and emissions-monitoring systems, policymakers can play an important role as centralisers of private-sector knowledge and best practices. The more the company-specific knowledge and experience can be gathered and shared across the industry, the faster industry-wide reductions in GHG emissions can be achieved.
Offer financing support for research and development of energy- and emissions-management ICT systems	Collection and distribution of best practices and lessons from the implementation of current ICT systems can speed up the adoption process, especially for smaller firms, leading to lower emissions per output for the aggregate sector. It would be wise to target support at research and development that furthers the cross-sectoral scope and implementation flexibility of current and new ICT-based energy- and emissions-management systems.
Increase awareness among end-users and manufacturers who form the market for energy-intensive industries	In general, increased public awareness and concern for emissions will also provide market-based pressure for emissions reduction when the public is the end-user. The greater the awareness, the greater the pressure on energy-intensive industries to implement energy- and emissions-management systems.

Source: DIW econ, 2009

measures, and the cost of implementing such ICT systems. Ideally, a measure of "embedded" ICT – the ICT systems hidden in other capital stock, such as vehicles, that are not classified as ICT stock per se – should also be made available. More detailed measures of ICT will allow for more precise cost-benefit analyses of how particular ICT innovations contribute directly to combating climate change and to other phenomena of policy concern.

5. Enhance relevant data collection measures and scope of available data to support more comprehensive analysis

In principle, recommendations that are applicable to all EU member states would be desirable in order to facilitate policy making. However, ICT and emissions policy should be carefully designed to consider the different nature of the relationship among sectors, among European countries, and even in a given industry over time. With this in mind, the offered set of recommendations may be used to promote the restricted but distinct potential for ICT to reduce emissions in European energy-intensive industries.

Acknowledgements

This study was conducted by **DIW econ** (http://www.diw-econ.de), an economics consultancy based in Berlin. The study authors are Dr. Ferdinand Pavel, Katja Frank and Madeleine Evans. The study was accompanied by an Advisory Board, consisting of Pietro Evangelista (National Research Council, Italy), Enrico Gibellieri (European Steel Technology Platform), Willy Spreutels (Solvay, Brussels), Graham Vickery (OECD) and Martin Wörter (KOF Swiss Economic Institute, ETH Zürich). The full study report can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

2.2 ICT and e-business in the glass, ceramics and cement industries

A study by empirica GmbH, with contributions from DIW econ and case study correspondents.
Main study author: Hannes Selhofer

In the glass, ceramics and cement (GCC) industries, companies use ICT mainly for optimising their internal processes rather than for data exchanges with suppliers and customers. A central objective of ICT use is the support of production processes. The digital divide between large companies with their advanced ICT systems and SMEs is more pronounced than in other sectors. The study warns that small companies are often not able to take informed decisions about their ICT strategy, due to a lack of e-skills. Thus they could underestimate the relevance of ICT for their own business and competitiveness.

A marked digital divide

More than two in three companies said that they conducted at least some of their business processes electronically in 2009. About 15% saw themselves as intensive users. The large international companies of the sector use advanced ICT systems to integrate their business processes, and for procurement and supply chain management, just as in other manufacturing industries. Many of the SMEs, however, in particular those operating in traditional, labour-intensive segments, do not see e-business as an opportunity. Nearly half of the small companies said that none of their processes were conducted electronically; many do not use any ICT systems other than e-mail. While this may make sense for individual firms, there is a risk that the ICT approach of many smaller companies is too passive and defensive (resulting from a lack of e-skills), and will have negative implications for their international competitiveness.

ICT enables process innovation – a critical success factor for European companies

Even if ICT adoption lags behind other manufacturing industries, the study also shows that ICT plays an important role even in this traditional and rather conservative sector. In particular, the study confirms the enabling function of ICT for process innovation. The capability for innovation will be critical for European companies to keep their position in higher market segments which rely on differentiation and quality.

Strategic responses by policy and industry

The study suggests four priority areas for measures to support the competitiveness of the European GCC industries through ICT and e-business:

- actions to improve the e-skills of small companies in the sector;
- promoting agreements on standards for e-business within sectoral value chains;
- improving the legal framework for electronic data exchange, for instance by following up the recommendations of the Expert Group on e-Invoicing;
- using ICT to facilitate compliance with legal requirements.

2.2.1 STUDY OBJECTIVES AND DATA SOURCES

Research objectives

The glass, ceramics and cement (GCC) industries constitute a mature, capital- and energy-intensive sector with normally predictable demand and relatively high barriers for market entry. There are many enterprises with a long-standing tradition and the sector is known to be rather conservative in terms of how business is done. Therefore, a basic assumption for this study was that ICT usage and e-business activity would be less widely deployed than in other manufacturing industries and would not be expected to have a fundamental impact on industry structure as a whole - definitely not as much as in service sectors such as tourism, banking and ICT services. These assumptions were confirmed.

A specific question was how the economic crisis (in particular the collapse of demand in important customer sectors such as construction and building) and increasing pressure on European companies to comply with environmental regulation would affect e-business developments in this sector in the next few years. On the one hand, these constraints could be a driver for companies to turn their attention to ICT, as they urgently seek opportunities to increase their process efficiency in order to cut costs. In this scenario, the crisis drives companies to exploit a possibly untapped potential to become more competitive. On the other hand, the economic difficulties may push ICT and e-business further down the industry's agenda. The budget for any investments would then be extremely constrained. If the business case for investments in ICT leaves doubts about a fast return-on-investment, companies will be strongly inclined to postpone or even cancel ICT projects, turning their attention to their day-to-day business and "more urgent" needs. The study found that the economic crisis was a major barrier for SMEs to engage with e-business in the first place. Large companies, while also cutting down on ICT investments, did not question the importance of e-business as such. This has led to a pronounced digital divide in the industry.

Against these general considerations, the study assessed the role and potential of ICT and e-business for companies in various segments of the GCC industries, both from a micro-perspective (strategic implications for individual enterprises) and from a macro-perspective (economic impacts on the sector as a whole).

Data collection

The study is based on a mix of micro and macro data, from primary and secondary data sources. Primary data stem from a representative telephone survey among 676 companies from the sector (see Annex I for more information), company case studies, and interviews with industry representatives. Secondary sources include literature, the EU KLEMS Growth and Productivity Accounts (for the analysis of ICT productivity impacts), sector statistics provided by industry federations, and Eurostat business statistics.

Advisory Board

The study was conducted in consultation with an Advisory Board, consisting of the following industry representatives and economists (in alphabetical order):

- Mr Renaud Batier, Managing Director, Cérame-Unie
- Mr Jean-François Mottint, Head of Intelligence Unit, ICT Project Development, CEMBUREAU
- Ms Brigitte Preissl, Editor in chief, Intereconomics Wirtschaftsdienst, Deutsche Zentralbibliothek für Wirtschaftswissenschaften (ZBW)
- Mr Frédéric van Houte, Secretary General, CPIV

2.2.2 THE EU GLASS, CERAMICS AND CEMENT INDUSTRY

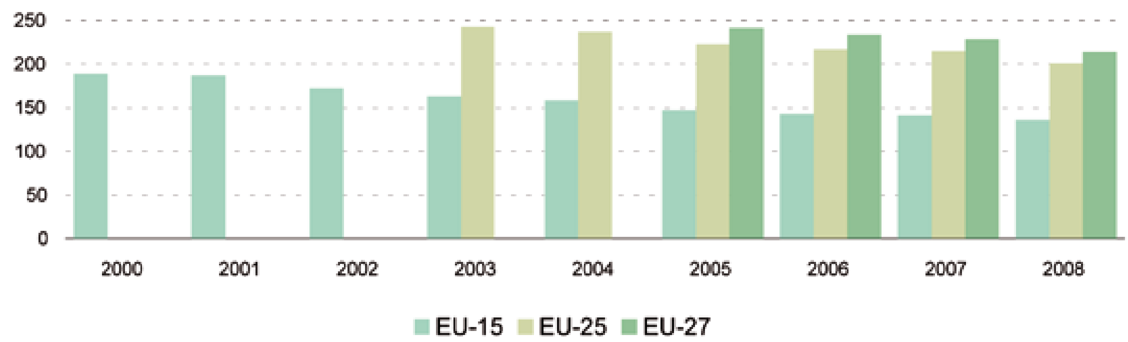
Basic facts and characteristics

The GCC industries as defined for this study cover business activities specified in NACE Rev. 2 Division 23 as the "manufacture of other non-metallic mineral products". The study focuses on Groups 23.1 to 23.6, which broadly comprise the manufacture of glass, ceramics, cement, concrete, lime and plaster, and of products made of these materials. According to Eurostat, the sector employs about 1.3 million[1] in the EU and comprises about 65,000 enterprises.[2]

The GCC industries are a long-established, traditional manufacturing sector in the EU and an important supplier to other industries. The sector produces raw materials and components for the building and construction industry, packaging solutions (container glass) for the consumer goods industry, and specific materials or components used, for example, in the aerospace, automobile, electronics and medical industries. The sector also produces household goods such as glass and ceramics tableware and cookware.

[1] Employment statistics provided by the European industry federations of the GCC industries for their members tend to be lower than those in official statistics.
[2] These figures are still based on the NACE Rev. 1.1 classification, Division 26 (whole sector).

EXHIBIT 2.2-1: EMPLOYMENT DEVELOPMENT OF THE EU GLASS INDUSTRY 2000-2008 (PERSONS EMPLOYED IN THOUSANDS)



Source: developed from CPIV

The three industries of the GCC sector have in common the blending of non-metallic raw material inputs before a heating process takes place to create the materials which give the industries their name (glass, ceramics, cement). This transformation process is energy intensive, as it requires high temperature procedures. The process inevitably leads to carbon dioxide (CO2) emissions. Coping with environmental objectives, in particular with the new greenhouse gas emissions regulation, is a critical issue for the sector. In the glass and ceramics industries, the basic materials are then further processed into a range of heterogeneous products. In the cement industry, the output is more homogeneous.

Most branches of the GCC industries have experienced a general trend towards consolidation. This can be demonstrated by the example of the glass industry. In member companies of CPIV, the European federation of the sector, employment in the EU-15 (of 2000) has decreased from 2000-2008 by 28%, from 189,000 to 136,000 (see Exhibit 2.2-1).

The role of international trade

The EU still has a surplus in international trade. However, imports of flat and container glass have notably surged in the past five years, largely due to Chinese exports. In the European glass industry, extra-EU trade represents about 5-10% of production and consumption. In the ceramics industry, roughly a quarter of EU output is sold on world markets. Cement is costly to transport over land. The area within which a typical cement plant is competitive extends to about 300 km. Consequently, the cement, lime and plaster industry is witnessing an accelerated internationalisation, but not necessarily a globalisation: big cement companies are expanding their positions into new and emerging markets, but in all markets where they operate, competition remains mainly local.

2.2.3 "E-READINESS": ICT INFRASTRUCTURE, INVESTMENTS AND E-SKILLS

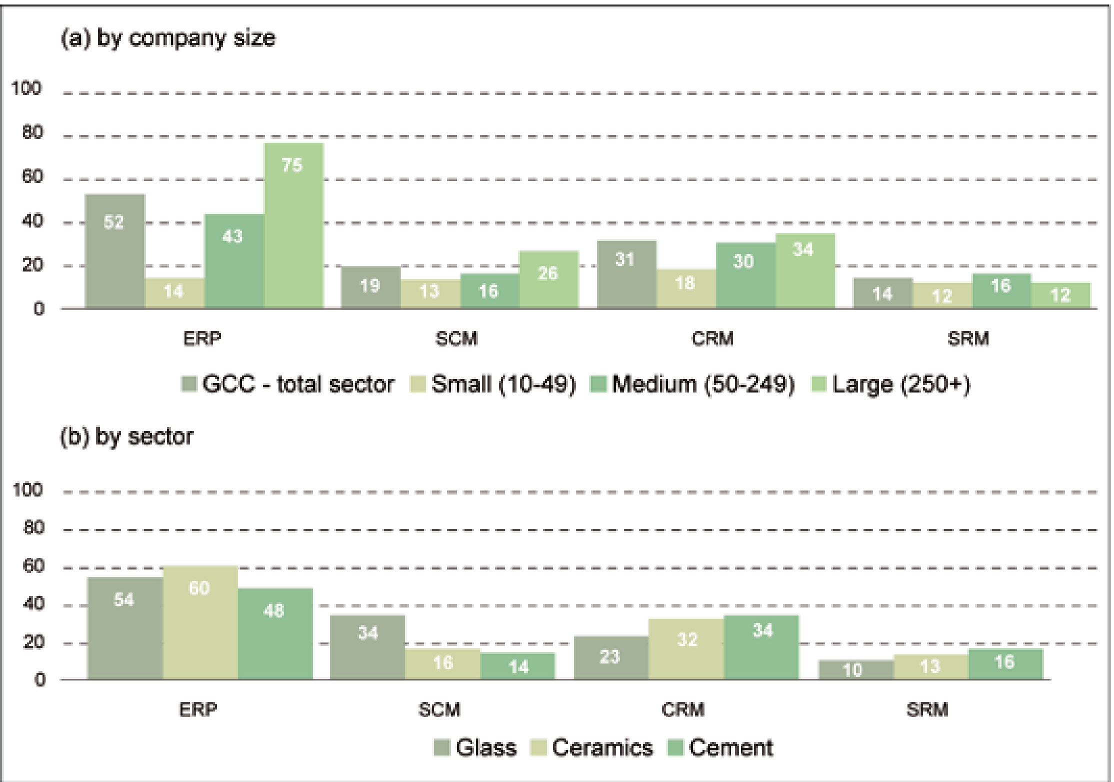
e-Readiness comprises three main dimensions which are discussed in this study: the technical infrastructure, ICT skills, and the financial aspect, i.e. the capacity and willingness to invest in ICT.

ICT infrastructure and skills

Basic technical infrastructure is no longer a critical barrier for the use of e-business. In the survey conducted for this study, more than 80% of all companies in the GCC sector, small ones (with 10-49 employees) included, said they had broadband internet access in 2009. About 60% of all employees worked in companies which enable employees to remotely access files on the company's computer network (e.g. from home or when travelling).

With regard to ICT skills, figures indicate that the vast majority of companies in the GCC industries are currently not directly affected by a shortage of ICT practitioners (i.e. staff with the specialised skills and tasks of planning, implementing and maintaining ICT infrastructure).

EXHIBIT 2.2-2: % OF COMPANIES USING ADVANCED E-BUSINESS SOFTWARE SYSTEMS



Base (100%): all companies. N = 676. Data for the sector totals are weighted by employment (companies representing x% of employment), data for size-bands are in % of enterprises. Reading example: "Companies representing 52% of employment in the GCC industries have an ERP system."

Source: e-Business Survey 2009

About 16% of the companies interviewed in 2009 said that they had outsourced ICT functions which they had conducted in-house in the 12 months prior to the interview to external service providers. Outsourcing ICT services does not mean that a company no longer needs a proper understanding of ICT and e-business related opportunities. On the contrary, there is evidence that companies with a better ICT infrastructure and a good knowledge of e-business are more likely to draw benefits from outsourcing specific ICT services, because they can leverage their own ICT infrastructure to better manage the interfaces with the external service provider.

Adoption of advanced e-business systems

The automation of data exchanges as discussed in Section 2.2.4, particularly in its more advanced forms, is supported and facilitated by special software systems. The most important systems in this context are ERP (enterprise resource planning), SCM (supply chain management) and CRM (customer relationship management).

Three in four large companies in the GCC industries have an **ERP system** in place (see Exhibit 2.2-2). Among medium-sized companies, more than 40% are ERP users. e-Business Watch case studies of ERP use show that most large companies implemented their ERP system in the late 1990s or in the early years of this decade. All case companies reported that the introduction of the ERP system has been a major milestone (and sometimes a turning point) in many respects, with a fundamental impact on the company's internal organisation and its workflows. The ERP-focused case studies presented in this study, the glassmaker BA Vidro (Portugal) and Lafarge Cement in Poland (see Section 2.2.6), confirm this assessment, and illustrate the central role that ERP systems can play in the effective and efficient management of business processes.

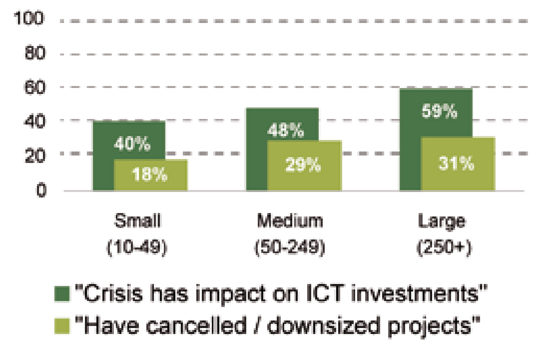
Companies representing about a fifth of employment said that they had an **SCM system** (see Exhibit 2.2-2). The adoption rate is somewhat lower than in manufacturing sectors such as the chemical industry (about 40%) and the steel industry (27%), which were surveyed in 2007. Within the GCC sectors, the larger companies in the glass industry are significant users of SCM systems.

CRM systems offer a company the ability to systematically gather information about its customers and their profitability. Marketing strategies can then be built and adapted on the basis of this intelligence. In the GCC industries, companies representing about a third of the sector's employment said they had a CRM software system in place (see Exhibit 2.2-2). Adoption rates increase with firm-size, but not to the same extent as those for ERP systems. Supplier relationship management (SRM) is the supply-side equivalent to CRM. An SRM system supports the strategic planning and central management of a company's relationship to its suppliers. SRM can also be seen as an element of SCM (see above) and an extension of the sourcing and e-procurement processes.

ICT expenditure and investments

The general climate for ICT investments has significantly changed due to the economic crisis since late 2007. Many large companies are cutting their ICT budgets or cancelling projects. In total, more than 40% of GCC companies said that the crisis would affect their ICT investments. More than 20% had already downsized or cancelled existing projects (see Exhibit 2.2-3), and 20% said that they planned to cut their budget. This was the highest trend towards decreasing ICT budgets ever recorded by e-Business Watch (in any sector) since surveys of this kind were first conducted back in 2002.

EXHIBIT 2.2-3: IMPACT OF THE ECONOMIC CRISIS ON ICT INVESTMENTS (2009)



Source: e-Business Survey 2009
Base (100%): all companies. N = 676.

2.2.4 "E-ACTIVITY": ELECTRONIC DATA EXCHANGES

Digitising business processes

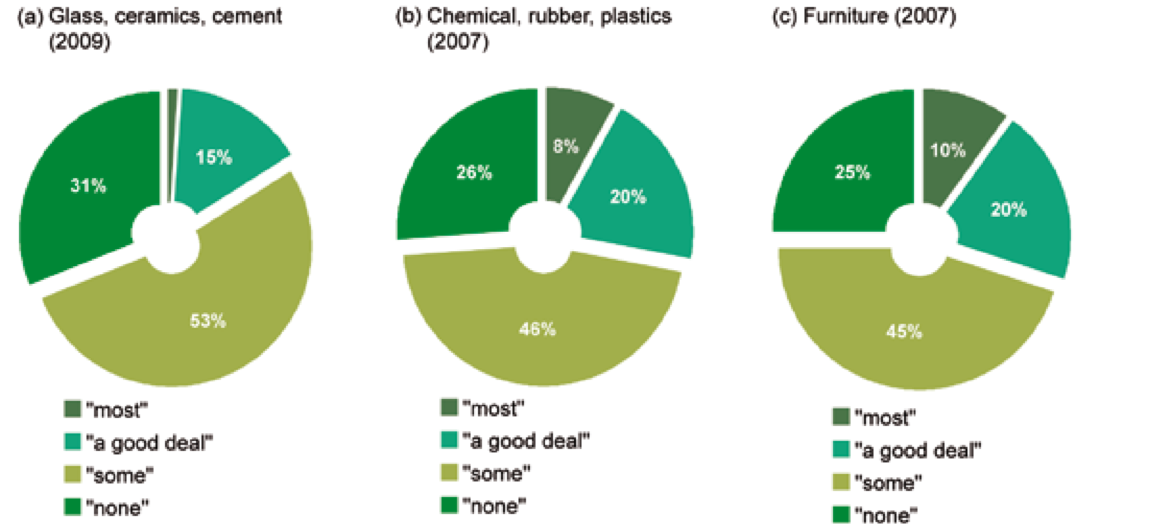
e-Business is about automating formerly paper-based document exchanges and their manual processing through electronic exchanges, both between and within companies. Most companies in the GCC industry focus on the use of ICT for optimising internal processes rather than on data exchanges with suppliers and customers. In order to get an idea of where companies position themselves on the road towards e-business, the Sectoral e-Business Watch asked GCC companies to estimate whether they conducted "most", "a good deal", "some" or "none" of their business processes as e-business. In total, about 70% of all companies in the sector (by share of employment) said that at least some of their business processes were conducted electronically in 2009 (see Exhibit 2.2-4). About 15% saw themselves as intensive users, saying that e-business accounted for "most" or "a good deal" of their business activity. The results are comparable to those of other manufacturing sectors obtained in the e-Business Watch Survey of 2007.

A good example to study the digitisation of formerly paper-based processes is electronic invoicing. e-Invoicing promises easy-to-achieve cost savings for both the invoicing entity and receiving entity, because processing invoices in a standardised electronic format can be accomplished much faster than the often cumbersome handling of printed invoices. The cost saving potential obviously depends on the number of invoices that have to be processed. e-Invoicing has therefore attracted much attention in recent years, not only within the business community, but also in policy, as complex issues remain to be solved in order to exploit its full potential (see Section 2.2.8 – strategic responses). In the GCC industries, 35-40% of the companies said that they sent and/or received electronic invoices in 2009.

Focus on efficient production processes

A central area of application for ICT systems in this sector is the support of production processes (e.g. demand planning) and their links with the supply chain. The case studies of BA Vidro and Gmundner Keramik (see Section 2.2.6) are good examples to demonstrate the important role of ICT in supporting flexible production schemes. Specific ICT systems such as CAD/CAM systems are widely used in the sector. Some of the larger companies use innovative RFID-based applications for many purposes, hinting at the future potential of this technology.

EXHIBIT 2.2-4: SHARE OF BUSINESS PROCESSES CONDUCTED AS E-BUSINESS (SELF-ASSESSMENT)



Reading example: "15% of the GCC companies (by their share of employment) said that they conducted a good deal of their business processes as e-business."

Source: e-Business Surveys 2007 / 2009

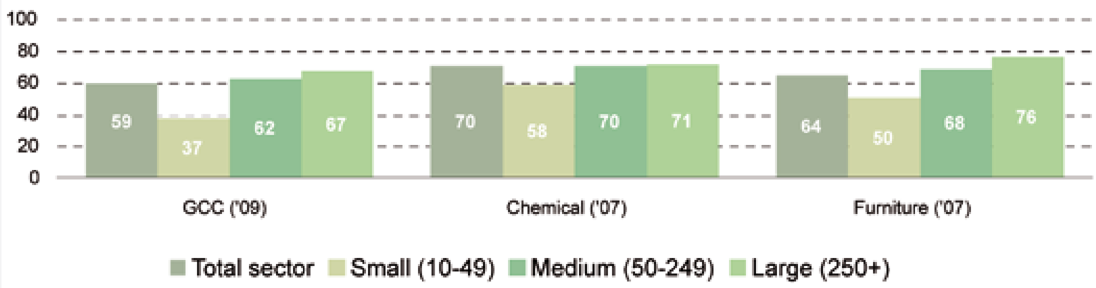
Supply-side e-business

Improving the efficiency of supply chain processes is an important objective for all manufacturing businesses. ICT can support this objective by facilitating data exchanges with suppliers and improving the transparency of procurement processes. In the GCC industries, companies representing about two-thirds of employment (in the six countries surveyed) said that they placed at least some **orders to suppliers online** (see Exhibit 2.2-5). Adoption among small companies, however, is below the levels of other sectors. Large companies also procure, on average, a higher share of their supplies online than smaller ones, and use more advanced systems for procurement. Direct supply goods which can be procured online include raw materials such as minerals and synthetic materials. In addition, online procurement is often used for "MRO goods" (maintenance, repair, and operating supplies). This category typically includes office supplies and other items which are not materials or components directly used for the products or services which a company produces. ICT equipment also falls into this category.

Companies use **different approaches** for connecting with their suppliers. Electronic data exchange via EDI is still among the preferred methods. A quarter of all companies (by their share of employment) said that they had access to the extranet of a supplier. Setting up EDI connections is expensive, as these are point-to-point connections with repeated costs for every installation. EDI is therefore mainly used by larger companies. More than 40% buy supplies by directly ordering them from the websites of suppliers. This is the simplest method of online ordering as there are no technical requirements other than internet access. More advanced methods include the use of specific ICT systems to coordinate the purchasing activities of different units, and e-procurement by conducting online auctions among selected suppliers. The case studies provide examples of such practices. The case study on Lafarge in Poland provides an example of an advanced e-procurement scheme, including the use of reverse auctions (see Section 2.2.6).

One of the most advanced business models of integrating with suppliers is **Vendor Managed Inventory** (VMI). In this model, the buyer of a product constantly informs the supplier of that product about inventory levels. This is normally done online by granting the supplier access to specific data in the buyer's ICT systems. The supplier, in return, takes full responsibility for maintaining an agreed inventory of this product. Thus, it is a means of optimising the supply chain. The buyer does not have to actively order replenishments from the supplier – the inventory is "automatically" replenished so that the agreed stock of products is always available. ICT systems are important in this close cooperation between buyers and suppliers. In the GCC industries, companies representing 14% of the sector (by their share of employment) said that they shared information about inventory levels electronically with suppliers and 5% said they had VMI arrangements.

EXHIBIT 2.2-5: % OF COMPANIES PLACING ORDERS FOR SUPPLIES ONLINE



Base (100%): all companies (N = 676). Data for the sector totals are weighted by employment (companies representing x% of employment), data for size-bands are in % of enterprises.

Source: e-Business Surveys 2007 / 2009

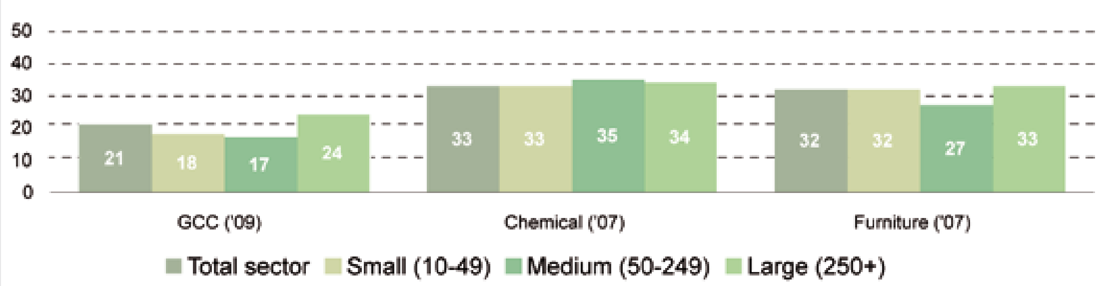
e-Marketing and sales

ICT, and in particular the internet, can be used in many ways to support marketing activities, including communication with customers, offering products for sale, and developing new marketing strategies. Several former e-Business Watch studies on manufacturing industries, notably the studies on the paper (2005) and chemical (2003, 2008) industries, concluded that these application areas would gain in importance in comparison to the cost-cutting perspective. However, e-commerce with customers is not widespread in the GCC industries, although web-based marketing would present opportunities in particular for the smaller companies, notably those in B2C sectors. Only about 20% of all companies active in the GCC industries made it possible for customers to order their products online in 2009 (see Exhibit 2.2-6). For these companies, online sales account on average for about 15-20% of total sales.

EDI is still one of the main channels for B2B data exchanges with business customers (see Exhibit 2.2-7). About 20% of the companies interviewed (by share of employment) said that they maintained an **extranet** for their customers. An extranet is a kind of website, or part a website, where the access is restricted to customers or suppliers. The functionalities typically include a well-structured overview of the status of all orders a customer has placed and their supply fulfilment. In addition, companies can provide additional information to their business partners on the extranet, such as product-specific information or the terms of business. Extranets are often operated by larger companies as a service for their SME customers, recognising that these SMEs do not have their own advanced systems for data exchange and managing orders. Maintaining an extranet for customers does not necessarily imply that these can also place orders online via the extranet.

Only about one in seven companies of the GCC industries let customers order products or services online on their **website** (see Exhibit 2.2-7). The low adoption rate is somewhat counter-intuitive, because setting up an e-shop on a website has become quite simple. It does not require major investments in technology, nor does it necessarily have significant organisational implications (depending on the degree of intended back-end integration of the e-shop).

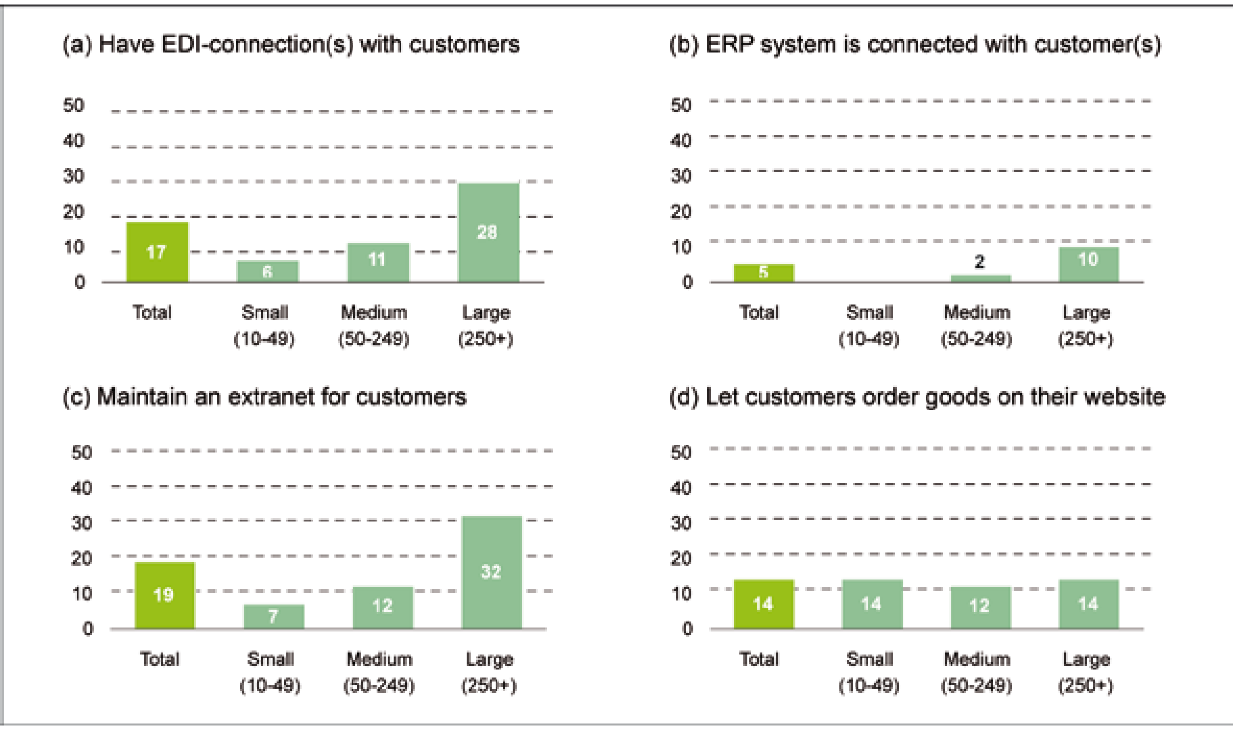
EXHIBIT 2.2-6: % OF COMPANIES PERMITTING CUSTOMERS TO ORDER GOODS OR SERVICES ONLINE



Base (100%): all companies (N = 676). Data for the sector totals are weighted by employment (companies representing x% of employment), data for size-bands are in % of enterprises.

Source: e-Business Surveys 2007 / 2009

EXHIBIT 2.2-7: DIFFERENT CHANNELS / PLATFORMS USED FOR E-COMMERCE WITH CUSTOMERS



Base (100%): all companies (N = 676). Sector total weighted by employment (companies representing x% of employment), figures for size-bands in % of companies. Source: e-Business Survey 2009

Many of the small, traditional companies, typically those in labour-intensive segments of the sector, believe that ICT (other than e-mail) does not present a business opportunity for them, neither for improving the products nor for providing a better service to customers. The dilemma is that they are caught in a vicious circle: the enormous business challenges and pressure in their daily routines do not give them the time to consider the issue and become knowledgeable about ICT – this, in turn, leaves ICT-based opportunities unexploited, and the pressure increases further.

Web 2.0 as a means for marketing

An emerging trend in ICT use for marketing and customer service is the exploitation of applications that are based on Web 2.0 models. The term describes a concept of using web technology for information sharing and collaboration among communities. In particular, it relates to web-based tools such as social-networking sites, wikis and blogs. The business model of many Web 2.0 applications is based on the principle that the content is mostly contributed by the users themselves (i.e. by the community), while the service providers establish and maintain the technical platform and make sure that the site is not abused. How far companies in the GCC sectors can exploit this concept for their own marketing purposes is difficult to answer at this point, considering that many companies currently use no e-marketing tools at all (see above). The Sectoral e-Business Watch asked companies whether they considered Web 2.0 as relevant for their own business. While only few companies regard Web 2.0 already as "highly relevant", more than 30% (in total) said that it was at least "partly relevant". Among large companies, more than 40% anticipate that Web 2.0 could play a role for them in the future.

2.2.5 ENABLING FUNCTIONS: ICT AND INNOVATION

Capability for innovation is critical for EU companies

The growing diffusion of ICT in all areas of business is commonly seen as a major enabler of organisational change and of the development of new products or services - in short, the diffusion of ICT enables innovation. The capability for innovation is considered very important by European companies in the GCC industries in order to face global competition and to keep their position in higher market segments which rely on differentiation and quality.[3] This study explored to what extent ICT enables innovation activities in the GCC industries. For example, ICT can facilitate product innovation in the technical ceramics industry, leading to the

[3] cf. ECORYS SCS Group (2008). Competitiveness of the Glass Sector / Competitiveness of the Ceramics Sector. Studies within the Framework Contract of Sectoral Competitiveness Studies (ENTR/06/054) on behalf of the European Commission, DG Enterprise and Industry. Final reports, October 2008.

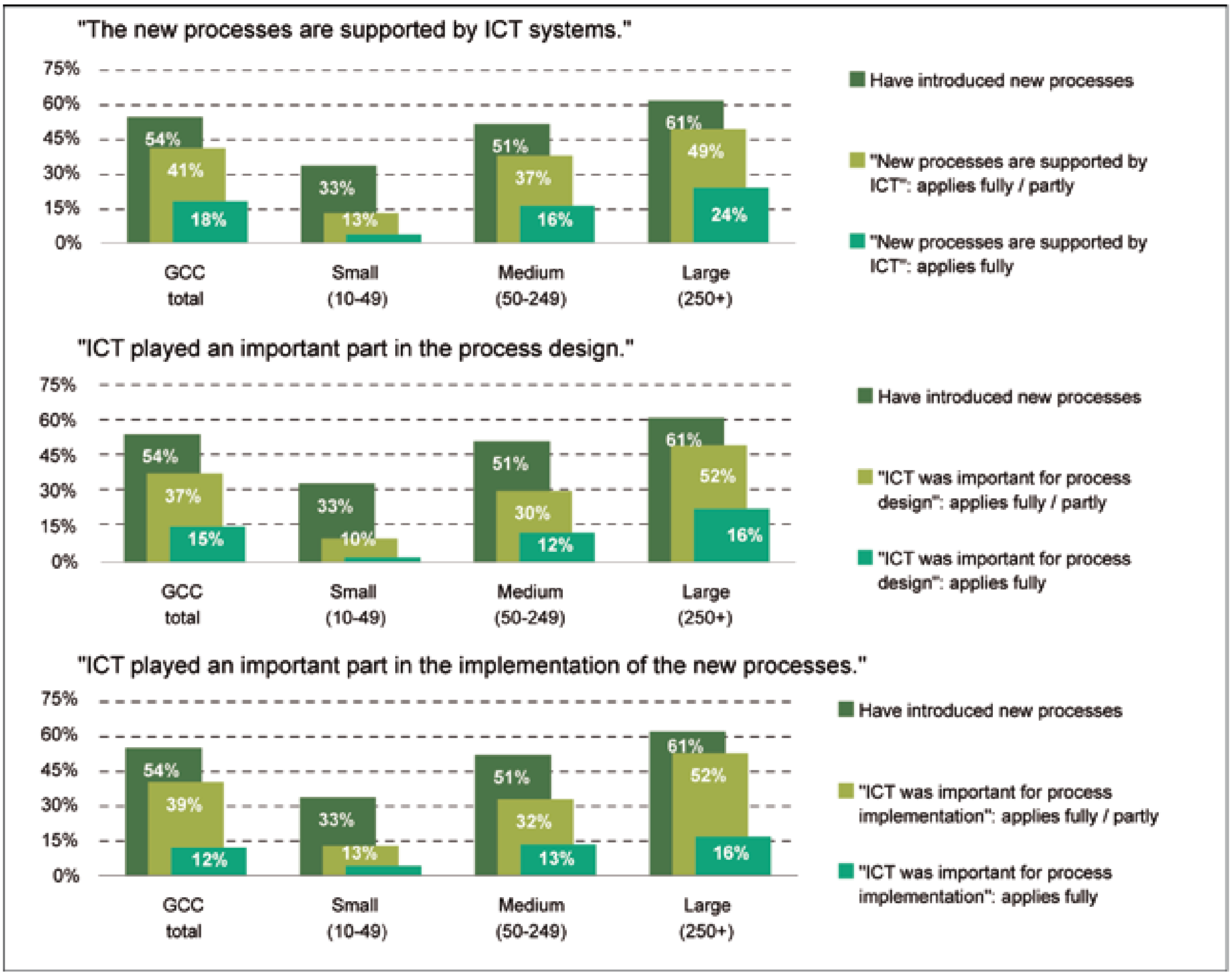
development of new materials. These new materials may in turn enable innovation in the medical equipment industry. Process innovation, on the other hand, has led to significant improvements in furnace output and efficiency in the glass industry, with a significant impact on the amount of energy required to melt a tonne of glass.

Process innovation needs ICT

Results broadly confirm the picture found in earlier years for most manufacturing industries. According to innovating companies, the majority of process innovations, at least for larger companies in the industry, are linked in one way or another to ICT usage. For product innovation, ICT matters as well, but to a lesser extent. In the survey, companies representing more than half the sector's employment said that they had introduced new or significantly improved internal processes in 2008/09 (i.e. in the past 12 months prior to the interview). These companies were asked about the role of ICT in the innovation process (see Exhibit 2.2-8).

- Among medium-sized and large process innovators, about 75% said that the new processes they had introduced were at least partly supported by ICT. About a third of them said this would fully apply. In small companies, new business processes are to a lesser extent directly enabled by ICT.
- Similarly, about 70% of the innovators say that ICT played – at least to some extent – a role in the process design. In this respect, company size matters even more.
- The same picture emerges for the implementation of the new processes: among medium-sized and, particularly, among large enterprises: a significant share of innovators say that ICT played an important or at least some part in the implementation.

EXHIBIT 2.2-8: THE ROLE OF ICT FOR PROCESS INNOVATION IN THE GCC INDUSTRIES



Source: e-Business Survey 2009

2.2.6 E-BUSINESS CASE STUDIES

The five detailed case studies presented in the study provide practical examples of e-business activity in companies, the enabling role of ICT, and the strategic implications of this activity for these companies. They document the diversity of activities and requirements in the sectors covered by the study, including global companies with highly automated production processes, and small niche-players in labour-intensive sectors.

Schott AG (glass industry, Germany)

Schott AG is a multinational technology-based manufacturer of glass and glass products for various industries. In 2003, the company implemented a new e-sourcing solution based on **electronic Request-For-Quotations** (e-RFQs) to support their worldwide sourcing of strategic goods and materials. The case study shows that e-sourcing in a large multinational company goes far beyond the implementation of electronic tendering tools. Schott also uses the solution to support collaboration between procurement, business and technical departments from the very beginning of the sourcing process, i.e. when the specification process starts. In 2008, Schott carried out about 1,700 electronic RFQs. Almost 900 internal users, more than 60 external engineering services as well as more than 4,200 suppliers and almost 2,000 additional document suppliers have used the platform.

The use of the e-sourcing platform has significantly improved the results of global procurement activities. Improvements were achieved on many levels, including:

- **Transparency**: there is one database now with up-to-date information that can be accessed in real time by all stakeholders.
- **Competition on price and quality**: the use of electronic RFQs facilitates the comparison of market offers in terms of both monetary and qualitative aspects. Total Cost of Ownership (TCO) considerations[4] have become a far more important factor in competition between suppliers.
- **Quality**: the use of templates with predefined text parts, position and question structures, allows for the enforcement of company-wide standards.
- **Faster processing**: the entire sourcing process can be accelerated. Simple RFQs, that used to be processed over several days or even weeks in the conventional way, can now be sent out almost immediately.
- **Transparency and comfort for suppliers**: the IT solution also provides a better orientation for suppliers.

The company emphasises that the success of e-RFQs depends both on technical and organisational issues. From the technical point of view, the usability of the system (both for internal and external stakeholders) is a critical success factor. From the organisational point of view, there are several issues that need to be considered. For example, company-wide procurement standards (minimum requirements in terms of quality, security etc.) are essential. Moreover, ensuring high quality of content and defining measures of quality improvements are necessary requirements.

BA Vidro, SA (glass industry, Portugal)

Since 1999, BA Vidro SA, a Portuguese manufacturer of glass flasks and bottles, has been using an **enterprise resource planning** (ERP) system to support its business both at the operational level and in decision making, and since 2002 a shop floor control (SFC) system to effectively manage the production floor. The case shows how the ERP system has been continuously adapted in line with business changes and new needs. The ERP system has proven beneficial to all major functional units of the company and is thus a truly horizontal system for company-wide information management. The main benefits experienced in different functional areas of the company are:

- **Sales**: increased effectiveness and efficiency in the management of orders and in product development, with positive impacts on customer loyalty.
- **Production planning**: reduced stock-outs through optimised consumption forecasts and production capacity planning.
- **Production**: a more systematic production set and detailed monitoring of the manufacturing process enabled the company to improve the quality assurance in production processes.
- **Procurement**: improved scheduling of raw materials purchasing and delivery, with positive impacts on purchasing conditions and stock levels.
- **Management**: managers are supported in predicting deviations and can act in time to avoid problems.

The main benefit of the SFC System was the standardisation of concepts for all the company's factories, in line with international standards. This avoids misunderstandings over different indicators that have the same name and

[4] A financial estimate that determines direct as well as indirect costs of a product or system.

allows BA Vidro to carry out benchmarking with companies all over the world.

Gmundner Keramik (ceramics industry, Austria)

Gmundner Keramik is a manufacturer of handmade ceramic tables and ornamental ware in Austria. For decades, the company used to produce for stock. However, as it was impossible to anticipate the demand for specific designs and items, this procedure proved inefficient. This case study shows how a technologically simple, self-programmed **production planning system** (based on a widely-used standard database software) has enabled the company to move from on-stock to order-based production, with a huge positive impact on process efficiency and reduced demand for storage capacity:

- **Stock reductions**: although overall production has increased, the warehouse today is only about a quarter of the size compared to the warehouse needed when the company still used to produce on stock.
- **Improved process efficiency – reduced lead times**: the introduction of systematic production planning and management has improved the transparency and flow of information between departments. Today, the company has a more accurate understanding of its own processes. This enables it to calculate and plan workflows more precisely and has led to reduced lead times.
- **Improved business intelligence**: in addition to its fundamental role in planning short-term and medium-term production, the PPS system is also a relevant source of information for general operational and strategic planning in the company.

The case demonstrates that ICT-enabled innovation in SMEs does not necessarily require major investments in hardware or software. In this case, a self-programmed ICT solution based on a standard software programme (essentially a production planning and management system based on a MS Access database) was sufficient to enable organisational innovation with a major business impact. Thus, the case study also points towards a caveat in the macro-economic analysis of ICT impacts: the importance of ICT for organisational innovation may not always be fully reflected by the amount of ICT capital stock a company uses.

The case also confirms that ICT can be a crucial tool in enabling process innovation. ICT was definitely not the "driver" of innovation itself (the source of innovation in this case was clearly "process-need"[5]), but without ICT - both the SAP and the PPS system - the company would not have been able to plan and manage production processes in this way.

Holcim Slovensko (cement industry, Slovakia)

Holcim Slovensko is a leading supplier of building materials and services in Slovakia, producing cement, ready-mixed concrete and aggregates. The company has placed great emphasis in the past 10 years on continuously improving the effectiveness and efficiency of its business processes. Procurement processes were identified as particularly relevant in this context. In 2005, Holcim Slovensko decided to introduce **e-auctioning** (including reverse auctions) in order to improve transparency in purchasing negotiations, and thus to achieve cost savings in the procurement of goods and services. The company selected PROe.biz, an application used on a "software-as-a-service" (SaaS) licence with the service provider.

As of 2009, Holcim Slovensko procures about 15% of its total purchasing volume through online auctions, using this solution. The company is very satisfied with the outcomes. Soon after its implementation, the internet-based reverse auctions were already having significant positive effects on procurement costs and on process efficiency. According to an analysis of auction projects conducted in 2006, the average cost saving was about 13%, with a maximum of 54% in one case. It improved the transparency of purchasing processes in general, led to more objectivity in the specification of prices, saved costs, and reduced negotiation times.

Holcim Slovensko warns, however, that simply implementing an e-auction may not be successful without having in place precisely-defined sourcing processes. The integration of the tool into these processes must be carefully prepared and takes time. Tests should be conducted. Furthermore, suppliers will actively engage in a reverse auction only if the value of purchases is high enough to make it of interest to them. The process costs of the auction usually have to be several times lower than the savings to be achieved. The profitability depends on the product, material or service, and the length of the contract.

Lafarge Cement S.A. (cement industry, Poland)

The Lafarge Group is one of the world's largest cement producers, with about 77,000 employees in 75 countries. The group has been present in Poland since 1995, initially as

[5] cf. Drucker, Peter (1985). Innovation and Entrepreneurship. New York: HarperCollins Publishers.

a shareholder in previously state-owned plants. Today, after consolidating all the plants it owned into one company, Lafarge ranks among the main cement manufacturers in the country, with a 20% market share. This case study describes how ICT and e-business have enabled the modernisation of the production line and the improvement of operating processes in the company. Full **ERP & CRM** suites were implemented to support virtually all business processes. A high degree of customisation has assured a full compatibility with company needs. More specifically, advanced ICT systems (ERP, CRM) have brought the following benefits:

- **Savings realised on maintenance costs.** The implementation of the plant maintenance module of the ERP system has led to significant savings and helped ensure continued production with minimal disruptions due to breakdowns on the production line. Inventory carrying costs have also been reduced.
- **Improved control and purchasing** of raw materials by online updating of inventory levels inflow and outflow. As the cost of raw materials is a significant factor in this sector, accurate planning is very important for appropriate production levels. The staff in the production and purchasing departments can follow the level of materials used on a daily basis and, with simple steps, produce accurate purchasing orders when needed.
- **Increased profitability** through a more accurate and efficient pricing model. Especially in times of lower demand, it is critical to price products accurately. The ICT system enables calculations based on real production cost data and sets the criteria accordingly.
- **Improved ability to track and control processes** in real time as they flow, resulting for example in accelerated times for order processing and invoicing. Rapid order processing and faster response times lead to increased customer satisfaction.
- **Improved communication with customers**, for example regarding the status of orders and availability of products.

2.2.7 THE MACRO-ECONOMIC IMPACT OF ICT IN THE SECTOR

Methodological basis

In 2007/08, the Sectoral e-Business Watch conducted a study on the "economic impact and drivers of ICT adoption and diffusion" in six industries[6] (2008), based on econometric modelling of industry statistics, using a standard growth accounting framework[7] and correlation analysis[8]. At the industry level, only modest impacts were found. In particular, the study found only weak links between the use of ICT and value added growth or change in labour productivity and employment. The econometric models that were developed and piloted in that study (with slight adaptations) were now applied again to assess the economic implications of ICT adoption (for industry growth and labour productivity) in the GCC industries. Results were compared with those obtained for the whole manufacturing industry.

The analysis is based largely on data from the EU KLEMS data base as provided by the Groning Growth Development Centre (GGDC). The EU KLEMS Growth and Productivity Accounts are the result of a research project, financed by the European Commission, to analyse productivity in the European Union at the industry level.

This summary leaves space for only the main results to be presented, and even then, in a highly condensed manner. Readers with a specific interest in this economic analysis are referred to Section 5 ("Macro-perspective: the economic impact of ICT") of the full study report where the statistical data of the econometric analysis are presented in detail.

ICT capital and industry growth

Using a standard growth accounting approach, the study analysed the contributions of the following input factors to gross value added growth: ICT capital, non-ICT capital, total working hours and the composition of the labour force by different skill levels, and total factor productivity (TFP)[9].

As in all sectors, real fixed **ICT capital stock** has surged in the GCC industries since 1991 in nearly all countries analysed for this study. The average annual growth rate (CAGR) from 1995-2005 was 12.8% across the seven EU countries analysed. ICT capital was found to contribute positively to value-added growth in the GCC sector as well as in the total manufacturing industry, but the contribution was low for both industry aggregates, typically accounting for 0.1-0.5 percentage points of annual growth. There are pronounced differences between the countries and the periods analysed. The contribution of non-ICT capital to industry growth is comparable to that of ICT capital. It is mostly positive, but does not account for a major percentage of growth in most countries, even if it is somewhat more significant than the contribution of ICT capital.

[6] The following sectors were analysed: chemical, rubber and plastics; steel; furniture; retail; banking; transport and logistics services. The study is available at http://www.ebusiness-watch.org/studies/special_topics/2007/impact_and_drivers.htm.

[7] Growth accounting is a standard technique to identify the contributions of different factor inputs to overall output growth. The methodology assumes a specific functional relationship between an output variable (e.g. value added) and all necessary inputs, typically labour and capital and intermediate inputs.

[8] Correlation analysis is a common method to measure the strength and direction of a linear relationship between two variables. Coefficients can take values between -1 and 1. The higher the absolute value of the coefficient is, the more interdependent the variables are. A negative value indicates a reciprocal relationship.

[9] TFP is the residual after all other input factors have been statistically accounted for. It includes a host of effects such as improvements in allocative and technical efficiency.

Total factor productivity (TFP) accounts for a relatively high share of growth in the GCC sector in most of the countries analysed (see Exhibit 2.2-9). This finding is quite specific for capital intensive manufacturing industries such as the GCC or the chemical industry, in particular in comparison to service sectors. It indicates the importance of non-tangible "assets" (that cannot statistically be accounted for), such as organisational innovation. Furthermore, it shows that the determinants for economic growth depend to a large extent on the general business context and situation of the industry in question in a given country.

The results can also be linked to those of the European Competitiveness Report 2008, published by the European Commission, which conducted a similar growth accounting exercise for the industry as a whole. This analysis also revealed that "TFP seems to be the main source of the difference in value-added growth between the US and the EU for most industries, especially manufacturing."

It should also be considered that the physical infrastructure accounted for as "ICT capital" may not always match the far-reaching implications of actual ICT usage in the company. What matters is the actual e-business activity, not the stock of ICT capital itself.

ICT and labour productivity

The second part of the analysis focused on the links between ICT capital stock developments and labour productivity in the period 1991-2005. In fact, changes in **ICT capital** showed a strongly positive correlation with labour productivity growth in the manufacturing industry and even more so in the GCC sector. The correlation with the number of hours worked was negative (at a less significant level). This indicates that growth in ICT capital stock tends to go hand-in-hand with a reduction in the number of working hours, while labour productivity increases. It does not imply a simplistic, direct causality, though. Other variables could also influence the development of ICT capital stock, labour productivity and/or the number of hours worked. For example, growth of the ICT capital stock might simply be a result of output growth due to higher demand.

To put this evidence to a test, not only the fixed ICT capital stock, but also the annual investments in new ICT capital, have been analysed in terms of their correlation with changes in labour productivity and hours worked. In contrast to (accumulated) ICT capital stock, **annual ICT investments** were not correlated with labour productivity growth and hours worked. This could imply a time lag between the point of investment in ICT and the actual return on investment in terms of productivity growth.

EXHIBIT 2.2-9: CONTRIBUTION OF DIFFERENT INPUT FACTORS TO VALUE ADDED GROWTH IN THE GCC INDUSTRIES, 1981-2005[10]

	ICT capital	Non-ICT capital	Total hours worked	Labour compos.	TFP
Denmark	+	o	- - -	+	o
Germany	o	+	- - -	+	+++
Spain	+	++	-	+	+++
France	+	+	- - -	+	+++
Italy	o	++	- -	o	++
The Netherlands	+	+	o	+	o
Austria	o	+	- -	+	++
Finland	+	+	- -	+	+++
United Kingdom	+	+	- - -	o	+++

+ / - means a positive / negative contribution of 0.2-0.5 percentage points of value-added growth
++ / -- means a positive / negative contribution of 0.6-1.0 percentage points
+++ / --- means a positive / negative contribution of more than 1.0 percentage points

[10] The "GCC industries" are here defined as NACE Rev. 1.1 Division 26.

2.2.8 CONCLUSIONS AND STRATEGIC RESPONSES

General conclusions

The empirical findings of this study do not allow any simplistic recommendations whether and to what extent there is a need for ICT-related policy initiatives specifically for the sector analysed. There is mixed evidence. Some of the findings do not support specific policy attention to ICT. An econometric analysis of the aggregate impact of ICT did not find convincing evidence for substantial productivity or growth effects of ICT capital in this sector. The empirical evidence was not fully conclusive; for instance, while ICT capital was highly correlated with labour productivity growth, investments in ICT were not. Growth accounting found that Total Factor Productivity (TFP), the residual that cannot be statistically explained ("accounted for") by the other input factors, accounts for a relatively high share of growth in the GCC sector. This indicates that the amount of technology in itself (measured in terms of capital stock) is not the key success factor; accompanying factors such as organisational know-how may be key. Case studies in this report tend to confirm this perspective.

Furthermore, the GCC industries are confronted with urgent and highly complex challenges that are not directly related to ICT, such as the rising costs of raw materials and energy, compliance with new environmental regulations, and increasing global competition. These challenges pose, by all measures, more direct concerns for companies and industrial policy than the use of ICT, even if ICT and e-business may play a certain role in these contexts.

On the other hand, the case studies and the representative company survey conducted for this study show that ICT and e-business are widely used even in this traditional sector, and play an important role in many companies, particularly in the larger ones. Many large companies, and in particular the global players in the sector, make intensive use of advanced ICT systems to integrate their business processes, for procurement and supply chain management. This was to be expected, and is not different from the activity of large companies in other manufacturing industries. Their business activity is characterised by a high degree of automation in production processes and the digitisation of data exchanges and information flows within the company and – increasingly – in their exchanges with suppliers and customers (at least in exchanges with other large companies).

A specific finding for the GCC industry, however, is the low level of ICT adoption and use among small companies. The "digital divide" between the large players and the small companies is even more pronounced than in most other manufacturing sectors. Many small companies do not use any ICT systems other than e-mail. One of the reasons is that the characteristics of production can be fundamentally different to those of larger companies. Many SMEs, in particular in the glass and ceramics industry, are highly labour-intensive, as they are selling hand-made products. Thus, in sharp contrast to the automated production schemes of, for example, flat glass producers, ICT has only a limited role (if any) to support production in these labour-intensive companies. ICT could nevertheless provide assistance in planning their production processes (see case study on Gmundner Keramik), but only few companies make use of it. All in all, the approach to ICT exhibited by the sector's small companies seems to be too passive and defensive. Non-adoption may be a rational decision in many individual cases, but collective reluctance to go digital could be harmful for the industry as a whole in terms of international competitiveness.

In summary, from a European perspective, the rising importance of ICT and e-business for the competitiveness of companies and, ultimately, industries, should not be ignored. ICT infrastructure and e-business can be seen as important "factor conditions" in an increasingly knowledge-based economy to achieve competitive advantage[11]. There are two main objectives that should be addressed:

- **to accelerate ICT-enabled innovation processes** by appropriate measures such as R&D activity, measures to improve the skills base, and awareness raising. This will be important in order to sustain and enhance the competitive advantages of European GCC companies.
- **to promote ICT and e-business for SMEs**, by addressing adoption barriers such as the widespread lack of understanding of the benefits ICT can offer.

Against these general considerations, the study findings suggest four priority areas for measures to support the competitiveness of the European GCC industries through ICT and e-business. Specific measures within each priority area are addressed to policy and / or industry. All suggestions should be considered as part of a general industrial policy in which innovation plays a central role. Any specific measures to create a favourable framework for ICT adoption should ideally be embedded in a larger innovation policy framework.

[11] cf. Porter, Michael E. (1990): The Competitive Advantage of Nations. New York: The Free Press.

EXHIBIT 2.2-10: STRATEGIC RESPONSES TO FOSTER THE COMPETITIVENESS OF THE GCC INDUSTRIES IN THE EU

Domain	Strategic response	Addressees
Skills	**Improving e-business skills of SMEs** (sector specific) Measures aimed at narrowing the pronounced "digital divide" in the sector by supporting the development of e-skills in SMEs; possibly with a specific focus on marketing, sales and customer service.	1. Competence centres, regional development agencies 2. Industry 3. Member States / regions
Standards	**Promoting agreements on standards and architectures for e-business within sectoral value chains** (sector specific) Consider sectoral initiatives to facilitate data exchanges within the sector and with its main supplier and customer industries, e.g. by agreeing on e-business standards.	1. Industry 2. Member States & EC as facilitators
Regulatory	**Continue improving the framework conditions for e-business by removing legal uncertainties** (horizontal) The EC and Member States should continue their efforts to improve the framework conditions for e-business in Europe, in particular by harmonising the legal framework. Initiatives in the field of e-invoicing are a good example.	1. EC 2. Member States
Regulatory	**Use ICT to facilitate compliance with environmental regulation** (horizontal) Explore opportunities to make it easier for companies to comply with legal requirements (e.g. ETS, REACH) by using ICT.	1. EC 2. Member States

Strategic response 1: improving e-business skills of SMEs

Several sector studies conducted by the Sectoral e-Business Watch in recent years discussed the implications of the "digital divide" between large and small companies in e-business practices, notably when it comes to advanced forms of data exchange.[12] This hampers the network effect of e-business and reduces the potential of productivity gains on the aggregate (industry) level. The digital divide in the GCC industries is even more significant than in other manufacturing sectors. Many small companies do not use any ICT systems other than e-mail, and the use of e-commerce (both with suppliers and with customers) is much lower than in other manufacturing sectors.

It is acknowledged that it may be perfectly rational in economic terms for individual companies not to make investments in ICT and e-business.[13] Companies base their decision on anticipated returns from the investment in relation to the costs. The challenge for many small firms, however, is to take an informed decision. Interviews with managers of small firms from the sector show that they often just do not have the time and opportunity to consider ICT-related issues. As a result, they do not have a proper understanding of how ICT could be useful for their company. This implies a risk that the ICT approach exhibited by the small companies of this sector is too passive and defensive, simply due to a lack of e-skills. If so, the decision not to invest in ICT may be short-sighted. The opportunity cost of non-investment may be higher than that of investment in ICT, even considering the daunting challenges SMEs are confronted with due to currently constrained economic conditions.

Against this background, sector-specific actions to improve the e-business skills of SMEs could be considered. Possible measures include awareness-raising and targeted provision of information about ICT solutions for SMEs. This suggestion

[12] Examples are the studies on the pulp and paper industry (2006) and on the chemical, rubber and plastics industry (2007). In both sectors, large companies are advanced ICT users, while many of the small companies are rather late adopters with little ICT use.

[13] For a more detailed discussion of rational choices for / against investments in ICT from a game theory perspective, see the Sectoral e-Business Watch study "An economic assessment of ICT-related industrial policy" by empirica and DIW econ (2009).

addresses in particular industry associations, SME support organisations, knowledge-transfer centres and regional development agencies. Currently, the promotion of ICT and e-business to their members is not on the agenda of most industry associations of the GCC sectors. They might consider adding this topic to their portfolio.

Strategic response 2: promoting agreements on standards for e-business within sectoral value chains

Sectors and companies that are faster in climbing the e-maturity ladder towards more advanced forms of electronic data exchanges have a competitive advantage. The study shows that e-business with suppliers and customers is not as widespread in the GCC industries as in other sectors. Apart from structural conditions, one of the reasons for the delayed adoption of e-commerce could be that the industry itself has not taken any coordinated initiatives to facilitate e-business, in contrast to several other manufacturing sectors, such as the chemical, paper and steel industries.

In general, the broad agreement on widely used standards among companies should be in the interests of the industry as a whole. In an expert survey conducted for the Sectoral e-Business Watch study on ICT-related industrial policy,[14] 82% of the respondents agreed that there is a "lack of widely used e-business standards that impedes e-business communication". There was also almost unanimous agreement that electronic data exchange, in particular between large companies and SMEs, needs to be improved. These findings certainly apply to the GCC industries. Experts also supported the view that the EC and Member States should foster regional or sectoral electronic networks of ICT-using companies. A recent study by the e-BSN (2007) about sectoral e-business policies (2007) concluded that "initiatives with a sectoral focus are not successful per se", but "can certainly be recommended".[15]

Based on these considerations, the industry could consider initiatives either to promote the use of existing e-business standards among companies, or to copy initiatives which other sectors have taken to facilitate e-business (see examples above).

Strategic response 3: improving the framework conditions for e-business by removing legal uncertainty

A specific business process which is well suited to be digitised is invoicing. The migration to structured electronic invoicing has been on the agenda of European institutions and a number of Member States for some years and is receiving increasing policy encouragement. In business, large enterprises have taken the lead and are eager to adopt e-invoicing. Sector studies by e-Business Watch confirm the fast adoption over the past few years. In the GCC industries, 35-40% of the companies said that they sent and/or received electronic invoices in 2009. On average, these companies estimated that they sent about 18% and received about 14% of their invoices as e-invoices.

However, there are still complex issues to be solved in order to exploit the full potential of e-invoicing. For all the evidence that e-invoicing is already an accepted and rapidly growing practice, there are still barriers to wider adoption, especially by smaller businesses and when it comes to cross-border e-invoicing. This includes technical, business and legal barriers. A central issue of debate in recent years used to be legal uncertainties for companies, as it still not entirely clear which e-invoicing practices would comply with legal requirements for invoices in respect of VAT regulation. Companies stressed that there was a strong need for harmonisation of the legal frameworks in the European Union.

The European Commission responded to this challenge early. It set up an informal Task Force in 2006/07 and implemented an Expert Group on e-Invoicing in early 2008 to make suggestions on how the framework conditions could be improved. The Expert Group submitted in November 2009 its final report,[16] which proposes a European Electronic Invoicing Framework (EEIF). The report specifies an ambitious vision for e-invoicing in Europe, including the objective that within five to eight years, structured e-invoicing should become "the predominant invoicing method throughout Europe", and that the legal and tax environment for the conduct of e-invoicing will have been harmonised across all Member States by then. It makes six recommendations on how to realise these (and other) objectives.

This study confirms the relevance of the work of the Expert Group. It strongly recommends following their recommendations. Efforts to improve the framework conditions for electronic data exchanges in the single market should be continued, in particular by harmonising and clarifying the legal and VAT framework across the EU.

[14] "An economic assessment of ICT-related industrial policy" (2009), study by empirica and DIW econ, see http://www.ebusiness-watch.org.
[15] European Commission (2007): Sectoral e-Business Policies in Support of SMEs. A study by empirica, Databank and Idate.
[16] DG Enterprise and Industry: Final Report of the Expert Group on e-Invoicing (Nov. 2009), see http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=5544&userservice_id=1 (accessed in November 2009).

Strategic response 4: use ICT to facilitate compliance with environmental regulation

Compliance with environmental legislation is a challenge for many companies in the GCC industries and has significant implications for their competitiveness. The Competitiveness Studies on the glass industry (ECORYS SCS Group, 2008a) conclude in their SWOT analysis (in the threats section) that "environmental regulation is a major cost-component in most sub-sectors" and that "the main challenge is that non-EU producers, especially from developing countries, have significantly less strict environmental legislation" (p. 138).

While these issues are not directly ICT-related, ICT systems can at least facilitate compliance with regulations, as they help companies monitor and report their energy consumption and greenhouse gas emission levels. However, such Energy Management Systems (EMS) are not yet widely used. Only about a fifth of the companies in the sector (by their share of employment) said they used an ICT-enabled EMS. On the other hand, about half the companies believe that EMS offer high or at least medium potential for improving energy efficiency. It is therefore recommended to promote and possibly support the adoption of ICT systems for energy and emissions management, in order to facilitate EU companies' compliance with environmental regulation. The goal should be to maximise the potential of ICT to make compliance with these regulations as efficient as possible – in the interests of both companies and regulatory authorities.

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This study was conducted by **empirica GmbH** (http://www.empirica.com), a research and consulting company in Bonn focusing on information society developments. Contributions were received from **DIW econ** (macro-analysis of ICT impacts) and case study correspondents. The study manager and main author is Hannes Selhofer, Senior Consultant at empirica. The full study report can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

2.3 The potential of Intelligent Transport Systems for reducing road transport related greenhouse gas emissions

A study by SE Consult. Authors: Jian Bani, Vicente Lopez and Paloma Dapena

Road transport and logistics related emissions are responsible for a significant share of environmental pollution and greenhouse gas emissions in the European Union and worldwide. This study explores the potential of Intelligent Transport Systems (ITS) for reducing these emissions. It is based on an extensive literature review and an illustrative case study.

ITS show significant potential – but more data are needed

Although ITS applications are rarely designed for environmental purposes, the literature suggests these systems could help reduce road transport emissions. Nearly all the studies reviewed revealed some positive effect of ITS technologies on emission reductions and air quality. However, few quantitative data are currently available on the subject. The study suggests examining the matter further through focussed research efforts – e.g. in the context of FP7.

Combining ITS and Ambient Intelligence is the key to success

To unlock the emission-reducing potential of ITS in road transport, Ambient Intelligence(AI) related technologies (such as ubiquitous computing and sensor network systems) may need to be combined with the existing infrastructure and deployment of ITS technologies.

Need for a common framework architecture

To date, no common framework architecture exists for road transport ITS. Maximising the impact of ITS on reducing emissions from road transport will to a large extent depend on how well different systems can operate with each other. A diverse range of ITS have been deployed throughout road transportation networks. They have often developed piecemeal with each system tailored for its application-specific purpose. The study recommends that EU policy should help create a common ITS framework architecture and establish interoperability guidelines by prioritising relevant research projects. It is further suggested that EU policy should enhance wireless interoperability guidelines and a new wireless communication protocol standard based on mesh-networks.

2.3.1 INTRODUCTION

Background and objectives

Emissions related to transport and logistics are responsible for a significant share of environmental pollution and greenhouse gas (GHG) emissions in the European Union and indeed the world today. A description of the environmental context reveals the magnitude of the threat presented by GHG emissions. However, reducing transport- and logistics-related GHG emissions is challenging, as measures must also be assessed in terms of their adverse effects on economic growth.

The 2006 review of the European Commission's 2001 White Paper on Transport Policy "Keep Europe Moving" highlighted the contribution that Intelligent Transport Systems can make to meet these challenges. It recognised the role ITS can play in delivering safe, efficient, sustainable and seamless transport of goods and people. The ITS Action Plan to this end estimates that optimising logistics using ITS could result in a 16% reduction in transport emissions and a 27% reduction in storage emissions globally. The ITS Action Plan further estimates that ITS-driven applications across logistics could achieve a reduction in total global emissions of 1.52 GtCO2.

Although the available literature lacks a comprehensive assessment of the impact of Intelligent Transport Systems (ITS) on GHG emissions (most studies on ITS focus on their potential to increase utilisation of infrastructure, improve transport and cargo management or improve customer service), its further development presents a strategic tool that could have significant potential in terms reducing environmental pollution and GHG emissions.

Against the outlined background, this study provides a first comprehensive qualitative analysis of the potential that ITS bear in terms of reducing road transport related GHG emissions, in particular focussing on freight management systems ("smart logistics"), travel demand or demand management systems ("smart mobility") and on the synergistic relationships between ITS and Ambient Intelligence technologies and their potential for monitoring and control of GGH emissions in road transport. Used properly, ITS applications could lead to cleaner transport and more efficient use of energy. In terms of scope the study is limited to road transport. ITS-related technologies that have been analysed in this framework are also linked to the concepts of pervasive or ubiquitous computing and ambient intelligence or smart environments, which involve integrating microelectronic processors and sensors into everyday objects in order to make them "smart". The objective is also to analyse how a ubiquitous system that is pervasively and unobtrusively embedded in the environment could help reduce GHG emissions.

Current evaluation methods tend to undervalue mobility management strategies that change travellers' behaviour to increase transport system efficiency and overestimate the overall benefits of technological innovation solutions. One objective of this study is therefore to clarify the potential of ITS in road transport on GHG through a combination of strong technological innovation (for fleet and freight management) and behavioural change (for mobility and demand management). The study describes the direct and indirect potential of each ITS-related technology covered and draws conclusions for policy implications.

Specifically the study contributes to the following:

- Clarifying the potential that strong technological innovation (for fleet and freight management) combined with behavioural change (for mobility and demand management) can have on GHG.
- Providing an overview of the link between Intelligent Transport Systems and Ambient Intelligence and its potential role in climate change solutions.
- Assessing to what extent mobility management is presently undervalued as an approach to reducing GHG and how mobility management could be valued more.
- Formulating recommendations for future EU policies and actions regarding GHG reductions from road transport.

Study methodology

In terms of information, the study is principally based on online research. It considers elaborated scenarios, short scenarios, research publications and project goals. These sources were chosen as they present novel ideas and interesting functionalities of ITS and Ambient Intelligence that could be expanded in the future. The study further includes one case study (original research) in e-Business Watch format.

The study analyses ITS in the context of a series of other ongoing initiatives. These initiatives include the 2001 IST Advisory Group (ISTAG) Scenarios for Ambient Intelligence in 2010, the 2008 Action Plan for the Deployment of Intelligent Transport Systems in Europe, the 2007 Green

Paper on Urban Mobility (Towards a new culture for urban mobility), New Green Transport Package, the 2007 Action Plan on Freight Transport Logistics, the 2008 Action Plan for the Urban Transport, Galileo deployment, the Internalisation of external costs proposal of 2008, the i2010 initiative on Intelligent Cars, eSafety, the 7th Framework Programme for Research and Technological Development, 2009 Green Paper TEN-T Policy Review, European Technology Platform for the Road Transport Research ERTRAC (European Road Transport Research Advisory Council) and the European Intermodal Research Advisory Council (EIRAC).

2.3.2 INTELLIGENT TRANSPORT SYSTEMS AND AMBIENT INTELLIGENCE

Intelligent Transport Systems (ITS)

A wide range of ITS-related technologies have been developed in the last decade to bring the advantages of information and communications technology to transport infrastructure and vehicles. These ITS technologies aim to manage imperatives that are typically at odds with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times, and fuel consumption. As mentioned before, this study will not deal with all ITS technologies and makes no attempt to establish the relative importance of the technologies it covers.

The study restricts itself to innovative ITS-related and Ambient Intelligence related technologies. Innovative use of ITS technologies will make it possible to address a wide range of environmental objectives, including emission reductions, better air quality and a better understanding of the role that ITS can play in the smart environment. Several different technology trends may be extrapolated and combined into a single scenario to analyse the bundled effects that these technologies could induce in GHG emissions. Among these technologies, the study addresses:

- Smart embedded systems (pervasive or ubiquitous computing and ubiquitous communication)
- Wireless Sensor Networks
- Smart products (monitoring critical product parameters)
- Smart labels or RFID tags and their application to pervasive computing
- Hybrid and electric cars that make use of intelligent control systems for operation and energy storage

Ambient Intelligence

Some of the innovative ITS-related technologies covered in this study are examples of Ambient Intelligence. Ambient Intelligence is seen as the next step in the development of automated systems and is liable to offer unprecedented opportunities in the transportation sector. The study gives an overview of the existing link between Intelligent Transport Systems and Ambient Intelligence in order to understand the impact it may have on ITS-related technologies and how it will affect the role ITS can play in climate change solutions.

The challenges faced by Ambient Intelligence in terms of detecting the relevant quantities, monitoring and collecting data, assessing and evaluating information, formulating meaningful user displays, and performing decision-making and alarm functions, remain daunting. The study will describe these challenges and identify promising ways of tackling them.

The Information Society Technologies Advisory Group (ISTAG) has defined four main trajectories for the next generation of ICT:[1]

- Networked, mobile, seamless and scalable, offering the capability to be always best connected any time, anywhere and to anything;
- Embedded into everyday appliances in a way that is either invisible to the user or brings new form-fitting solutions;
- Intelligent and personalised, and therefore more centred on the user and the user's needs;
- Rich in content and experiences and in visual and multimodal interaction.

These four main trajectories are all aspects of what Ambient Intelligence can offer. Wireless systems are moving from the domain of mobile telephony to a wide range of every-day appliances in response to a demand for ubiquitous access to information. This trend opens up a new range of uses for sensors such as RFID tags and smartdust, performing long-term experiments like real-time environmental pollution monitoring, correlating microclimates with population health, or tracking the spread of biochemical agents. These developments have also been analysed in the present study.

In line with the key trajectories for the next generation of ICT, the study analysed the repercussion of this ambient intelligence vision and the associated technology

[1] Report from the Information Society Technologies Advisory Group (ISTAG) (2006) Shaping Europe's Future Through ICT: ftp://ftp.cordis.europa.eu/pub/ist/docs/istag-shaping-europe-future-ict-march-2006-en.pdf

developments (in connection with ITS-related technologies) and their impact on GHG reductions.

2.3.3 LITERATURE BASED EVIDENCE

(1) A review of existing ITS related literature confirms that ITS has significant potential to contribute to reducing road transport-related GHG emissions. The growth of electronics, computing and communications technologies has, in recent years, facilitated new applications of ITS technologies in the road transport sector. Nearly all the studies reviewed reveal some positive effect of ITS technologies on GHG reductions and air quality. The firsthand case study (Deutsche Post DHL, Germany) presented in the study as well as the parallel Sectoral e-Business Watch Study "ICT impact on greenhouse gas emissions in energy-intensive industries" by DIW econ agree with this finding.

(2) Most studies on ITS focus on its potential and/or impact on fields with no connection to the environment, such as road safety, traffic management, intelligent vehicles. There are insufficient studies on GHG emissions. While many cases studies acknowledge that ITS may also have an important environmental impact, none analyse its potential impact in depth.

(3) The combined application of Ambient Intelligence related technologies such as ubiquitous computing and sensor network systems with the existing infrastructure and deployment of ITS technologies may unlock the potential of ITS in terms of reducing road transport related GHG emissions. On the one hand ITS technologies increase the level of intelligence in the infrastructure, on the other hand Ambient Intelligence increases the sensing, processing and communications capabilities of both vehicles and travellers.

The concept of Ambient Intelligence is to embed processors and sensors into everyday appliances, enabling the appliances to access information, react to their environment and interact with other smart devices, offering a new range of functionalities. Technological innovation will lead to greater integration of so called smartdust and RFID sensors with other technologies such as sensor network technologies. Ambient Intelligence has long remained an enticing vision. In the near future, the decreasing cost and size of smart objects (such as microprocessors and advanced sensors) and the rapid development of wireless technologies could turn the application of Ambient Intelligence to transport – including to road transport – into reality.

Ultimately, the combined application of ITS and Ambient Intelligence technologies is likely to lead to new paradigms in how transport networks are managed, controlled and operated. For the transport sector –in particular for transport managers and policy makers– it is likely to have an enabling role in terms of decision making as it will provide transport related data of unprecedented quality and accuracy. These data will prove valuable for informing policy and real time management decisions including in areas related to reducing road transport-related GHG emissions.

(4) To date, no common framework architecture for ITS systems exists. The impact of ITS on GHG emissions will to a large extent depend on how well different systems can interact with each other. A diverse range of ITS have been deployed throughout transportation networks. They have often developed piecemeal with each system tailored for its application specific purpose. Consequently public transport management authorities may find themselves with an extensive series of non-interoperable ITS systems with incompatible data sets and storage techniques. Demand for a European Framework Architecture derives from the need to harmonise ITS systems throughout Europe. There is significant ongoing work in the area of ITS architectures. The Keystone Architecture Required for European Networks (KAREN)[2] project is of particular interest to European ITS developers. Integrating individual intelligent transportation systems into comprehensive platforms is a key challenge faced by transport authorities in the provision of optimal services to users.

(5) Cleaner cars (electric and hybrid vehicles) are set to become an important part of the global transport system. ITS-related technologies will allow these new vehicles to provide data to road infrastructure managers that will prove valuable for efficient traffic management. The development of standardised functionalities related to an in-vehicle platform and its interoperability and interconnection with the infrastructure require functional characteristics that have to be defined. The functional design of existing applications and services also has to be taken into consideration in electric and hybrid vehicles. Standards are an essential feature of the market landscape and will be important as Europe fosters the development of these new vehicles.
(6) e-Freight is an ICT based ITS tool for a paper-free, electronic exchange of freight transport-related documentation. It is

[2] The first version of the European ITS Framework Architecture defines the underlying vision as being "the minimum stable framework necessary for the deployment of working and workable ITS within the European Union until 2010".

regarded as a promising technology in the effort to reduce GHG emissions from road transport. However, e-freight presently remains a policy and research vision. The policy aspect is implicit in the Freight Transport Logistics Action Plan which presents a number of short- to medium-term actions that will help Europe address its current and future challenges and ensure freight transport system remains competitive and sustainable. In terms of research, FP7 sub-call "FPT-SST-2008-TREN-1 (SST.2008.2.1.5 Co-modal IT Transport solutions)" calls for the development of a roadmap for the implementation of e-freight, building on work to develop the "Internet of things" and identifying the problem areas where EU action such as standardisation is required. However, it does not call for analysing the qualitative or quantitative impact of e-freight on GHG emissions.

2.3.4 CASE STUDY EVIDENCE

A case study was conducted on "GoGreen" at Deutsche Post DHL, a company which uses ITS as a means of measuring, understanding, and ultimately cutting their GHG emissions. The results can be summarised as follows:

(1) The company uses several (and is considering using more) ITS technologies which have a direct or indirect effect on reducing its freight transport related GHG emissions.

(2) The case study confirms that ITS shows significant potential in terms of reducing GHG emissions from road transport. Despite still being in its pilot phase, the SmartTruck project has proved particularly promising in this respect. Following its success, an expansion of the project is planned. Over time, it is expected to spread to other German and European cities and even worldwide.

2.3.5 POLICY IMPLICATIONS

One of the great challenges policy makers are facing at the beginning of the 21st century is to reconcile the different priorities between economic development and environmental sustainability, whilst at the same time recognising the different social priorities and the distributional consequences of decisions. Transport offers a good example of the complexity of these choices. The real value added is reflected in making the actual transport systems and the complementary communications networks compatible. This can only be achieved through common organisational and operating systems and through high quality monitoring and information systems.

The policy recommendations resulting from this study are designed to complement the ITS Action Plan, the European Commission initiative aiming at launching and supporting the use of ITS in the field of transport. The Action Plan is supported by 5 Directorates that cooperate closely: Directorate General Energy and Transport, Information Society and Media, Research, Enterprise and Industry and Environment.

The main policy implications arising from this study are:

ITS has significant potential to reduce road transport related GHG emissions – targeted research is needed

The present study confirms that ITS bears significant potential to contribute to reducing road transport related GHG emissions. However, there is to date a shortage of targeted research on the relationship between GHG emissions and ITS. While the present study offers a good starting point, the impact of road transport on GHG emissions makes further research in this field highly recommendable (if not imperative). It is recommended targeted research efforts be dedicated –e.g. in the context of FP7– to further exploring the quantitative impact of ITS on GHG emissions and to prioritise further ITS R&D investments accordingly.

Combining Ambient Intelligence and ITS is key

The combined application of Ambient Intelligence related technologies and ITS technologies may unlock the full potential of ITS in terms of reducing transport related GHG emissions. With a view to this, EU policy should prioritise collaborative research efforts in the context of FP7 that focus on the combined application of Ambient Intelligence and ITS technologies. Within these efforts, it appears recommendable to dedicate specific attention to the smartdust concept as its application to the field of transport has only been recently investigated and initial results appear promising.

Focus on interoperability of systems

Interoperability of ITS systems presents a key to maximising the potential of ITS in road transport, including its potential on reducing GHG emissions. EU policy should enhance the creation of a common ITS framework architecture and interoperability guidelines by prioritising relevant research in European collaborative research projects under FP7 and other relevant technological research initiatives. An ITS architecture encourages structured development and integration of ITS systems that in turn minimise redundancies and maximise the capabilities of ITS. A study carried out at Trinity College Dublin,1 in Ireland, provides a good example of such a solution. It presents a distributed framework for a multi-layered ITS architecture that has been designed for integrating information generated and used by future as well as existing intelligent transportation systems and applications.

Enhancing wireless interoperability guidelines

The importance of wireless communication technologies for ITS and Ambient Intelligence related technologies is fundamental. Future vehicles will use wireless technologies to remain in continuous communication with the surrounding infrastructure. New sensors and ways of managing these networks are emerging. The development of standardised functionalities related to an in-vehicle platform and its interoperability and interconnection with the infrastructure require functional characteristics that have to be defined. With a view to this, EU policy should enhance wireless interoperability guidelines and a new wireless communication protocol standard based on mesh-networks.

Conducting research on e-freight potential

e-Freight is an ICT based tool developed within the scope of the ITS Action Plan that aims to enhance paper-free, electronic exchange of freight transport-related documentation. The technology shows considerable potential for reducing GHG emissions from road transport. However, e-freight remains a policy and research vision in its initial stages of development. Further targeted research is required to clarify its exact potential.

Consider indirect support measures for electric and hybrid cars

Electric and hybrid cars will become an integrated part of the global transport system, providing road infrastructure managers with data needed for more efficient traffic management. In parallel, the functional specifications for infrastructure-to-infrastructure, vehicle-to-infrastructure and vehicle-to-vehicle communication for these new kinds of vehicles have yet to be defined. Functional specifications, that is, the documentation describing what is needed by the system user as well as requested properties of inputs and outputs (e.g. of the software system), are technical matters that require the support of policymakers. The political environment will influence how far and fast the use of these new vehicles is extended. There is a need for indirect policy support to foster their development.

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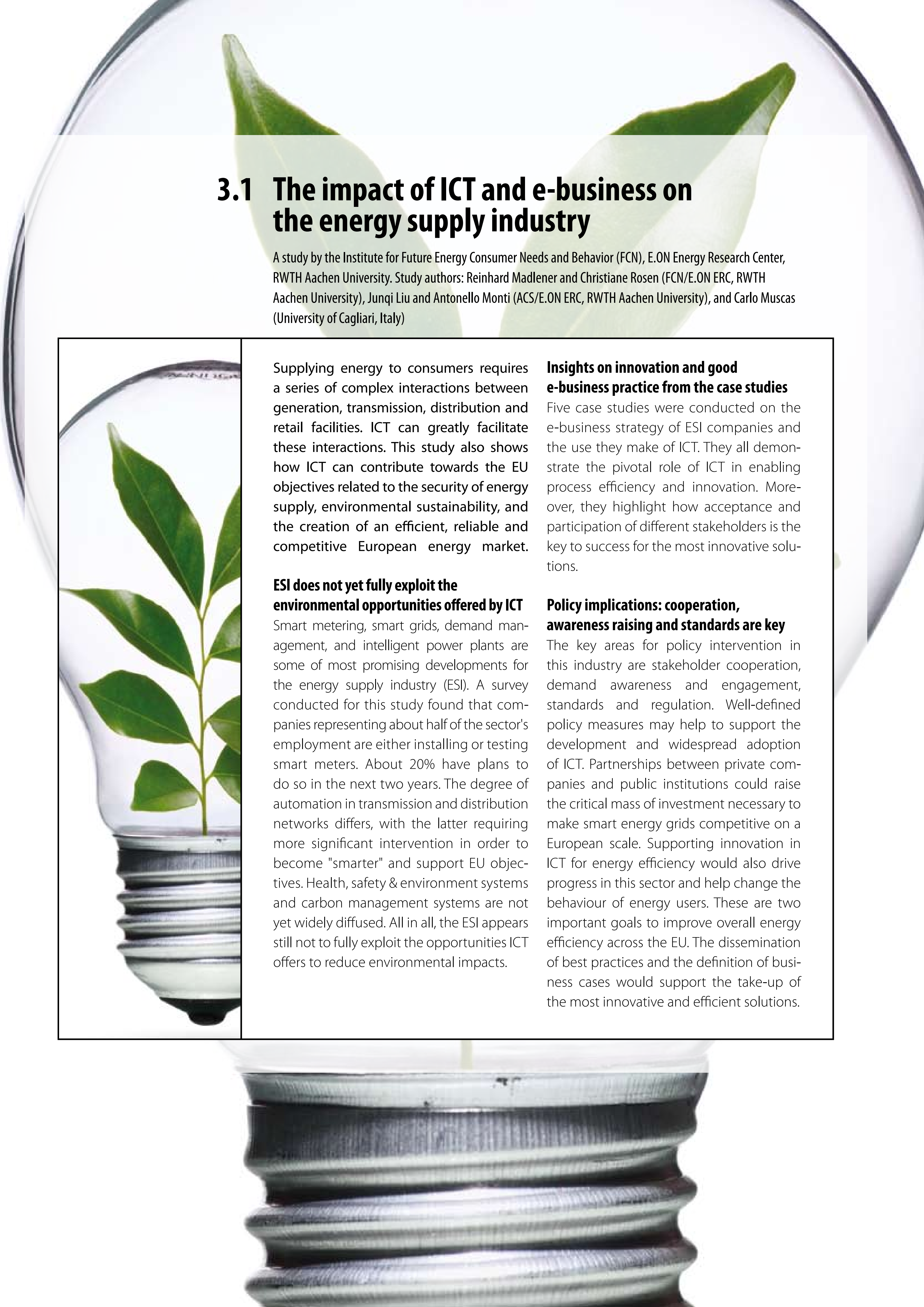
Sector studies: ICT in the energy supply sector

3.1 ICT and e-business in the energy supply industry

3.2 Metering and measurement facilities as enabling technologies for smart electricity grids in Europe



3.1 The impact of ICT and e-business on the energy supply industry

A study by the Institute for Future Energy Consumer Needs and Behavior (FCN), E.ON Energy Research Center, RWTH Aachen University. Study authors: Reinhard Madlener and Christiane Rosen (FCN/E.ON ERC, RWTH Aachen University), Junqi Liu and Antonello Monti (ACS/E.ON ERC, RWTH Aachen University), and Carlo Muscas (University of Cagliari, Italy)

Supplying energy to consumers requires a series of complex interactions between generation, transmission, distribution and retail facilities. ICT can greatly facilitate these interactions. This study also shows how ICT can contribute towards the EU objectives related to the security of energy supply, environmental sustainability, and the creation of an efficient, reliable and competitive European energy market.

ESI does not yet fully exploit the environmental opportunities offered by ICT

Smart metering, smart grids, demand management, and intelligent power plants are some of most promising developments for the energy supply industry (ESI). A survey conducted for this study found that companies representing about half of the sector's employment are either installing or testing smart meters. About 20% have plans to do so in the next two years. The degree of automation in transmission and distribution networks differs, with the latter requiring more significant intervention in order to become "smarter" and support EU objectives. Health, safety & environment systems and carbon management systems are not yet widely diffused. All in all, the ESI appears still not to fully exploit the opportunities ICT offers to reduce environmental impacts.

Insights on innovation and good e-business practice from the case studies

Five case studies were conducted on the e-business strategy of ESI companies and the use they make of ICT. They all demonstrate the pivotal role of ICT in enabling process efficiency and innovation. Moreover, they highlight how acceptance and participation of different stakeholders is the key to success for the most innovative solutions.

Policy implications: cooperation, awareness raising and standards are key

The key areas for policy intervention in this industry are stakeholder cooperation, demand awareness and engagement, standards and regulation. Well-defined policy measures may help to support the development and widespread adoption of ICT. Partnerships between private companies and public institutions could raise the critical mass of investment necessary to make smart energy grids competitive on a European scale. Supporting innovation in ICT for energy efficiency would also drive progress in this sector and help change the behaviour of energy users. These are two important goals to improve overall energy efficiency across the EU. The dissemination of best practices and the definition of business cases would support the take-up of the most innovative and efficient solutions.

3.1.1 STUDY OBJECTIVES AND SCOPE

Objectives

This study focuses on the adoption and implications of ICT and e-business in the energy supply industry. It describes how companies in this industry use information and communications technology (ICT) for conducting business, assesses the impact of ICT for company performance in a context of competition, and points at possible implications for policy. The analysis is based on findings from a telephone survey among decision-makers in European energy enterprises, on five case studies, on an econometric analysis of the relationship between ICT investment and greenhouse gas emissions, on literature, and on interviews with industry representatives and experts in the field of energy supply.

In contrast to many recent studies in the field of ICT and energy, this study does not focus on a narrow selection of issues for energy specialists. Instead, it provides a bird's-eye view for a broader audience of decision-makers and experts in policy, business, industry associations, consultancy and academia. A key objective of this study is to provide concrete data and inputs to the stakeholders for discussing issues related to ICT and energy supply.

The energy supply industry (ESI) as defined for this study is included in NACE Rev. 2 Group, "electricity, gas, steam and air conditioning supply". Thus the study focuses on the value chain of the utility business, which includes:

- **production** of electricity and steam from any type of primary source – gas, coal, oil, wind, ocean and biomass as well as nuclear, hydro, solar and geothermal power – and any type of energy technology, including distributed generation;
- **transmission and distribution** (T&D) of energy, i.e. the physical delivery of electricity and steam from the generation plant to the users, and, in the case of gas, from extraction or storage fields and re-gasification terminals to the users;
- **trading**, i.e. the wholesale of energy both on physical and future markets (power or gas exchange operators are not covered by the study);
- **supply to final consumers**, which may be industrial, commercial, agricultural or residential.

3.1.2 RESULTS OF THE ENERGY SUPPLY SURVEY 2009

The Energy Supply Survey 2009 consisted of 351 telephone interviews with ICT decision-makers in the six largest EU countries (Germany, France, Italy, Poland, Spain, UK). Interviews were carried out in March 2009, using computer-aided telephone interview technology.

The survey explores to what extent companies in the ESI sector use ICT for managing their processes and the importance they attribute to e-business. Most significantly, it provides a detailed analysis of the most innovative and promising areas that will affect ESI evolution in the upcoming years. The analysed issues have been selected in coordination and agreement with DG Enterprise and Industry as particularly relevant and topical. Key findings are illustrated in the following sections.

ICT infrastructure

All interviewed companies are connected to the internet. Companies' internet access is very high across all sub-sectors and size bands, notably among SMEs (small and medium sized enterprises). The average share of employees with internet access at their workplace is approximately 85%. This can be seen as an indicator for the degree of automation of work, applied also to the field workforce.

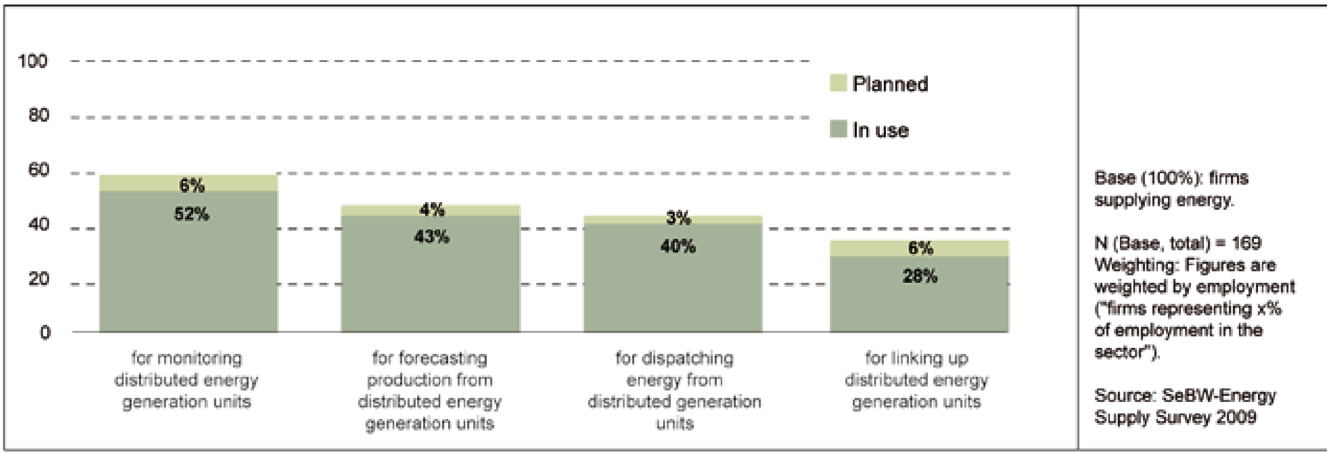
Enterprise solutions

Among solutions supporting enterprise business processes, **Enterprise Resource Planning** (ERP) is currently the most widely adopted within the energy supply industry. ERP allows companies to automate and optimise business processes and facilitate integration with other sector-specific systems. Companies representing 67% of employment have adopted an ERP. This percentage ranges from 79% in the energy sector to 45% in the heating/cooling sector. Standardising corporate processes through ERP technology can support companies, notably in terms of their customer relations, coping with regulation, and remaining competitive.

Supply Chain Management (SCM), which implies a high degree of integration along the supply chain, possibly with utility operations, has limited diffusion in the ESI, even among large companies, and is scarcely present in heating and cooling.

Companies representing 56% of employment use **Customer Relationship Management** (CRM). With a growing number

EXHIBIT 3.1-1: APPLICATION AREAS OF ICT SYSTEMS FOR MONITORING, FORECASTING AND DISPATCHING ENERGY FROM DISTRIBUTED GENERATION UNITS



of customers able to compare prices and service options from different suppliers on-line, and the emergence of independent websites reviewing suppliers, utilities have begun to make more intensive use of CRM systems. CRM appears to be more widely diffused than online data exchanges with customers. This may suggest that there is a lack of integration in the management of customer-related activities. It could also mean that outbound practices towards customers are more diffused than the collection of inputs and feedback.

Overall, companies in the energy supply industry make substantial use of ICT to support enterprise processes and specific core processes. The sector nevertheless has a long way to go in terms of integrating the technical and business applications of the ICT it has adopted.

ICT for distributed generation

The coordinated operation of several distributed small generation units acting in parallel as a single power plant is currently referred to as a Virtual Power Plant (VPP). ICT solutions for monitoring, forecasting and dispatching energy from such generation units are used by close to half of all enterprises (by their share of employment) – see Exhibit 3.1-1. These applications run at unit level and are necessary for managing the traditional distribution networks. The share of companies currently linking distributed generation units in order to manage them as VPPs is significantly lower (28%). Many companies generating energy through distributed units still run them as "islands" of activity rather than in an integrated manner. Leading-edge VPP initiatives have been implemented in the EU. However, it is not yet possible to perceive a standard architecture among them, nor has a consensus been reached on the costs and benefits of such implementation.

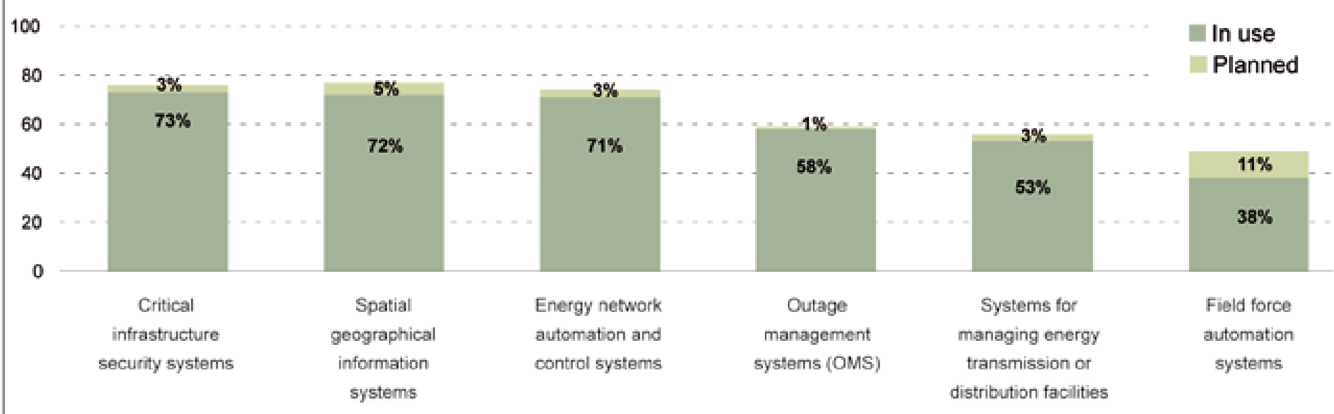
ICT for energy demand management

Renewable energy sources are important for reducing dependence on fossil fuels (much of which are imported), for reducing emissions and for decoupling energy costs from oil prices. The development of renewable electricity generation implies substantial technological and organisational challenges which call for changes along the entire ESI supply chain. ESI companies will require reliable forecast information on the quantity and availability of power output. Forecasting systems are therefore one of the primary requirements for wind and solar to penetrate the energy market further. Fully integrated renewable energy information systems will optimise the use of renewable generation resources. One in three companies in the ESI sector already have a renewable energy information system in place and 83% (employment weighted) foresee ICT will have a considerable impact on management of renewable energy generation in the future.

ICT for smart grids

Electricity networks are traditionally split into transmission networks and distribution networks. A transmission network usually consists of high- to very high-voltage power lines designed to transfer power from major generators to areas of demand. Only the largest customers are connected to the transmission network. Distribution networks are usually designed and operated to distribute power passively from the upstream generation and transmission system to the

EXHIBIT 3.1-2: ADOPTION OF ICT SYSTEMS SUPPORTING ENERGY TRANSMISSION AND DISTRIBUTION



Base (100%): Companies engaged in the distribution and retail of energy and heating and cooling in six EU countries (France, Germany, Italy, Poland, Spain, UK). N = 265. Figures are weighted by employment.
Reading example: "Companies representing 23% of employment in the energy sector were testing smart meters in 2009."

final customers. However, the way power is generated, transported and used is changing.

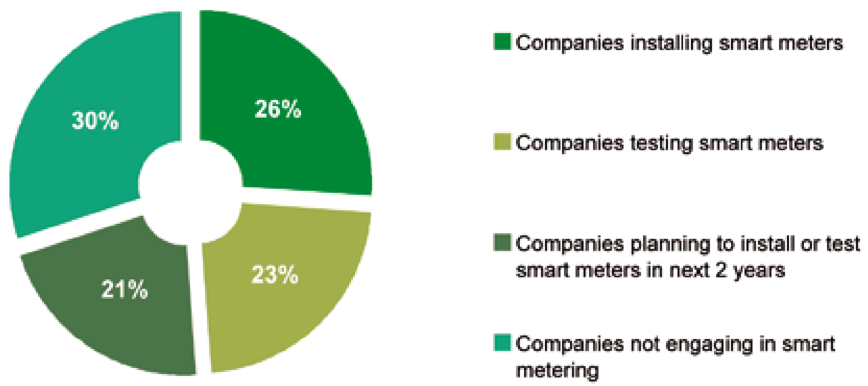
A challenge that electricity distribution networks in Europe are increasingly facing is the integration of numerous small-scale units generating renewable energy, such as photovoltaic solar energy. Integrating distributed generation into Europe's electricity networks will require newly designed distribution grids. The vision that has formed over recent years regarding the way networks will meet current challenges and fulfil policy mandates in electricity distribution is commonly referred to as "smart grids". A smart grid is seen as an upgrade of distribution and transmission grids that aims to optimise operation, include and efficiently exploit alternative energy production, and integrate generators, distributors and consumers, in order to efficiently deliver sustainable, economic and secure electricity supplies. Smart grids will rely on ICT, advanced metering and data management techniques to overcome challenges that are common both to transmission and distribution networks.

The survey analysed the pace at which European ESI companies are adopting ICT systems for energy transmission and distribution. Exhibit 3.1-2 shows the results. ESI companies are well equipped with systems supporting energy network automation and control. Companies representing over two thirds of employment already have these systems in place. The challenge of managing distributed assets is reflected by the widespread adoption (by companies representing 72% of employment) of geographic information systems (GIS). As security is an important issue in the sector, systems supporting critical infrastructure IT security are also largely adopted (by companies representing 73% of employment). Surprisingly, a significant number of companies say they are not relying on outage management systems, despite the fact that companies representing 58% of employment have adopted this technology.

The sector may benefit from applications for field-force automation. These applications allow companies to schedule, route and dispatch their field workforce for activities such as service restoration and routine maintenance. They can stream the flow of information, enable timely response and increase the level of service, ultimately improving customer satisfaction. Field-force automation has not, however, been exploited yet, as only companies representing 38% of employment have such systems in place and another 11% plan to adopt it in the near future. The adoption of smart grids is expected to benefit both operators and consumers. Their most notable advantages are expected in terms of:

- Energy efficiency and better, more reliable usage of existing grids through increased asset optimisation.
- Savings on the construction of new infrastructure, as power plants that are run optimally will run longer, allowing utilities to postpone - or avoid - investing in new generation capacity.
- Reducing demand. On the consumer side, smart grids may enable consumption monitoring, therefore allowing more energy efficiency. Moreover, they provide timely

EXHIBIT 3.1-3: SMART METERING IMPLEMENTATION STATUS



Base (100%): Companies engaged in the distribution and retail of energy and heating and cooling.
N (Base, total) = 265
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector").

information on energy pricing that allows consumers to optimise their consumption patterns.

- Facilitating the penetration of renewables. Smart grids can manage different sources of power more easily than traditional infrastructures, therefore allowing more distributed generation to be integrated. Moreover, smart grids encourage the owners of homes and other buildings to invest in micro-generation technologies.
- Increased understanding and predictability of the state of the power system, in such a way that operators can easily optimise their operations, manage peak demands and provide value-added services.

Smart metering

The evolution towards smart grids implies that the associated metering infrastructure must be likewise transformed in order to change consumers' behaviour and provide the data transparency needed to make the network work. Currently, the technology through which end-user efficiency can be encouraged is referred to as smart metering or Advanced Meter Management (AMM). Definitions of smart metering may differ slightly, but the main feature is that it should allow for two-way communication between the utility (supplier or DSO) and the meter.

Typically, in the context of residential or small-business distribution, smart meters measure the characteristics of electricity consumption and supply. Data are stored and access to these data is allowed for consumers and authorised third parties, according to the market model adopted. Embedded functionalities include the regular remote transfer of consumption and other metering data to the utility (thus also allowing accurate billing), as well as the remote control of connections, without requiring access to the premises.

Enabling automated delivery, processing, management and usage of metering data has significant ICT implications. Such functionalities mean that a smart metering system would include an electronic meter capable of data storage and communication, a communications network to a central data collection point, and high-capacity data storage and processing systems. Data then needs to be integrated in utility systems. These need not be limited to billing systems; they can include GIS, OMS, load forecasting/balancing, load research, distribution/facility design, and revenue assurance systems for theft, tamper and fraud detection. Beyond the meter, there may be a further system - a smart energy box - in the house (for instance, for controlling electric appliances, or micro-generation, when photovoltaic panels, for instance, are installed).

The SeBW Energy Supply Survey 2009 provides data about the implementation of smart metering in the ESI - see Exhibit 3.1-3. Companies representing about half the employment in the sector are either installing or testing smart meters and another fifth plan to do so in the next two years. These plans for investment represent the unique exception in the scenario for investments from the SeBW Energy Supply Survey 2009: no other application or technology enjoys the same attention.

About half of the ESI companies that do not currently implement smart metering nevertheless allow customers to provide meter readings online, including internet or other computer-mediated networks (excluding e-mails). Most of the companies that are engaged in the distribution of energy, wholesale energy trading, retail sale of energy, or heating and cooling supply have computerised meter data management solutions or plan to introduce them.

The SeBW Energy Supply Survey 2009 analysed the barriers to the implementation of smart metering in the EU – see Exhibit 3.1-4. For companies representing more than a third of employment, the barriers are related to the interoperability of the devices and systems. Companies representing 37% of employment indicate that implementation of smart meters was hampered by insufficient regulation of public entities.

Companies that have not and are not entering this business have cited several reasons for their decision. Interoperability of devices and integration with existing ICT emerged as the main deterrent. Concerns about return on investment (ROI) are also important, as they are expressed by firms representing more than half of the employment across the sector. An important issue in the roll-out of smart metering is the building of a business case. Migrating to smart metering requires an overhaul of existing systems, as well as investment in hardware, networking and software. Sharing the cost and benefits of smart grids among the players along the value chain is a central theme. If investors are unable to reap the full benefits of the roll-out (for instance if suppliers invest in smart meters and the customer then changes supplier), the deployment of smart metering projects will be limited. The barriers presently hampering the development of smart metering have to be overcome in order to fully exploit its potential for energy savings, process efficiency and new value-added services.

ICT for energy demand management

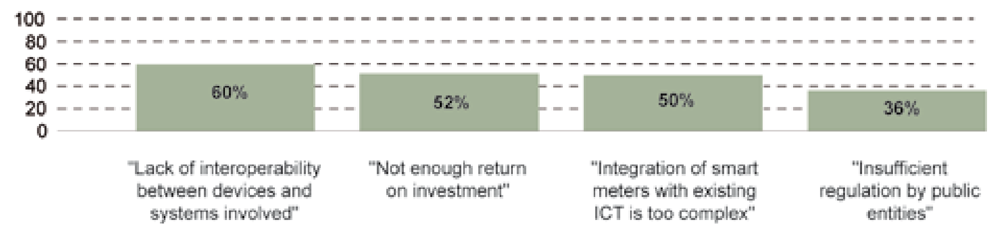
Demand-side management means managing the consumption of energy to optimise available and planned generation resources, with the ultimate goal of reducing energy consumption. Demand-side management can be achieved by, for instance, offering financial incentives to consumers, by educating them, or by giving them the means to continuously monitor and actively manage their domestic appliances. Related to demand-side management is demand response. Typically, demand response encourages consumers to use less energy during peak times or to shift consumption to off-peak times, such as night-time or weekends. The active participation of consumers is becoming increasingly important, with initiatives such as incentive pricing and new tariff schemes.

Once consumers have information on how energy prices vary over the day; and their energy consumption is time-specifically metered, they can adjust their consumption pattern accordingly. They can for example switch off certain energy-consuming devices at peak times. This may result in what is called "load balancing" and "peak shaving". Ultimately, demand response may allow suppliers to develop targeted contracts, tariffs and offers for consumers. Demand-side management and demand response, therefore, can help the European Union reach the goals it has set itself in terms of energy efficiency and, in turn, reduction of emissions.

To fully exploit the potential of demand-side management and real-time pricing, adequate ICT systems are necessary. ICT can facilitate the efficient use of energy by helping energy suppliers analyse consumption data and stimulate consumers' response to energy prices at specific times. On the supply side, companies can use ICT for purposes such as complex billing, remote meter reading and advanced metering infrastructure solutions. Their use could facilitate the collection and analysis of consumption data. Based on these analyses, energy suppliers could set their prices according to the time of day, or week, or even year. Time-

EXHIBIT 3.1-4: REASONS WHY COMPANIES NEITHER USE NOR PLAN TO USE SMART METERS

Base (100%): companies neither implementing nor testing nor planning smart meters N (Base, total) = 76
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).
Source: SeBW-Energy Supply Survey 2009



specific prices would reflect the true value of energy during bottlenecks in the system, and make energy cheaper during off-peak hours.

The SeBW Energy Supply Survey 2009 investigated how ESI companies communicate with their end users on matters of price changes, and encourage them to reduce or shift their consumption. Firms were asked if they adopted ICT solutions to support demand response programmes of this kind. The results showed that the spread of demand response programmes in the ESI has remained limited. This is not surprising, considering the organisation and technical implications involved in their implementation. Only companies representing just under a fifth of total employment acknowledge using ICT solutions in this field. It is however becoming more common for companies to set up real time communication channels with end users (via web portals, displays, or links with customers' programme).

ICT systems for Health, Safety & Environment and carbon management

The EU is heavily engaged in facilitating the transition towards a more climate-friendly energy sector. Its policy in this field is based on emission cuts and the related Emissions Trading System, energy efficiency, and mandatory quotas of energy from renewable sources. This transition is supported by a range of ICT solutions that respond to the changing regulatory, safety, and security requirements, while enhancing value chain visibility and ensuring continuity of operations.

The SeBW 2009 survey analysed the adoption of ICT systems that address environmental issues. These include systems for electronically managing health, safety and environment aspects (HS&E) and, more specifically, IT solutions for carbon management. HS&E systems that maximise compliance for electric utility industry facilities have been adopted by companies representing half the employment across the industry, which corresponds to only about a third of firms. It should be noted that only one out of two large companies has HS&E systems in place.

The diffusion of carbon management systems remains limited to companies representing a quarter of employment. Considering the pressing need to document carbon emissions and comply with recent regulation, it is striking how little this kind of ICT appears to have diffused across the ESI. The prevalence of small companies in the sample may partly explain the limited diffusion observed in terms of advanced ICT solution, but nor had either of the two large companies surveyed adopted these solutions on a large scale.

ICT for reducing greenhouse gas emissions

In April 2009, the European Council adopted the climate and energy legislative package that includes a revised Emissions Trading System (ETS) for greenhouse gases, in order to achieve greater emissions reductions in energy-intensive sectors. To stimulate the adoption of clean technologies, the new ETS provides that greenhouse gas (GHG) emissions permits will no longer be given to industry for free, but will be auctioned by Member States from 2013 onwards. The results from the SeBW Energy Supply Survey 2009 indicate that many companies are concerned about the impacts of the EU ETS. Nearly two thirds of ESI companies engaged in generation activities consider ETS to be very important. In general, medium and large companies are more aware of its implications than small ones.

One company out of four thinks that ICT has a high potential for reducing greenhouse gas emissions in the ESI. A similar proportion believes that ICT has medium potential, and just slightly fewer companies believe that ICT has little potential for the task. Most firms in the sector therefore believe that the use of ICT alone is not enough, and that accompanying tools and actions are necessary. Coherently with their views on the role of ICT, ESI companies representing only a quarter of employment - and irrespective of their size - have an ICT-enabled system to monitor greenhouse gas emissions. Nevertheless, companies representing 12% of employment have introduced a dedicated process for systematically monitoring greenhouse gas emissions.

Perceived importance of ICT and e-business in the ESI

An unexpected outcome of the survey is its depiction of ESI companies' views of the role and impacts of e-business. ESI firms largely recognise that ICT can provide a relevant contribution (for instance for reducing greenhouse gas emissions) and that its use will have an increasing impact on future energy management. However, the same companies indicate that at present most of their processes are only partly managed as e-business. According to the companies interviewed, the main constraint to the adoption of e-business is that partners along the value chain are not prepared for it. Cost, the second deterrent, lags far behind. Even larger players shy away from driving the adoption of

ICT technologies that are nevertheless commonly recognised as beneficial for the industry.

Automated data exchange with suppliers and customers

Supply chain integration by connecting ERP systems (or similar standard software packages) is generally considered the most efficient way of doing business, provided that partners use compatible systems. Electronic exchanges with business partners may however take simpler forms, as in the case of electronic exchanges of orders for goods and services. In the ESI, firms representing close to two thirds of employment order goods or services from their suppliers on the internet or via other computer-mediated networks. Considering that two thirds of all electronic exchanges use ERP, more automation of ordering might have been expected. The limited diffusion of this practice is confirmed by the fact that, for most companies, fewer than 10% of orders are carried via a network.

Firms representing one fifth of employment in the ESI said that they offer customers the possibility of concluding contracts on-line. Seven out of ten of these companies say these orders account for up to 15% of their total orders received. e-Commerce, even in this rather simple form, is not a common practice in this sector.

Outlook on ICT investments

The SeBW Energy Supply Survey 2009 asked about the plans for investments in ICT in general and in sector-specific devices and applications. The results are mixed. On the one hand, the plans of most firms were affected by the economic crisis, leading to reductions compared to 2009 budgets and the cancellation of many ICT projects. On the other hand, the majority of the companies interviewed believe their investment in ICT will increase in the near future, specifically in innovative applications such as smart handheld devices, electronic billing systems and the integration of IT systems. These plans may prove overly optimistic, and will depend to a large extent on how fast economic conditions improve.

ESI companies were asked about any changes that might have affected their ICT budget for 2009. Companies representing just over half the employment in ESI decreased their budgets in 2009, a fifth kept it at the same level as 2008, and just over a quarter increased it. Companies representing 42% of employment reported the economic crisis has had an impact on ICT investment plans, and half of these companies actually scaled down or cancelled ICT projects. Not surprisingly, the economic crisis has affected investments in ICT considerably.

ESI companies were also asked what they expected to happen to their investment in smart handheld devices in the two years to come. Similar questions were asked about electronic billing and investment for integrating monitoring and control systems with business systems. Smart handheld devices allow employees in the field to communicate directly with the company's information systems in an efficient and integrated way. Electronic billing is an important component of customer service and permits significant efficiency gains. Integrating monitoring and control systems with business systems may increase the overall efficiency of business processes.

Companies representing close to half the employment in the industry stated that they will increase their investments in smart handheld devices, electronic billing and integrating systems for monitoring and control with business systems. Some companies - ranging from one in ten for smart handheld devices to one in five for integrating systems - plan no investment, and the rest will continue to spend the same as in previous years.

Case studies

The following sections summarise case studies which were conducted for this study. They describe innovative examples of implementation of ICT in the ESI. The full case studies are included in the study report, available on the Sectoral e-Business Watch website (http://www.ebusiness-watch.org).

3.1.3 CASE STUDY: VIRTUAL POWER PLANT AT RWE, GERMANY

Background and objectives

RWE in Germany, one of Europe's five largest utilities, is collaborating with Siemens in Germany on the implementation of its first Virtual Power Plant (VPP). The project started in 2007 and aims to aggregate decentralised plants such as combined heat and power (CHP) plants together with biomass or wind-power plants to form a VPP controlled from a centralised management system. The generation capacity that RWE Energy is able to bring together is sold on the European Energy Exchange (EEX), and reserve capacity is sold through internet auctions. The current success of the project has given the partners the possibility to continue it by expanding its capacity from its current 10 MW capacity to 30-40 MW over the next two years.

e-Business activities

Siemens' Distributed Energy Management System (DEMS) is the central feature of the VPP, and it is combined with a Distributed Energy Resources (DER) controller. DEMS is a software solution that constitutes the 'brain' of the system, enabling demand-driven production planning, production optimisation, monitoring and control. The programme is fed with all relevant information, such as the latest electricity prices and customers' energy requirements. On the basis of this data, the software calculates a scheduling plan for the upcoming day and determines which plants are to be dispatched. The other component is the DER Controller, locally installed at the generation unit site, which allows bi-directional communication with DEMS. Its main function is to execute control commands. Communication plays a fundamental role in the success of VPP management. In order to fully integrate the generation units to the central control system and among themselves, each unit is tracked by General Packet Radio Services (GPRS). The GPRS signals feed relevant information into the DEMS.

Impacts

The conceptual model for VPP aggregation was developed in order to improve the economics for distributed energy resources integration.[1] DER integration leads to a more optimal use of distributed power facilities. It is also valuable as a "network replacement" and may deliver services (balancing services) to the distribution system. With this pilot project, RWE Energy is demonstrating the technical and economic viability of the VPP concept and the key enabling role of ICT in innovating in the ESI business.

Initial findings showed that it is more economical to integrate generation units with a capacity of a minimum of 500 kW. Below this threshold the cost of communications related to the hardware equipment (i.e. modem) to be installed and operational communication costs (to transmit data) are too high compared to revenues from the limited quantity of energy that can be sold on the market to produce a positive margin (the main goal of distributed generation units is to provide energy for their owner's consumption).

RWE (in particular its trading company) offers its services as an 'aggregator' allowing customers to take advantage of portfolio effects and to reach a size that is sufficient to enter energy markets or to obtain better selling conditions, and eventually to provide services to network operators. VPP also introduces an interesting change in the relationship between the customer and the energy supplier, with the former becoming a 'supplier of the supplier'[2].

Overall, the partnership between RWE and Siemens is accumulating results and experience for further project extensions. RWE Energy currently generates about 10 MW from its first VPP. The success so far of the pilot project has convinced the two partners to continue their research and extend the number of generation units involved, to bring its generation capacity up to 30-40 MW. The plants will continue to be customer plants, such as engine-based cogeneration plants, biomass and wind power plants. The project is also supporting scientific studies and an overall economic analysis which will provide information on the contribution VPP can make to reducing CO2 and to improving energy efficiency. Results can be expected in a year.

Lessons learned

From a technical perspective, the most important lesson from this case is the importance of a reliable communication system. The availability of 15-minute period data is a prerequisite to trade on the power exchange (EEX). If information on tradable capacity is not available, the VPP cannot operate. Communication costs (equipment investment and operating cost) are still the most significant economic barrier to the inclusion of VPP aggregation generation units with a capacity lower than 500 kW. Increased standards related to communication and deployment of smart meters (in the case of residential DER) could facilitate interoperability and foster DER integration at lower cost.

From an application perspective, the pilot made it possible to field-test Siemens DEMS software, which proved to be a robust application allowing effective energy management of the distributed generation units. Customer knowledge, acceptance and participation are critical aspects of running a VPP. Customers displayed great enthusiasm to join the RWE pilot with their generation units. The keys to success were clear communication and understanding of expectations and the creation of a transparent partnership.

[1] Integration of small numbers of DER is traditionally accomplished using simple on/off electronic controls or verbal requests to the DER owner. Even if most distribution networks exhibit margins in terms of voltage, flow and fault current allowing them to accept a proportion of distributed generation, this is not possible when DER scale up to thousands of units.
[2] Commonly referred as "prosumers".

3.1.4 CASE STUDY: THE EDISON PROJECT, DENMARK

Background and objectives

In February 2009, a consortium of energy companies, research institutes and private technology providers launched the "Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks" (EDISON) project in Denmark. EDISON aims to design a full-scale system for implementation of electric vehicles. The main objective is to prepare the electricity distribution network for the extensive adoption of electric vehicles fuelled by sustainable energy, mainly wind power, in Denmark. The vision is to support 400,000 electric vehicles by 2020. The aim is to design and test the infrastructure, covering both hardware and IT solutions, such as connection points for the vehicles, central charging stations for large car parks, fast charging stations, grid control strategies, and a marketplace for energy.

The interesting feature of electric vehicles (EVs) is that, thanks to their onboard battery capacity, they also provide energy storage. Increasing the number of electric vehicles will automatically increase the storage potential – particularly important in Denmark – to store wind power. The development of the smart grid infrastructure would also allow EV owners to sell the stored power back to the electrical power grid when the vehicle is not in use for transportation. In summary, EVs could power the electrical grid in times of high demand or, more likely, could function as reserves or other ancillary services, a concept commonly referred to as vehicle to grid (V2G).

e-Business activities

ICT will be crucial in turning the vision of EDISON into reality, and particular emphasis will be given to collection, communication and management of data on energy demand and supply. The main ICT enabler for the EDISON project will be IBM. The company will develop a smart recharging system that will collect data from the vehicles and from the supply side of the energy system. The system will process these data, balance them, and optimise the recharging of the vehicles – for instance recharge them when there is a lack of demand on the grid. The system will even have vehicle-to-grid functionality in the sense that excess capacity in the batteries of the individual cars can under certain circumstances be made available for other consumers in order to provide capacity or other ancillary services to the grid. The smart recharging systems will also include a metering and billing solution and a system to provide real-time pricing to users. IBM has also provided the servers hosting these applications.

The Edison project involves three steps for developing the IT solution: designing the IT solution; test lab validation; and island demonstration. The target of the EDISON project is full-scale implementation of EVs in the energy system of an entire country, and it is therefore an improvement upon previous and more limited EV projects launched in France, Sweden and, lately, in Germany and Italy. The project is market-based and the prospective implementation is supposed to be aligned with four separate business cases, related to consumers, car manufacturers, EV service companies, and the transmission system operator. The consortium is not linked to a single car manufacturer, as the aim of the project is to define open standards that any type of car can adopt, and then plug in.

Prospective impacts

The EDISON consortium is designed as a proof-of-concept initiative. It aims to demonstrate that EVs can in fact function on a large scale, both in terms of customer acceptance and in terms of the stability of the overall energy system.

The projected benefits of EDISON apply at the national level, grid level and user level.

- National level: Support environment-friendly development; optimise power production and consumption; promote energy independence.
- Grid level: Maintain security of supply; actively integrate distributed energy resources.
- User level: Provide an economic incentive to contribute to CO2 reduction.

The wide adoption of EVs will facilitate the achievement of the EU's 20-20-20 target (a 20% cut in emissions, 20% improvement in energy efficiency and 20% increase in renewables by 2020). In particular, a higher share of renewable resources and a reduction of CO2 emissions are targeted. The EDISON project is also meant to create a Denmark-based, global research environment to address future energy challenges.

Lessons to be learned

As the project is in its initial phase, it is still too early to derive specific lessons. The degree of innovation of such a project will require the development of new IT solutions as well as power and control electronics technologies. The main assumptions behind the project and the related prospective lessons to be learned include:

- Understanding the ICT functional requirements needed to support EVs on a full-scale rollout. This includes applications such as meter data management, billing, and the design of IT architecture.
- Testing the smart recharging system in a real environment.
- Creating a standardisation of communication protocols, and electrical interfaces such as voltage and current ratings.
- Evaluating the business case results.
- Providing the infrastructure framework to test and evaluate the feasibility of alternative business models.

3.1.5 CASE STUDY: ENEL'S WORK FORCE MANAGEMENT SYSTEM, ITALY

Background and objectives

In order to enhance field-force operations, Enel, Italy's largest power company, and Europe's second listed utility by installed capacity, implemented a new work force management (WFM) system. The project, completed in 2008, aimed to redesign the operations of the approximately 8,500 field engineers leveraging mobile technology and processes automation. As a result, around 5,300 vehicles (representing about 70% of the fleet) were transformed into 'mobile offices', equipped with 'rugged' notebooks.

e-Business activities

The key components of Enel's WFM project are:

- rugged notebooks, suited to demanding environments. Specifically, rugged notebooks have superior shock and vibration specifications, making them ideal for use in moving vehicles. They can store large amount of data and are equipped with a larger screen which is more practical for technicians. Moreover, a rich range of applications is available in a 'standard' Windows environment;
- equipment installed on the vehicles (dashboard monitor, mobile communication facilities, docking station and hardware cabling) that are equipped as 'mobile offices' in order to significantly ease the day-to-day work of field engineers. A key element of the project, therefore, is to set up an effective communication system between the vehicle and Enel's operational centre;
- mobile ICT applications developed to support the activity of field engineers. Crew members have a single mobile interface for all business processes (called EnelMobile), which is fully integrated with central enterprise applications;
- a field-force management solution, which includes: asset management, vehicle localisation, task assignment.

Additionally, ad-hoc applications were developed to manage the entire project rollout, namely a vehicle deployment plan, a rugged notebooks deployment plan and assignment, training plan, and documentation. A dedicated web site was created to support all the phases of the project.

Impacts

Major benefits obtained by Enel with the implementation of the solution can be summarised in two categories: quality of service and operational efficiency.

Quality of service: reduction of the time spent on customer services (fault management); improvement in managing appointments with customers (i.e. the appointment window-time agreed was always respected in the case of operations that needed to be performed at the customer's premises); all tasks were completed on time in line with the regulations of the Italian authority (i.e. customer switching).

Efficiencies: The use of the rugged notebook tablets increased as time passed, especially as field workers became more comfortable doing their once paper-oriented activities electronically. Over time the following improvements were observed:

- reduction in back-office work;
- optimisation of maintenance processes: more jobs per day and more network inspection completed per year;
- increased efficiency of logistics, in particularly reduction of travel costs;
- greater effectiveness of interventions: with all necessary information and documentation (including manuals) readily available, field crews found it easier to perform their job.

Lessons learned

A critical success factor was change management, as the project directly effected the daily routines of employees. The field engineers played a lead role in this change and were on board since the beginning. They were asked to track and report all the problems they discovered and to provide every piece of advice they deemed useful to improve the new WFM solution.

It was also well known that for the project to be successful it would need to have strong and clear management sponsorship. Hence, Enel's top management was also directly involved in organising the project through a steering group, which attended crucial project meetings where milestones were defined. In addition, periodic updates were provided by regular internal reports for company-wide circulation. The human resources and organisation unit also needed to be a part of the project from the outset, to assure success and assist the change management phase within the company.

From a more technical perspective, Enel identified the following points as key elements for success:

- Much care should be taken in clearly defining the development and maintenance (different components, different vehicles) as well as assistance (call centre knowledge) processes.
- Navigation applications must be accurate, constantly updated and integrated.
- Notebook interface must be as simple and user-friendly as possible.
- GPRS is not available at all times nor everywhere. Notebooks need to have resident applications in order be able to work off-line.
- It is crucial to monitor results, but it is key to measure human behaviour and not IT in order to see what is effective and being used, and what is not.

Overall results of the project were very positive, with the field force asking for additional rollout. Daily usage of the WFM continuously produces ideas to enlarge the spectrum of activities that can be leveraged with the solution implemented; for instance, legal security documentation can be uploaded on the rugged notebook rather than provided by printed manual to be distributed in each vehicle.

3.1.6 CASE STUDY: SMART GRID JOURNEY AT AUSTIN ENERGY, TEXAS, USA

Background and objectives

Austin Energy is the ninth largest community-owned electric utility in the United States. The company serves some 410,000 customers from a population of 1,000,000 in an area encompassing 650 square kilometres. In 2003, Austin Energy undertook a major project to revolutionise its company's ICT architecture and prepare itself for the construction of a modern energy system, one that would be customer-driven, integrated, interactive, optimised, distributed, secure and self-healing.[4] The project, completed in August 2009 is known as Austin Energy Smart Grid 1.0. It focused on installing about 5,000 digital devices and related ICT solutions, from the central power plant through the transmission and distribution systems and all the way to the meter and back again. Even before the project was completed, Austin Texas had started preparing phase two by launching the "Pecan Street Project" to develop a citywide smart grid.

e-Business activities

Starting in 2003, Austin Energy undertook a complete modernisation of all its IT applications, migrating all of its software to become Java-based. As part of Smart Grid 1.0, Austin Energy began a long process of deploying a series of new technologies and applications, including the rollout of smart meters to all its household and business clients (completed in August 2009).

The activities were led by the redesign of ICT enterprise architecture, and a major step was the deployment of smart meters and the related automated metering infrastructure (with a two-way communication network). In total the project covered the installation of about 500,000 devices, including 410,000 meters, 86,000 thermostats, 2,500 sensors, 1,700 computers and 1,000 network elements.

The deployment of a new meter data management system started in December 2008. It fed into the outage management system, customer information system, distribution planning system, energy efficiency management system and asset management system. All this was accompanied by the rollout of a distribution management system (DMS) and integrated all the elements into a supervisory data acquisition and control system (SCADA) and energy management system. In May 2009, a

[4] A self-healing network uses real-time information from embedded sensors and automated controls to anticipate, detect, and respond to system problems, automatically avoiding or mitigating power outages, power quality problems, and service disruptions.

new billing system was also rolled out, enabling demand response programmes and new billing rates - e.g. Time of Usage (TOU), net metering, and prepayment. It will be completed by 2011.

The new Austin Energy IT infrastructure is being designed to accommodate exponentially larger quantities of data. Currently, Austin Energy needs to handle 20 terabytes of data per year. This figure will reach 100 terabytes when meter readings are carried out every 15 minutes across the entire network, and 400 terabytes when readings are carried out every 5 minutes.

Impacts

Austin Energy's objectives of energy efficiency, as well as of further development of green energy, will not be achieved without the creation of the smart grid described in the previous sections. Even if ROI analysis of already completed projects is not publicly available, it is worth mentioning that all the activities were carried out with no impact on electricity tariffs, which have not risen in the last 15 years. Overall, it is still too early to quantify the potential benefits from such a broad implementation. Major results are expected in terms of the reduced need for construction of additional generation and transmission capacity, the reduction of operating costs, service improvement, the implementation of demand response programmes, and building automation.

Lessons learned

Austin Energy plans to share lessons learned with other cities around the nation and the world. The collection of different technologies, business models and practices can be mixed and matched by other municipalities to create their own smart grid. It is this open-ended policy that has helped Austin garner some of the top professionals in the country.

During Smart Grid 1.0 Austin Energy quickly learned that one of the most difficult challenges to overcome is people's aversion to changing processes and culture. Changing a culture affects skills, jobs and lives. It requires time, commitment and people's willingness to change. It is not something that can be 'mandated'. For this reason the company believes the participation of customers in the second step towards smart grids must remain voluntary. As Austin Energy already controls 22% of its customers' thermostats, for example by regulating them during peak hours, the company feels it already has a good sense of what its customers want and need. However, it remains prudent when asked whether it would be able to manage 100% of its clients' thermostats.

Austin Energy has come to the conclusion that utilities alone cannot set up the future smart grid single-handedly. A consortium of experts from different market segments will prove crucial for this task, not only to exchange best practices, but also to contain costs and spread risks. Utilities need to take on the role of orchestrators to coordinate the tasks needed to make smart grids a reality. Finally, Austin Energy emphasises that the redesign of enterprise system architecture and back-office integration were key to successfully orchestrating all the pieces of the project.

3.1.7 CASE STUDY: AUTOMATIC METER MANAGEMENT AT GAS NATURAL, SPAIN

Background and objectives

In 2005, Gas Natural, an energy services multinational headquartered in Spain, began a long process of evaluating, testing, piloting and selectively deploying an automatic meter management (AMM) system, mainly for the gas distribution sector.

Gas Natural's AMM project has three main objectives: cost reduction, customer satisfaction and energy efficiency. Gas Natural expects to reduce its costs both by reducing the cost of manual readings, and by avoiding further verification of readings by ensuring readings are accurate the first time around. Gas Natural's AMM deployment should also allow better forecasting of demand, enhanced gas network management, and improved network security due to constant remote monitoring. It should improve customer satisfaction by minimising the number of disturbances due to manual readings at the customer's home and the number of phone calls asking customers to provide readings. It should simplify accurate billing as well, as estimations of consumption will no longer be required. New and more flexible tariffs could also be introduced as part of the scheme. Gas Natural also sought to achieve better energy efficiency from improved consumption control by providing customers with real consumption data via web applications. The data allow customers to better control and forecast their expenditures.

e-Business activities

After defining its own specific requirements, Gas Natural carried out two demonstration projects that, combined, covered 10,000 meters on its distribution lines. Each demonstration was defined to test AMM under different conditions: town typology, density of clients, gas network configuration and communication technologies. The installations in both projects have a common architecture with four basic components: meter interface, repeater, concentrator and AMM software. The project uses radio frequency communication from meter interfaces, repeaters and concentrators. These communicate data to Gas Natural's management system via the GPRS network.

Impacts

By conducting its extensive pilot, Gas Natural was able to build a detailed business case on the AMM project, identifying its total investment as € 45.24 per meter of distribution line covered, and its annual savings to be € 5.33 per meter.

Gas Natural performed a ROI analysis to define how to move forward. The reference scenario is built on a ten-year plan to cover the roll-out of meters for all its residential customers, including meter replacement investments. The company expects an ROI of 9.2 years. Based on this analysis, Gas Natural decided to postpone full implementation of AMM, and focused instead on areas where meter-reading costs are higher than € 4 per year. This represents a deployment across some 300,000 meters of distribution lines.

Lessons learned

From a technical perspective, the project demonstrated that AMM technological platforms have grown more mature, more reliable, open, scalable and price competitive. It also confirmed that radio range communication is sufficient for the company to provide its services. Nevertheless, configuration tools and the installation process need to be simplified for mass deployment rollouts to succeed. In fact, many incorrect meter interface installations occurred, requiring additional field force on site visits. This is one of the most important lessons learned from the demonstration. Gas Natural is presently redefining procedures and tools for system installation.

During the pilot, Gas Natural created a committee to manage the cooperation of the business units involved, i.e. engineering and technology, operations, metering and asset management, as well as information technology. This has made a positive contribution to effective and coordinated project management.

Project economics, under the existing regulation scenario, are inadequate for full-scale implementation of AMM. From the perspective of Gas Natural's customers, the increased availability of consumption data was well received, even if at times the company encountered difficulties explaining why meters needed to be replaced or updated.

3.1.8 IMPLICATIONS FOR TECHNOLOGICAL DEVELOPMENTS

This study illustrates the role ICT and e-business can play in achieving the objectives of sustainability, security, efficiency, and innovation in the ESI. It also makes clear that the adoption of ICT is uneven across the sector. The potential benefits of ICT are largely recognised, but the overall attitude towards its further adoption is very cautious. Moreover, the economic crisis has led to deep cut backs on plans for investment. There is a risk that uneven or delayed adoption of ICT-based innovation may weaken the ESI's competitive position, and result in missing an opportunity that could benefit Europe's economy and the lifestyle of its citizens.

The findings of this study suggest that there are technological developments that may be particularly helpful in supporting the ESI. There is a need to further demonstrate the technical architecture and commercial implications of DER and VPP. Research is needed for the use of ICT in planning, monitoring and controlling decentralised units. Further efforts are needed in standardising the interfaces.

Improving energy efficiency on the demand side calls for action in the areas of standardisation (i.e. open and agreed standards for integration of devices), harmonisation of a regulatory framework, and the development of business models demonstrating the benefits for each stakeholder.

The introduction of smart grids, a central feature of EU energy policy, requires the widespread adoption of ICT for monitoring and control. There is a need for open and agreed standards in order to integrate different tools and devices. It is also necessary to improve architectures to better integrate data communication networks and intelligent equipment. In addition to technological requirements, there is a need for methods and tools that can assure interoperability, flexibility, effective security and expandability of the systems. Decision support systems to improve the reliability of predictions would also be needed. As smart grids involve various players along the value chain, coordination and harmonisation are needed both at technical and at regulatory level.

The portrait of smart metering in the EU provokes recommendations for action, addressing technical standards that support interoperability between different systems and devices, and the definition of required functionalities.

Overall, the analysis leads to the conclusion that efforts for ICT developments should address the areas of monitoring and control, system-to-system integration, interoperability standards and standardisation of interfaces.

3.1.9 POLICY IMPLICATIONS

Well-defined policy measures may help to support the development and widespread adoption of ICT in this industry, as well as the related business and organisation changes that are necessary for the European energy sector to remain competitive, reliable and sustainable.

Promote stakeholders' cooperation

The successful development and implementation of smart applications depends on close cooperation among all players, not only along the ESI value chain, but also with other stakeholders and other industries. There is a need for multidisciplinary and cross-sectoral cooperation, including between industry, scientific institutions, academia, public administrations and consumers (both business and domestic). Although cooperation among stakeholders is most urgently needed in the areas of technical development and standardisation, it is needed in terms of knowledge management and information sharing.

At policy level, it is therefore important to establish measures that involve the relevant stakeholders, that encourage the development of better solutions, and that disseminate best practices. This study highlighted the role that local governments may play in pioneer projects, under the umbrella of EU sustainability policies and targets, establishing frameworks that can be replicated on a larger scale. This is particularly true for implementing smart grid and smart metering initiatives. The Austin Energy case study shows the importance of city authorities in the successful rollout, and similar initiatives at EU level are emerging (e.g. Amsterdam Smart City, Malaga Smart City).

A private-public partnership for the future internet for smart grids development

One of the most effective ways to foster cooperation is the public-private partnership (PPP). At the time this study was conducted, the publication of the European Commission's Communication on the Future Internet PPP was widely anticipated. The Communication will be proposing actions to foster the development of the future internet, through the specific modality of public-private partnership to support research and innovation on the topic. The PPP is expected to provide an early "internet response" to the societal challenges, specifically a "bold contribution" to the economic recovery through innovation. Initially funded under the ICT component of the 7th Framework Programme, the PPP could evolve into a joint undertaking at the beginning of the 8th Framework Programme (2014). The Communication suggests focusing on three major societal topics of major economic interest to Europe:

1. Smart energy grids
2. Smart urban transportation systems and mobility
3. Smart healthcare systems.

Clearly, the findings of this study support the launch of a PPP of this kind. The launch of a PPP for the future internet with a focus on smart energy grids could provide a solution to many of the problems identified. It could foster cooperative technological development and standardisation, pan-European developments (which facilitate diffusion at the EU level), and increased investment in ICT-related research (in a period of scarce funding opportunities). Furthermore, a high-profile PPP could overcome two common problems for research and innovation in Europe - namely, the inability to reach a critical mass of investments, and the duplication of efforts.

Support research and technological development of ICT enabling new key energy technologies

It is unlikely that market forces will deliver technologies and solutions in time for the EU to reach its energy policy targets (a low-carbon, secure and competitive energy system). It therefore makes sense to consider whether innovative and commercially immature energy technologies (for instance, the VPP examined in this study) may benefit from EU stimulus co-funding. The key-enabling role of ICT in the implementation of these solutions needs to be highlighted, and supporting measures should be taken to foster innovation.

In particular, considering the EU energy-efficiency target, specific actions should be developed to support innovation in ICT for energy efficiency both in the ESI value chain and, even more importantly, to drive the process and behavioural changes of energy users (industrial, commercial and residential). ICT can enable energy efficiencies in other sectors and is fundamental to support the necessary transformation to a low-carbon economy and society. However, this will not be achieved without action and appropriate policy support.

Promoting the adoption of common technical standards

The analysis carried out by this study consistently showed that action is needed in the area of standards:

- Interfaces must be standardised between transmission service operators (TSOs), distribution service operators (DSOs), generation units, traders and customers. Proprietary protocols that inhibit integration and management must be eliminated and critical communication standards must be developed. This should include efforts on standardisation of data formats and database management to facilitate data exchange across the entire value chain.
- Devices from different vendors must be standardised to guarantee interoperability. Such a move may lead to unforeseen advantages. It may, for instance, make it easier for consumers to switch between suppliers and boost the deployment of smart metering in the EU.

It is not the role of the EU to define market standards. However, considering the complexity of the ESI value chain, the high level of regulation, the high level of risk related to the innovation required to attain the objectives of energy policies, and the pressure to preserve existing investments, it appears that the market and the ESI itself are encountering difficulties in setting the basis. The lack of standards and interoperability is hampering innovation. This can be seen, for instance, from the study in the smart metering rollout.

In order to overcome these barriers, there is a need for pan-European policies defining the key functionalities to be implemented by Member States with regards to smart grid initiatives. For instance, in order to successfully develop smart meters in Europe, it is essential to define what the key mandatory functionalities of a smart meter are. If this is done, the market will look for homogeneous solutions, and defining standards will become easier.

Visibility and demand engagement

Energy policies should pay attention to the potential of ICT. This will lead to a deeper engagement on the demand side, both in terms of businesses and consumers. The analysis in this study demonstrated that the full deployment of demand side and response management programmes is complex, as it requires active participation from the customer's side, with considerable organisational and technical implications. It is also necessary to develop and disseminate ICT-based platforms and user tools. These could be used to inform consumers and other stakeholders about energy consumption and emissions in different sectors of the economy. New design and simulation tools should also be made available and the dissemination of best practices should be improved.

Interactive user tools could also be developed to address issues with final consumers. These could conceivably be built on Web 2.0 technology. Business examples of demand response management and the Austin Energy case study have demonstrated that providing users with feedback on their energy consumption effectively induces reductions in consumption. The availability of user-friendly and easily accessible tools of this kind may have a significant impact on consumer behaviour. The industry should be involved in these awareness-raising and networking activities, providing active support and cooperation.

Support the development and dissemination of best practices and definition of business cases

The analysis in this study pointed out that for some of the most innovative ICT solutions (such as VPP and smart metering), a positive business case is difficult to prove. In terms of smart metering, the distribution of cost and benefits among the various players along the value chain is a central theme. If investors are not able to retain the full benefits of the roll out (for instance if suppliers invest in smart meters and the customer changes supplier afterwards), the deployment of smart metering projects is prejudiced. The same applies to VPP. It is not yet possible to perceive a standard architecture, nor has a consensus been reached on the costs and benefits of VPP, although the potential benefits appear significant. A policy implication from this study is that demonstration projects are needed to establish and disseminate knowledge about the economic implications of the most innovative technologies. Business case models should be developed on ICT investments and should be disseminated to all relevant stakeholders.

The findings of this study support the launch of initiatives like the DG Research and DG Transport and Energy joint call for proposals, part of the 7th Framework Programme, aimed at large scale demonstration of smart electricity distribution networks with distributed generation and active customer participation. As for awareness raising actions, the development of business cases requires the active support and cooperation of the industry.

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3.2 Metering and measurement facilities as enabling technologies for smart electricity grids in Europe

A study by the Institute for Future Energy Consumer Needs and Behavior (FCN), E.ON Energy Research Center, RWTH Aachen University. Study authors: Reinhard Madlener and Christiane Rosen (FCN/E.ON ERC, RWTH Aachen University), Junqi Liu and Antonello Monti (ACS/E.ON ERC, RWTH Aachen University), and Carlo Muscas (University of Cagliari, Italy)

Changes in the electricity market are mostly expected to affect distribution. The extent to which smart metering will be introduced is still unclear, and depends heavily on customer acceptance and on agreement on standards for communication and data management. From the utility perspective however, changes regarding network operation and services are likely, largely in response to political pressure. More active control of the distribution system by utilities may consequently be needed.

Situation at the low and medium voltage level

Unlike the high voltage system, the low and medium voltage systems are not yet fully automated. The reason they are lagging behind is historical. The high voltage system needed early automation in order to remain functional. In recent years, the introduction of distributed energy generation has imposed similar requirements on the distribution network, particularly at the medium voltage level. Now, at the low voltage level, the concept of demand side management and automated operation is gaining support, and constitutes a driver for smart metering.

Case studies encourage deployment

The case studies conducted for this analysis look at cost savings achieved by smart deployment of technology. In the first study, savings resulted from large scale deployment of smart meters in private households. Automated operations permit economies through, for instance, remote reading. Furthermore, this study shows that consumers are accepting smart devices and responding accordingly. Most users adjusted their behaviour by reducing and shifting the timing of their electricity consumption. The second case study looks at how to build an economical smart distribution grid. In order to control such a grid, Distribution State Estimation needs to be used. This task is performed by Intelligent Electronic Devices, which remain to date very expensive. Costs can however be minimised by optimising the number and position of these devices.

Policy implications

An agreement on common standards would greatly assist the diffusion of intelligent measurement facilities. Organisations such as the European Union are well placed to filter and speed this process. But there is still no business case for utilities to deploy smart meters. The potential benefits for the environment and society warrant the use of political pressure to foster the changes needed in today's electricity distribution system.

3.2.1 STUDY OBJECTIVES AND APPROACH

Study rationale and objectives

This study aims at analysing the **current situation of the measurement and metering infrastructure in the power distribution grid**. The level of maturity of this infrastructure is considered as an indicator of the possibility for the smart grid to become a reality in the electricity market. As there can be no control over such a system without measurement, the availability of measurement defines the upper limit for the implementation of smart grids.

However, the availability of **data** alone does not make automation of the grid possible. Other important elements are the level, quality and timing in introducing adequate standards in the field. **Standards** guarantee interoperability and create the conditions necessary for the emergence of profitable markets for application developers. As a second aim, this study probes the level of maturity of the standards and attempts to forecast their evolution and impact on future markets.

As a third objective, the study aims to identify possible **future scenarios** of the electricity distribution grid. While 'smart grid' is currently a popular buzzword, a robust technical definition of what a smart grid is, and a clear view of its business and market consequences, remain to be formulated.

Foci of the study

This study has two main components that represent the two foci of the analysis. One focus is the **customer perspective** and the potential role of the customer in relation to smart metering. This focus is presented as the main driver of the low voltage network evolution. The **utility perspective** is the second focus. This analysis offers a review of the current situation at the medium voltage level. In this case, the direct role of the customer is marginal (with the exception of large industrial energy consumers) and the problem is mostly one of defining the correct business case for the utility.

Methods

The research undertaken for this study is mostly based on a **review of the relevant scientific and non-scientific literature** in the field, merged with the expertise of the authors. Based on the collaboration of authors with different backgrounds (both technical and economic), this study aims at combining technical knowledge with a business - or market-oriented perspective. In addition, selected **case studies** are presented in order to offer a more comprehensive view of the possible evolution of the sector.

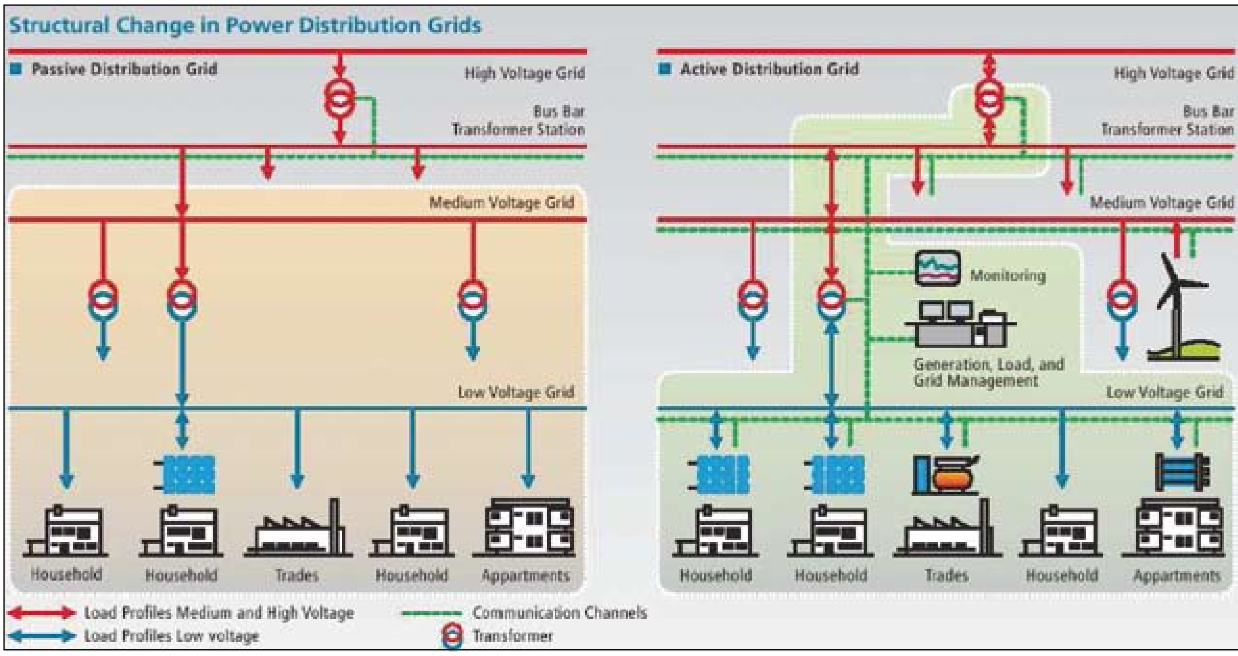
3.2.2 CURRENT AND PROSPECTIVE ELECTRICITY GRID INFRASTRUCTURE AND MEASUREMENTS

Traditionally, electricity grids have been seen as passive distribution grids with no power supply from the consumer side. They were characterised by a hierarchical and unidirectional energy flow structure, from higher to lower voltage levels. In addition, for monitoring and controlling the grid, utilities' centralised controls measured **system operation values such as voltages, currents and power** almost uniquely at the high voltage level. On the end-use consumer side, electricity consumption was measured and recorded at the consumer's premises by electromechanical meters, which were read by utilities only for billing purposes. In this scenario, communication between the measurement nodes and the control centre as well as between the consumers and the utilities was only one-way.

Technological innovation is driving fundamental change in the electricity grid. The popularity of small-scale distributed generation units is growing. These are often located very close to end-use consumers, and connected to the low or medium voltage power distribution grids. The consumer side, formerly seen by utilities as a passive element, is becoming active, as consumers can now generate electricity and feed it back to the grid. The former hierarchical and unidirectional system is turning into an active distribution grid with bi-directional energy flows, as illustrated in Exhibit 3.2-1.

This new architecture for the electricity grid raises challenges for ensuring stable and reliable network operations, and needs to be managed by advanced control and monitoring technologies. A modernisation of the electricity delivery system, the so-called **smart grid**, has therefore been proposed. Its aim is to integrate, monitor, protect and automatically optimise the operation of all interconnected elements in the grid. The smart grid will operate from the central and distributed generator via the high voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric

EXHIBIT 3.2-1: STRUCTURAL CHANGE IN POWER DISTRIBUTION GRIDS



Source: bmvit (2006)

vehicles, appliances and other household devices (for further information see EPRI (2009)).

3.2.3 SMART METERING - MEASUREMENTS FOR DEMAND-SIDE MANAGEMENT

Smart metering: definition

A smart metering system changes the traditional metering methodology at the low voltage end-use consumer side. Innovative smart meters are advanced electronic devices combined with modern two-way communication technologies. They can provide a wide range of useful information, including more accurately measured data on households' electricity consumption and billing, load profiles, time-based electricity pricing and tariffs. Smart meters can make such information available not only to utilities but also to consumers. The **basic components** of a smart meter may include large storage capacity, programmable devices and a digital display.

Smart metering technology enables demand-side management and is an essential constituent of the smart grid. It can also be expected to substantially change the relationship between consumers and service providers. Based on analyses of the data collected by smart meters, utilities are able to optimise operations regarding quality and cost, as well as to improve consumer services.

Smart metering is expected to prompt consumers to be more thoughtful regarding their energy usage by informing them of their daily and even hourly consumption and the different tariffs that apply. Moreover, an improved quality of energy supply by utilities is expected through automatic meter reading, improved network monitoring, faster reaction to system faults and faster restoration. These developments are expected to improve energy efficiency, helping bring within reach the ambitious "20-20-20" targets of the European Union (to increase the share of renewables to 20%, to increase energy efficiency by 20%, and to reduce greenhouse gas emissions by 20%).

Current situation regarding standards

Since November 2006, and within a ten-year transition period for implementation at national level, a wide range of measuring instruments, including gas, water and electricity meters, has to satisfy regulations stipulated in **European Directive 2004/22/EU**. The aim of this directive is to create a common European market for such instruments. Commercially available smart meter solutions are developed by different manufacturers for geographically different markets and mainly used for **Automatic Meter Reading (AMR)**. In general, the technical specifications of such smart meters are based on existing standards for traditional electricity, gas and water meters – such as ICE 62051-62054 and ICE 62059 mainly in Europe, and the ANSI C12 series in the USA – combined with modern wired or wireless communication standards, like PLC, GPRS, WiFi, and ZigBee.

Several entities and associations have proposed technical requirements or standards packages for AMR or smart metering, with particular emphasis on communication protocols and data models. However, the **lack of international open standards** concerning all issues of interoperability, security and communications hampers the deployment of smart metering on a larger scale.

Risks and benefits of smart metering deployment

There are several risks associated with smart metering deployment, but these can also be seen as opportunities. One of the major issues is **consumer acceptance** of smart meters, as consumers will have to use the devices to reap the benefits of the smart grid. This can be remedied by a carefully studied design that takes into account the specific (and heterogeneous) needs of consumers. The smart meter's frequency of update, visual design as well as the nature of the data it displays and the benchmarks it provides are likely to be crucial influences on the technology's acceptance.

In addition, smart meters presuppose readiness among consumers to change their consumption patterns. Consumers tend not to think about their energy consumption or to envisage sacrifices in comfort. **Business ideas such as** switching off electricity during peak hours are, therefore, not likely to be successful in practice. However, more active consumers with their own generation equipment will welcome the possibility of selling electricity back to utilities.

In this context, **political support** is vital. Introducing a framework that requires smart metering, as has been done by the EU, is an important first step, but it needs to be followed by active information campaigns to consumers on a national or even local level. This will share some of the burden shouldered by utilities and dispel consumer mistrust, ensuring good relationships and enhanced consumer acceptance on a broad basis. Such an approach makes sense in view of the environmental benefits of smart metering. Inaction leaves utilities at risk of incurring the costs of the transition without seeing immediate returns.

Security concerns arise in respect not only of maintaining system stability and functionality in the event of disruptions, but also for the protection of confidential data in smart metering. In Romero et al. (2009a), it is suggested that the concept of "defence in depth" should be applied to the global system: security at each layer of infrastructure, from the centralised part of the smart metering system to the end-point meters, including networks.

Smart metering must also be subject to data protection laws. The utility and the consumer have to agree on what personal data on consumers can be collected, who owns the data and for what purpose the data are used.

Calibration has an important role in ensuring the accuracy of measurements and is mandatory for any kind of meter. The calibration issue for smart meters has not yet been explicitly addressed. A remote calibration approach with well-defined hardware and software architecture as well as proven performance is a potential solution.

Business models

Possible changes in **business models predominantly** include tariff schemes with time-of-use pricing. Moreover, the expected evolution of energy trading offers opportunities for market operators and wholesalers. Intermediaries can offer contracts for private households to be part of a virtual power plant. Utilities or service providers can support customers in financing, installing and maintaining generation devices. The increasing diffusion of plug-in hybrid electric vehicles offers prospects of energy being stored in them and sold back later at a higher rate.

Additionally, **insurance policies against, for example, blackout risks**, price fluctuations and weather risks will emerge as secondary products. Entrants from other industries, such as telecommunications and the financial sector, can also offer bundles with related and unrelated products. These could include credit cards, telephone contracts and other services.

3.2.4 MEASUREMENT INFRASTRUCTURES FOR CONTROL AND PROTECTION

New scenarios for Distribution System Operators (DSO)

The management of future distribution grids (active networks and smart grids) will rely on a constant flow of information between different nodes of the network. How well the system operates therefore depends on the quality (accuracy, robustness, reliability) of the system employed to **acquire** and **transmit** these data.

State estimation (SE) procedures will provide the basis for the advanced control and management functions needed in Smart Grids. In the past, these functions were required only in transmission systems, but they are likely to spread to distribution systems in the future.

SE requires measurement instruments to be located at different nodes of the distribution grid. How closely estimations match the reality increases with the number of measuring instruments installed in the network. This consideration contrasts sharply with the current economic requirement that continuously pushes DSOs to reduce costs. As a consequence, in medium voltage distribution systems today, contrary to what happens in transmission grids, the number of measurement points is low with respect to the total number of network nodes. Two aspects of this problem should be considered: **Ad-hoc solutions** are necessary to define suitable reliable procedures (DSE, Distribution State Estimation) to estimate the network status starting from a limited number of measured data. And the implementation of DSE will ultimately require **distributed measurement systems** to be extensively used in smart grids.

Measurement functions and Intelligent Electronic Devices

In traditional power systems, the equipment was designed for a specific task, thus leading to a clear separation of the functions performed by each device. As an example, measurement instruments were logically and physically different from the protection devices. The progressive introduction of Intelligent Electronic Devices (IEDs) is changing this. Indeed, IEDs are based on the digital processing of signals that have been acquired and converted to a digital form. Thus, the different functions implemented are not necessarily based on different hardware, but rather on different processing routines. As a consequence, measurement functions can be integrated into IEDs used for different purposes, such as protection, or even – thanks to their communication capabilities – implemented by combining the operation of different physical IEDs.

Communication systems for measurement data

Communication supports represent the backbone of any distributed measurement system and this rule holds for smart grids. The performance of these systems depends directly on the characteristics of the physical channels employed to transmit measurement information to and from the remote stations. As a consequence, DSOs are facing decisions on how to upgrade their communication infrastructure to enable the **new smart functionalities**, while bearing in mind what is available in terms of existing equipment and infrastructure. Different solutions could be adopted, based on either copper/fibre support or wireless networks. In the most critical tasks, such as when **safety** is involved, the reliability of the system could be improved by using two different channels, one operating as a backup of the other.

Current standards and possible evolution

Many different organisations (ANSI, IEEE, IEC, ISO, etc.) are involved in the process of standard making. As an example, in the USA the Energy Independence and Security Act of 2007 charged the National Institute of Standards and Technology (NIST) with the task of developing an **interoperability framework of standards and protocols**, while IEEE and several organisations were specifically named as key organisations to work with NIST on this framework. Up to now, however, the **lack of universal standardisation** discourages companies from investing in the new technologies required for smart grids. This is probably the greatest barrier to the deployment of such technologies. It is therefore urgent that standards projects are agreed upon, in order to provide a (possibly reduced) set of **open and long-lasting standards**. Some good practice examples of integration between committees already exist, as in the case of the possible introduction of IEEE 1588 synchronisation into IEC 61850 communications.

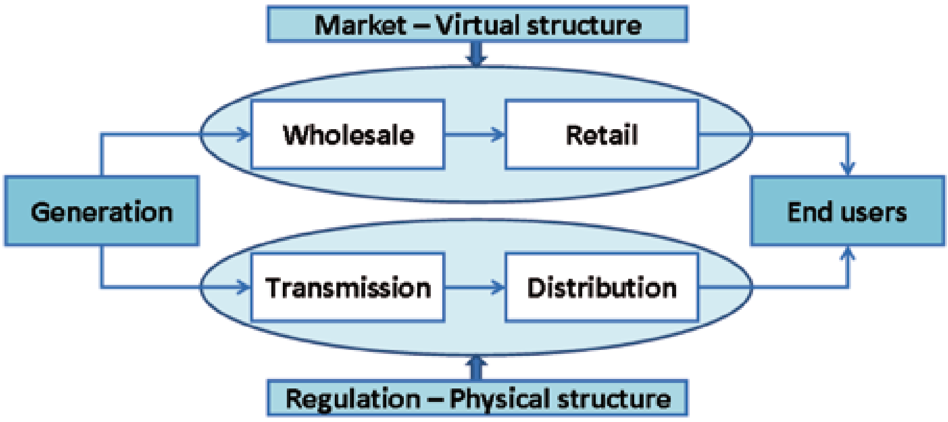
Risks and benefits of measurement infrastructure deployment

As for many other items related to smart grids and, more generally, to the use of Distributed Energy Resources (DER), it is hard to assign a direct economic return to the deployment of the measurement infrastructures outlined in the previous sections.

On the other hand, measurement facilities must be seen as an indispensable tool for making new distribution networks feasible. Their motivations therefore cannot be separated from the **driving elements** behind the smart grid platform (CEC, 2006):

- benefits to the environment and public health (improved energy efficiency and reduced emission of greenhouse gases);

EXHIBIT 3.2-2: LIBERALISED ELECTRICITY MARKET STRUCTURE



Source: own illustration

- benefits to the energy producers (grid access, particularly for renewable power sources and high efficiency local generation);
- benefits to distribution system operators (possibility of delaying investments on large-scale equipment; identification and prevention of failures; awareness of in-service equipment health and capacity);
- benefits to the customers (access to electricity market opportunities; enhanced safety, reliability and power quality).

In addition to these points, social benefits, related to new job opportunities, should not be ignored.

Business models

The liberalisation of the electricity market has altered the value chain of the electricity industry and has led to the redefinition of roles, as schematically represented in Exhibit 3.2-2.

DSOs are often seen as market facilitators (Lorenz, 2009) whose role is to enable customers to choose among suppliers. In order to do so they should act as impartial information hubs. Their role should include managing metering, providing master data and consumption information to market participants, and smoothing the process of changing suppliers. Furthermore, they can engage in virtual power plants, micro-grids and to some extent in plug-in hybrid electric vehicles. These business opportunities are also important in the end-consumer market.

3.2.5 CASE STUDIES

This section provides summaries of two case studies that were conducted especially for this study. The complete case studies are included in the main study report, available on the Sectoral e-Business Watch website (http://www.ebusiness-watch.org).

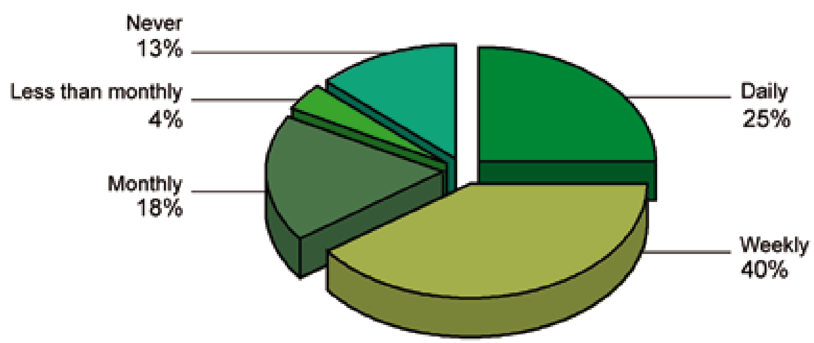
Telegestore ENEL

ENEL is the first utility in the world to have developed and to operate an automated system to remotely manage more than 30 million electricity meters. The ENEL Automated Meter Management (AMM) solution, named Telegestore, started deployment in 2001. This investment enabled savings in many other areas. Remote operations make customer service, field operations and (via more frequent reading activities) revenue protection less expensive. Furthermore, ENEL observed that the massive deployment of Smart Meters has an impact on the habits of customers. The "Smart Info", an indoor smart device to act as an interface with the consumer, plays an important role in this respect. Exhibit 3.2-3 shows that most customers used it on a weekly (or even more frequent) basis. In addition to this, more than half of the customers changed their behaviour. For instance, they started operating washing machines in the evening, and switching off devices in stand-by mode.

Optimal placement of IEDs for DSE

Choosing the optimal number and position of the measurement devices needed to perform Distribution State Estimation (DSE) is an important matter for consideration

EXHIBIT 3.2-3: COSTUMER INVOLVEMENT: USAGE FREQUENCY OF SMART INFO DEVICE



Source: Cotti et al. (2009)

Database: ENEL Survey (2008), representative market test in more than 50 Italian cities.

in evaluating the practical applicability of the Smart Grid approaches. The key idea is that in active networks the topology can be modified to optimise power flows and to solve critical contingencies. Indeed, the adoption of on-line network reconfiguration makes it possible to improve the system's performance in terms of voltage regulation, losses and supply reliability.

The objective of the DSE considered here is to estimate with a given level of accuracy the currents flowing in each branch. The input data of the DSE procedure are the measured branch currents and powers in each node, either pseudo-measured or measured, if related to loads or generators, respectively. The quality of DSE can be affected by:

- measurement devices that introduce uncertainties;
- changes of the network topology (network reconfiguration) and deviations of the network parameters from their nominal value;
- partial lack of communication (emergency mode).

The number of measurement devices needed is minimal for optimised locations. It further depends on the accuracy of the instruments used and the maximum tolerance required for the estimated quantities.

3.2.6 CONCLUSIONS

Overall, major changes in the power distribution grid are expected in the next couple of years. One of the most crucial steps is **standardisation**. Once this is achieved, developments will speed up. Another important factor is **governmental support from all levels**. Great benefits may accrue on a societal level, i.e. to the environment and in terms of power supply reliability. This also means that utilities lack the incentive to invest immediately, and only wide-scale organisations like governments can force such a change. Their support can take the form of setting guidelines to decrease uncertainty, informing customers, and providing financial incentives for investment, as far as public budgets allow.

3.2.7 REFERENCES

A complete list of references can be found in the full report.

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Romero, G., F. Tarruell, G. Mauri, A. Pajot, G. Alberdi, M. Arzberger, R. Denda, P. Giubbini, C. Rodrí-guez, E. Miranda, I. Galeote, M. Morgaz, I. Larumbe, E. Navarro, R. Lassche, J. Haas, A. Steen, P. Cornelissen, G. Radtke, H. W. Kneitinger, T. Wiedemann, C. Martínez & Á. Orcajada (2009a): Report on the identification and specification of functional, technical economical and general requirements of advanced multi-metering infrastructure, including security requirements. OPEN meter, Energy Project No 226369, funded by EC.

Acknowledgements

This study was conducted by **Future Energy Consumer Needs and Behavior (FCN), E.ON Energy Research Center, RWTH Aachen University** (http://www.eonerc.rwth-aachen.de), a research institute based in Aachen, Germany. The study authors are Reinhard Madlener and Christiane Rosen (FCN/E.ON ERC, RWTH Aachen University), Junqi Liu and Antonello Monti (ACS/E.ON ERC, RWTH Aachen University), and Carlo Muscas (University of Cagliari, Sardinia). The full study report can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

Policy-oriented studies

4.1 An economic assessment of ICT-related industrial policy

A study by empirica GmbH and DIW Berlin. Study authors: Stefan Lilischkis and Pio Baake

Main results

ICT-related industrial policy comprises policies for ICT innovation in ICT-producing companies and ICT adoption in ICT-using industries. These two sectors should be seen as two sides of the same coin when it comes to enhancing the competitiveness of European industry. This study analysed how such policies could be refined.

Theoretical analysis

The study modelled developments in ICT using a theoretical framework based on game theory, industrial organisation theory, market failure and state failure theory. It concluded that the following issues in ICT-related industrial policy should be carefully considered: specificities of ICT such as short innovation cycles and high commercialisation costs; possible downsides of European research, development and innovation (R&D&I) joint ventures such as misuse of market power; and how to prevent late joining and early leaving of companies in joint programmes to avoid self-serving behaviour.

Expert survey

In an online survey conducted for this study, ICT experts from policy, research and industry agreed that there was a need for industrial policy to support ICT R&D&I and adoption. Most experts confirmed that the European Commission has been focusing on the right issues in its ICT- and e-business related industrial policies, but encouraged the EC to extend the scope of these policies. They believed that ICT companies tended to grasp the importance of the European single market for selling their products rather than the importance of ICT R&D&I.

Case studies

Three case studies illustrate selected ICT-related policy instruments in different countries. The US Networking and Information Technology Research and Development programme coordinates dispersed ICT R&D&I activities. The Korean IT839/u-IT839 master plans provided massive public support to ICT R&D&I, closely intertwining public and private activities. The initiative "Cluster Automotive Region Stuttgart" in Germany illustrates the importance of e-business adoption in SMEs if they are to remain part of the supply chains of large manufacturers.

Policy implications

This study advances a concept for developing ICT-related industrial policy that distinguishes between policy themes and counterparts. The two principal themes are policies for ICT product innovation and policies for e-business adoption. The two principal counterparts are companies and Member States. Together there are four distinct fields of ICT-related industrial policy. The study makes twelve suggestions on how policy might be refined.

4.1.1 STUDY OBJECTIVES AND APPROACH

Study rationale and objectives

One of the principal additions to the Sectoral e-Business Watch in comparison with its predecessor, the European e-Business Market Watch (2002 – 2006), is a stronger focus on industrial policy implications. More refined industrial policies may be necessary to sustain and enhance the competitiveness of European industries in an increasingly competitive global business environment. To this end, this report offers a more refined concept to help develop ICT-related industrial policies. Such a concept requires sound theoretical and empirical foundations. Hence this study describes, analyses and assesses ICT-related industrial policy practices with theoretical and empirical methods.

Study focus

ICT-related industrial policy is a complex field with many actors as well as many possible approaches and instruments. It was therefore necessary to limit the scope of the study from its outset. The study is primarily interested in the activities of the European Commission which involve European Union Member States and companies. It therefore focuses on policy fields of principal importance for current ICT and e-business development. The principal policy fields analysed are ICT innovation and adoption. The study also focuses on policies for ICT-producing industries and ICT-using manufacturing industries, but not service industries.

Methodology

Data was collected and ICT-related industrial policy was analysed by means of a theoretical analysis, an online survey, case studies, expert interviews, and literature evaluation. The theoretical analysis of ICT-related industrial policy is the principal component of the report. This analysis adopted a micro-economic approach and drew from game theory, the theory of industrial organisation, market failure theory and also, cursorily, from state failure theory. A sound literature evaluation was conducted and relevant sources were assessed objectively. As regards practical policy, the most important sources included the European Commission, the OECD and principal European industry associations. Key articles of the economics literature were followed up, in particular for the theoretical analysis.

4.1.2 DEFINITIONS AND BACKGROUND

ICT-related industrial policy: definitions and current trends

ICT-related industrial policies are defined in this study as measures to promote ICT research, development and innovation (R&D&I) in ICT-producing industries as well as ICT adoption in ICT-using industries. The objectives of such policy are to foster competitiveness, growth and employment in the industries concerned. ICT-related industrial policy may include many of the instruments used in more general industrial policy, such as market regulation, infrastructure enhancement, financial incentives, and involvement in entrepreneurial decisions. The industrial policy of the European Commission (EC) combines horizontal and industry-specific approaches. Its objective is to "create the right framework for industry to thrive", free from protectionism and subsidies. In doing so, it will have to overcome the challenges not only of increasing global competition and climate change but also of the current economic crisis.

ICT-related industrial policy of the EC

There EU is no officially defined "ICT-related industrial policy"; the term was introduced for this study. The EC's ICT innovation policy includes for example ICT-related R&D&I under the seventh EU Framework Programme, in the Competitiveness and Innovation Programme, and in the framework of the European Research Area. Within DG Enterprise and Industry, the following activities are related to ICT and e-business adoption: the e-Business Support Network for SMEs (eBSN), support for ICT standardisation and standards adoption, initiatives to improve e-skills, and activities to create a favourable legal environment for e-business.

The strategic priorities of the EC's ICT-related industrial policy have changed over the years, from co-financing ICT investments towards stimulating SMEs to explore the innovation potential of ICT and, more recently, supporting SMEs to develop their e-business strategy in cooperation with their business partners. The next shift may be towards innovation of key elements of ICT and their adoption in companies of all sizes.

Study focus on ICT-producing and ICT-using industries

This report focuses on ICT-producing industries and on ICT-using manufacturing industries. The competitive position of

European hardware and software producers is ambiguous. In some segments, European firms are strong, for example in mobile phones and business software. In others, Europe is weaker, for example in semiconductors and packaged software. A strategic challenge for the European software industry and policy makers is to strengthen Europe's competitive position by shifting towards new paradigms such as the "internet of things" and the "internet of services".

ICT-using manufacturing industries have many characteristics in common. Their supply side is typically an important and fragmented business activity. As regards market structure, ICT-using manufacturing industries typically have at least some sub-sectors that are highly concentrated, dominated by large international players. As regards e-business adoption, large and medium-sized companies are typically better equipped with ICT and perform higher rates of e-business practice than micro and small companies.

4.1.3 THEORETICAL ANALYSIS

Concept of the theoretical analysis

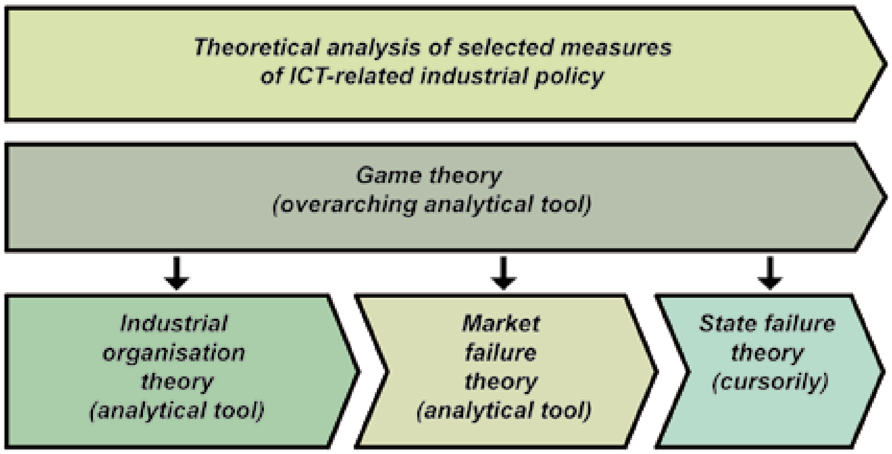
The theoretical analysis in this report is meant to offer an insight into the strategies and behaviour of companies, Member States and the European Commission when dealing with ICT innovation and adoption and related policies. The report presents two analyses: one dealing with ICT R&D&I in ICT-producing industries, the other covering e-business adoption to enhance electronic value systems in ICT-using manufacturing industries. Both issues are important for enhancing the competitiveness of European companies. Furthermore, an analysis of ICT R&D&I based solely on game theory was conducted as an example.

Theories applied and sequence of the analysis

The analysis is based on applied game theory and includes three steps: applying industrial organisation theory, market failure theory, and state failure theory. The rationale behind selecting these theories was as follows:

- **Game theory** was chosen as the basic approach because it is the principal theory used in economics for analysing interactions among decision makers. Industrial policy deals mainly with interactions among companies, between companies and political decision makers, and political decision makers among themselves.
- **Industrial organisation theory** was chosen because it is the principal approach to analyse the relationship between market structures, company conduct and company performance. Well-founded industrial policy requires a profound understanding of market structures and developments in the industries concerned.
- **Market failure theory** was chosen because it is the principal approach to probe whether political activity is needed and, if so, what kind of political activity.
- **State failure theory** was employed to describe possible shortcomings of political activity. Interactions between companies and political decision makers and among political decision makers are crucial for industrial policy.

EXHIBIT 4.1-1: THEORETICAL CONCEPT FOR THE STUDY OF INDUSTRY-RELATED ICT POLICY



Source: empirica/DIW

> Overarching: characterise different kinds of strategic interactions and explain their relevance for ICT-related industrial policy. Analytical tool: game theory
Game theory is used here to analyse possible strategic behaviour of companies and public entities. The following interactive constellations are considered: ICT-using companies among themselves, ICT-using companies versus ICT-producing companies, companies versus governments, and governments among themselves.
> First step: Describe typical situations of ICT investment, analyse strategic interactions between firms, examine the impact of different market structures Analytical tool: industrial organisation theory
Specific approaches of the theory of industrial organisation and game theory have been applied. The focus is on the strategic conduct of companies and their performance in given market structures. Companies' decisions to invest in ICT are also explained.
> Second step: Discuss whether distorted ICT investment decisions can be interpreted as market failure Analytical tool: Market failure theory
The next step is to discuss whether the distorted decisions of companies to invest in ICT can be interpreted as market failures. From the point of view of economic theory, market failures may be due to external factors, imperfect competition and imperfect information.
> Third step: Discuss whether industry-related ICT policy measures comply with market failure arguments Reference tool: State failure theory
The analysis discusses to what extent selected policy measures comply with market failure arguments. Arguments from state failure theory are used to discuss possible shortcomings of policy measures.

The theoretical analysis is conducted in line with the concept described in Exhibit 4.1-1. All steps of the analysis are linked to produce concrete results. The theoretical analysis is target-oriented towards policy implications.

Assumptions and subjects of the theories considered

The theoretical concept applied in this report comprises numerous aspects. Exhibit 4.1-2 provides an overview of the theories as well as their key assumptions and subjects.

Policies to promote ICT innovation

The importance of ICT R&D&I for growth and employment in Europe is undisputed. In its Communication on ICT research, development and innovation (R&D&I) of March 2009, the European Commission considers ICT as vital "to recover from the current economic slowdown, to build robust economies, bring the efficiency gains needed in our public sector and cut the rising costs related to e.g. ageing, energy and the environment" (p.3). However, the European Commission sees a critical need for European ICT R&D&I to be better co-ordinated, concentrated and specialised in order to improve competitiveness of ICT-producing industries. Exhibit 4.1-3 presents the key results of a theoretical analysis related to ICT R&D&I in companies.

In summary, industrial organisation theory suggests that large firms may have more incentives to conduct ICT-related innovation and may be more successful in innovation than small firms. Potential market failures related to ICT R&D&I include above all underinvestment in R&D&I from a societal point of view and non-commercialisation of new technology due to incomplete information about potential demand. Possible state failures in ICT R&D&I support are related to inefficient allocation of grants, misuse of results of publicly supported R&D&I joint ventures to restrict competition, and a prevalence of national grants that cost more than an internationally coordinated grants scheme.

Policies to promote electronic value systems

The use of e-business for electronic communication between companies can enhance value systems, increase business process efficiency, and improve the competitiveness of the companies involved. In particular, SMEs may benefit from e-business adoption in order to remain as suppliers or customers in the value systems of large companies.

EXHIBIT 4.1-2: OVERVIEW OF THEORIES APPLIED IN THIS REPORT AND KEY ASPECTS

Game theory	
Definition:	Theory of strategic interactions ("games") between consumers, firms and policy makers ("players").
Key assumptions:	Rational behaviour: players use all the information at their disposal and always act to maximise their gains. "Strategy": a complete plan of action. "Best response": action maximising gains given the actions of the other players.
Key subjects:	Aim: predict the behaviour of players by looking at strategies constituting an equilibrium. Equilibriums are crucial because they make it possible to analyse the outcomes of games. Key concepts: Nash equilibrium, Harsanyi/Selten's refined equilibrium, dynamic games and subgame perfection, perfect Bayesian equilibrium.
Industrial organisation theory	
Definition:	Theory of strategic behaviour of firms, their interactions and the structure of markets ("theory of imperfect competition").
Key assumptions:	Company and industry performance determined by conduct of buyers and sellers, which in turn is determined by market structure.
Key subjects:	Generally: relationships between market structures, company conduct and market outcomes; network effects and coordination problems. Here: influence of horizontal and vertical market structures on ICT innovation and e-business adoption.
Market failure theory	
Definition:	A market failure is a situation in which free markets produce inefficient results.
Key types of market failure:	Market failures with respect to ICT investments can be traced back to three factors: (1) Difficulties in appropriating the returns from innovation due to external effects. (2) Imperfect competition and strategic behaviour distort firms' investment incentives, which may lead to sunk costs and inefficient investment levels. (3) Network effects and strategic complementarities can lead to coordination failures.
State failure theory	
Definition:	Theory of possible failures in governmental decisions, i.e. inefficient policies.
Key assumptions:	Companies and lobby groups seek to maximise their individual utility; governments seek to maximise social welfare.
State failure between governments and companies:	Imperfect information is the principal source of state failure. Special issue: companies that might benefit from industrial policy may provide biased information.
State failure between EU and Member States (MS):	Possible negative external effects from national policies => suboptimal benefits at EU level. Asymmetric information between EU enacting policies and MS implementing them => MS may implement ICT-related policies in unwanted manner. => due to the risk of infringement, companies may hold up ICT investment decisions.

Source: empirica/DIW

EXHIBIT 4.1-3: KEY FINDINGS FROM THE THEORETICAL ANALYSES OF ICT R&D&I

Insights from industrial organisation theory	**Large firms may have more incentives to innovate and may be more successful in innovation than small firms.** Reasons: • Short innovation cycles imply two advantages for large firms in R&D&I: a large customer base, and reputation with regard to product quality. • Firms offering established systems with large customer bases can easily become dominant on markets for new and compatible components. • Large firms may be especially willing to imitate the innovations of small firms.
Possible market failures	• **Underinvestment** in R&D&I: While the firms' incentives to innovate are driven by expected profits, socially optimal investments in R&D&I are based on overall social benefits. • Possible **overinvestment** in R&D&I: Since innovations may increase market shares at the expense of competitors, firms have an incentive to invest more than necessary for the social optimum. • **Incomplete information about potential demand** when facing high marketing costs may imply that firms do not commercialise new technology. • With **strategic use of incompatibility** of their products, firms may seek to establish new monopoly positions and to prevent market entry. • Large firms may **(mis-)use R&D&I joint ventures** with small firms to control their innovations.
Possible state failures	• ICT **R&D&I grants can be allocated inefficiently** because incentive schemes for agents assessing the ICT R&D&I proposals from companies are not necessarily efficient. • Companies involved in **publicly supported R&D&I joint ventures may (mis-) use results** of the co-operation to restrict competition. • **R&D&I grants to national companies** may cost each country more than if countries coordinated their grants.

Industrial organisation theory suggests numerous problems may arise from the development of electronic value systems. It identifies the two main shortcomings of value systems as their failure to coordinate mutually related e-business investments, and their tendency to favour large companies with larger e-business investment incentives than SMEs. SMEs also risk getting locked into a given e-business solution if this solution is designed to interact with only one large company. Theoretical considerations about e-business adoption therefore question whether policies to promote SMEs' participation in electronic value systems enhance efficiency. Exhibit 4.1-4 summarises these findings.

As regards policies to e-business **standards adoption**, policy makers need to be aware that the companies involved have strategic incentives to hide relevant information in order to reduce the costs they incur from implementing new standards or to receive direct grants. They should also bear in mind that national governments may tend to promote standards that are prevalent within the country.

Insights from a game theory analysis of joint R&D&I programmes

In order to gain insight into ICT R&D&I policy, an analysis of ICT innovation policy has been conducted for this report by applying game theory. The example is related to joint R&D&I programmes such as the European Framework Programmes. The establishment of dedicated programmes is understood as a strategic interaction of players in terms of game theory: the European Commission seeks to maximise expected benefits in the EU, national governments seek to maximise expected benefits in the country, and companies seek to maximise expected profits.

By means of backward induction, i.e. by analysing possible outcomes of the game beginning with the last stage (competition), the analysis leads to the findings presented. The most important lessons for the European Commission are related to the optimal design of the framework conditions of the joint R&D&I programme before its inception. The EC faces a dilemma: on the one hand it has to ensure that firms and national governments profit from taking part in the programme, in order for the programme to gather a critical mass of protagonists; on the other hand the incentives offered to firms and national governments must remain as low as possible, in the interests of the broad European public. The design of joint R&D&I programmes may therefore require special attention.

Key insights are that public funds need to be conditioned on the R&D&I investment of each firm, i.e. public funds should be

EXHIBIT 4.1-4: KEY FINDINGS FROM THE THEORETICAL ANALYSES OF E-BUSINESS ADOPTION

Insights from industrial organisation theory	**1. A single firm's view on e-business process innovation** • Firms may have an incentive to forego actual cost savings by delaying their investment in order to benefit from lower prices, better technologies or compatible standards in the future. • Firms producing large quantities or interacting with many suppliers and customers may be more willing to invest in process innovations. **2. Horizontal market structure issues** • The more an expected or existing e-business innovation hurts competitors, the higher the innovation incentives for other firms. • Investment incentives increase with the size of the market as well as a firm's market share; large firms may invest more in ICT than small firms. **3. Vertical market structure issues between ICT suppliers and users**: ICT producers may increase demand for their products by reputation building, relational contracts, second sourcing. **4. Vertical market structure issues among ICT-using companies** • Strategic incentives imply that a group of firms may not be able to coordinate their mutually related e-business investments or that they agree on suboptimal e-business solutions. • Asymmetric vertical market structures lead to asymmetric ICT investment incentives, favouring large companies and disadvantaging small suppliers. **5. Coordination and network effects**: Firms at either level of the value system may try to use their own e-business standards to protect their positions by preventing other firms from entering the market.
Possible market failures	**Market failures in developing electronic value systems** • e-Business investment may reduce the number of firms in the market and thus contribute to a higher degree of market concentration. But this does not imply a market failure per se. • If large firms invest in proprietary e-business solutions, small suppliers face a higher risk of getting locked into one specific ICT solution. • Even though overall gains from trade may be distributed asymmetrically between suppliers and buyers, this does not imply a market failure as long as quantities are chosen efficiently.
Possible state failures	• Policy measures which simply focus on the participation of SMEs in the digital supply systems of larger companies may not alter the investment of these companies' decisions, and may even distort the equilibrium of market structures, sustaining uncompetitive SMEs, and decreasing the overall efficiency of the sector. • Large firms may opt for public policies which subsidise SMEs in order to ensure that their up- or down-stream markets remain competitive. • International harmonisation can be detrimental for large domestic firms, which may induce national governments to stick to national solutions.

EXHIBIT 4.1-5: KEY FINDINGS FROM THE GAME THEORY ANALYSIS OF A TECHNOLOGY PLATFORM

Stage	Implications
Competition	• Asymmetric knowledge acquisition, economies of scale and scope, and first mover advantages may lead to high competitive advantages for large firms, and induce asymmetric market equilibria with a small number of dominant firms. • National governments may face a prisoners' dilemma: if all governments supported their national firms, their efforts would cancel each other's out, and no country would benefit from the overall situation. Coordination between governments can avoid these inefficiencies.
Application-oriented research	• Firms with a high probability of prevailing in tomorrow's market invest in their own application-oriented research and are supported by their national governments. • Groups of firms and countries acting cooperatively outdo non-cooperative research strategies targeted at monopolising the market. While the application-oriented research stage can lead to different equilibria, a few firms or countries may trigger one of the extreme equilibria leading to either symmetric or asymmetric market equilibria.
Basic research	• There are three main reasons why an R&D technology platform has not yet emerged: the free-rider problem, commitment problems, and independent research by large firms. • Investment in basic research can be either inefficiently high or inefficiently low, depending on the players' equilibrium strategies.
Framework conditions	**General instruments** of the European Commission to prevent non-cooperative company strategies include: • consideration of the industry's history (including precedents for joint R&D without public support) • independent evaluation of research proposals from companies • conditioning public funds on prior investment from the company Instruments for the **first stage** of the game (basic research): • explicit rules for national governments not to establish competing national research programmes • prescribe minimum investment requirements in basic research • banning firms that did not participate in basic research from joining the platform in later stages Instruments to prevent strategic behaviour in **later stages** of the game: • dissuading firms and national governments from leaving the platform and pursuing their own research programmes • preventing national governments from subsidising national firms

granted only to projects that have already gathered a given amount of investment, and where national governments are prevented from establishing their own programmes and subsidising national firms.

4.1.4 CASE STUDIES

This section provides summaries of case studies that were conducted for this study. The complete case studies are included in the study report, available on the Sectoral e-Business Watch website.

Case 1: Networking and Information Technology Research and Development (NITRD) Programme, USA

Initiated by the United States Congress in 1991, the Networking and Information Technology Research and Development (NITRD) programme has evolved into the principal tool to support, manage, and coordinate the US Federal government's non-classified ICT-related R&D. The NITRD programme comprises more than a dozen Federal member agencies and has an operating budget of US$ 3.5 billion (projected for 2009). This budget is directed towards grants for advanced ICT R&D, workshops designed to foster R&D and innovation in the ICT-producing industry, and working partnerships with academia and the private sector to foster technology transfer.

Evaluation by the Council of Advisors on Science and Technology

The NITRD programme's principal mechanism for assessment and evaluation of its programmes' overall operational performance is the President's Council of Advisors on Science and Technology (PCAST). The August 2007 assessment (with a new assessment scheduled to be published in 2010) provides a review of the global ICT competitive environment, the domestic ICT landscape, and an assessment of how well "the NITRD programme is positioned to help sustain and strengthen US leadership in these critical technologies". According to the PCAST's assessment, the most critical challenge for the NITRD programme in the future is to expand and improve the ways in which networking and information technology R&D is funded and conducted. This pertains not only to the Federal government but also to universities and ICT producing industries. Some critical lessons that can be learned from the NITRD's programmes and projects in the past are related to groundbreaking research and technology transfer.

Focus on groundbreaking research

In its present state, the Federal ICT R&D portfolio is skewed towards low risk, small scale and short-term efforts. Few projects, whether large or small, can be seen as visionary or groundbreaking. Therefore, Federal agencies, as well as the NITRD programme itself, should seek to support R&D projects that operate on a large scale and have longer time horizons. Moreover, greater emphasis should be placed on innovative, and often high-risk, R&D that may improve upon current paradigms or standards in the ICT arena.

Technology transfer and commercialisation

To date, the NITRD programme has not realised its potential as a conduit for ICT-related R&D to the private sector through the process of technology transfer. Historically, attention has mainly been placed on coordination of ICT R&D between the Federal agencies that are members of the programme. However, as more nations pursue an aggressive ICT public policy, the ability of the private sector to flourish in ICT-related fields may have important implications for the Federal government's use of IT as both a public policy tool and a strategic resource.

Therefore, increasing both the breadth and depth of communication between Federal agencies and the private sector might help facilitate technology transfer. Regular working groups can improve communication in such a way. They may also lead to a more robust relationship, where leaders of industry and Federal agencies meet regularly to talk about strategic issues facing both arenas, rather than simply organise policy functions and projects. For technology transfer to be truly effective, public-private communication and partnerships need to be institutionalised as a process and used as a starting point rather than an objective. Furthermore, clear strategic objectives should be published, with metrics for how to evaluate and analyse the success or failure of any given partnership or programme.

Case 2: South Korea's former IT839/u-IT839 strategy

South Korea's economy depends heavily on international trade, and its IT-related products account for almost one third of its total exports. In particular, the mobile telecommunication sector is a strategic trade commodity for South Korea. The former IT839/u-IT839 master plans that lasted from 2004 to 2008 played an important role in this respect. Having successfully pioneered the world's first commercialisation of the Code Division Multiple Access (CDMA) mobile telecommunications services in 1996, South Korea forged ahead with the deployment of next-generation techniques that evolved from CDMA, such as Wideband CDMA (W-CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) technologies, under the new directions of the IT839 master plan in 2004. As a result, South Korea became exceptionally strong in mobile telecommunications and broadband technologies. The IT839/u-IT839 master plan contributed to the strengths of South Korea's mobile phone industry today: a world class mobile communications infra-structure, a leading position in business related to the CDMA mobile standard, and the presence of diverse content developers.

What distinguishes South Korea from other economies, such as the US and Europe, is the intense cooperation between the IT industry and the government, where the government allocates adequate resources towards the development of broadband, mobile and wireless technologies. In fact, the birthplace of several of Korea's technologies is not the laboratories of corporate IT giants, such as Samsung Electronics or mobile operator SK Telecom, but in the non-profit government-funded Electronics and Telecommunications Research Institute (ETRI). The ETRI was established in 1976, in Daeduk Valley, a high-tech region of Daejeon City, 170 kilometres south of Seoul. By 2008, ETRI had hired some 3,000 employees, almost two-thirds of which were researchers.

Considering this high dependence on external trade, it is rational for the national government to focus development efforts on the IT industries. The following lessons can be learned from the IT839/u-IT839 master plan for the successful development of the mobile telecommunications industry.

Proactive government support is crucial: The South Korean government plays a dominant role in influencing the country's IT industry. The proactive role of government policy in the telecommunications industry was crucial in propagating new standard platforms such as ADSL for the Internet and CDMA for mobile phones. As the policy of IT839/u-IT839 has shown, the integrated development of IT services, infrastructure, and devices creates synergies and is essential along the industry's value chain. The government also fosters business networks and develops well-equipped infrastructures to support entrepreneurship in the local IT industry. Furthermore, the government maintains close international links.

Assisting entrepreneurs: With increasing numbers of successful entrepreneurs, the South Korean government can tap into a pool of positive role models to mentor newcomers. Through support programmes and entrepreneurial educational programmes, potential inventors are encouraged to commercialise their ideas. Many established entrepreneurs have become key players in establishing business networks among technical specialists, venture capitalists and angel investors. A noticeable obstacle that most technical specialists who invent technologically innovative and cutting-edge products face is launching their inventions. A positive business atmosphere that shares market-related knowledge, such as customer contact and access to distribution channels, would in turn motivate innovative scientists and engineers to create new firms.

Internationalisation: The IT839/u-IT839 strategy has encouraged entrepreneurs to build ventures based on technical innovations. However, most venture firms are observed to concentrate primarily on the domestic market. This is in part due to the lack of contacts, experience and business collaborations with and in foreign markets. Thus, strategic partnerships could be encouraged to alleviate this trend. The focus today is on providing better market positioning and support for the Korean IT sector to penetrate the global market further.

Case 3: Cluster Automotive Region Stuttgart (CARS), Germany

Cluster Initiative Automotive Region Stuttgart (CARS) is an initiative of the regional economic development agency in Stuttgart, Germany, which seeks to enhance co-operation between car manufacturers and their suppliers and to foster innovation. Establishing and improving electronic linkages in the companies' value systems and addressing problems related to e-business standards are among the important objectives of the initiative. CARS includes three IT initiatives which seek to raise awareness for the benefits of e-business and which provide guidance for implementation: one of the initiatives, named "Cluster Initiative Automotive Stuttgart Region – IT" (CARS-IT), was designed for the regional automotive industry. The other two, "Virtual Dimension Competence Centre" (VDC) and "Collaborative Virtual Engineering for SMEs" (COVES), follow a cross-sector approach. These three initiatives also develop new technologies for the electronic linkage of the value system.

Impacts, and barriers to more intense impacts

All three ICT initiatives as well as CARS itself reported that the major difficulty in enhancing e-business use is the prevalence of proprietary standards for hardware and software. The interviewees expected the European Commission to play an important role in standardisation policy. In particular, they referred to software standards, from basic office applications to specific e-business standards for PDM, CRM, ERP and CAD software. Standards of the most prevalent products are owned by large software companies. One issue is the power of automobile manufacturers. Suppliers are obliged to use particular e-business systems when cooperating with large companies. If they do not comply, they risk being excluded from the procurement process. The pressure of investment in systems operating with proprietary ICT standards is therefore on suppliers. However, many SMEs face severe difficulties in funding investment in such systems. They risk being replaced by competitors – or not becoming a part of the value chain in the first place. There have been cases of companies that dropped out of the value chains because they did not comply with the requirements of large companies.

The interviewees reported that e-skills are highly relevant for the CARS cluster with regard to being able to apply and manage increasingly complex hardware and software. The Stuttgart region's specialised universities, training organisations and employers provide a large pool of well-educated ICT practitioners. Nevertheless, CARS-IT and VDC perceive a demand for e-business and practitioner e-skills in SMEs within the cluster. They try to play a broker role between regional training institutes and SMEs, and develop curricula that are specialised in e-skills.

Lessons learned and further initiatives

With regard to e-business and ICT-related industrial policy, there was one issue that repeatedly surfaced during the interviews: proprietary standards are impeding innovation. Actors in the Stuttgart region tackle the problem of e-business standards with two principal measures:

- CARS managers articulate the issue towards the European Commission within a network of other cluster initiatives within Europe Innova. Policy making in the field of e-business standards was reported to have a long tradition, but regional actors have not seen many major improvements.
- The regional development agency WRS and CARS-IT try to raise awareness among car manufacturers and suppliers about the e-business standards issue with regard to the barriers to innovation and probable solutions. Some interviewees saw the application of open source software as the key to a solution. Open source software provides a promising alternative to subsidising SMEs, as it is often free, and therefore sidesteps the problem of whether smaller companies can afford it.

Many interview partners mentioned a further issue relevant for enhancing e-value chains: mentality differences between engineers and IT developers. Due to different experiences and expert knowledge backgrounds, a broker between the different knowledge types may be needed to bring both sides together. This may help to connect different segments of the value chain.

4.1.5 EXPERT SURVEY ON ICT INNOVATION AND ADOPTION

Survey methodology

In June 2009, empirica conducted an expert survey on ICT innovation and adoption, which is included in this report in the section "the SeBW ICT Innovation and Adoption Survey 2009". The purpose of this survey was to validate, extend and deepen insights from literature evaluation, theoretical analyses and interviews also conducted for this report.

The 236 experts invited to participate in the survey were members of the European e-Business Support Network (eBSN) and of an informal group managed by empirica named "European Network for Information Society Research". Since the selection of experts was deliberate, not random, findings presented in the following are not representative in a stochastic sense. Nevertheless the survey provides insightful opinions about ICT innovation and adoption.

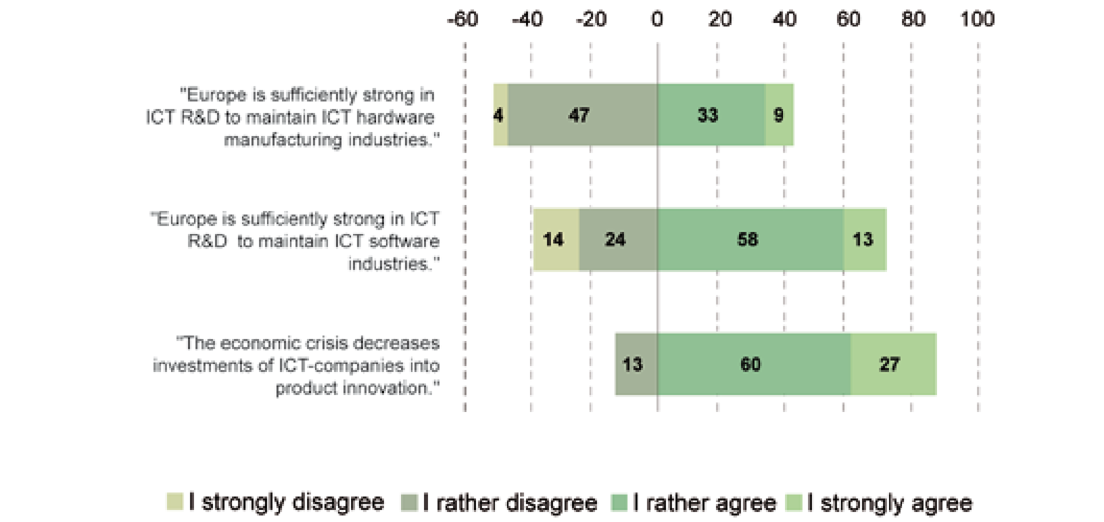
The survey took place in June 2009. The experts were asked to fill in an online questionnaire. 45 complete replies were received, resulting in a response rate of 19%. A key design aspect of the online survey was to allow for a reasonably quick completion while ensuring insightful findings. The intended average time to fill in the questionnaire was ten minutes.

Respondents' professional affiliation and country of origin

About a third of the respondents were affiliated with universities and research organisations (34%), and about a quarter with public authorities (23%). The other respondents came from consulting (13%), business associations or trade unions (11%), e-business initiatives (9%), ICT-using manufacturing companies (5%) and other organisations (4%).

Respondents from 19 European countries answered the questionnaire. The six largest countries in the sample were the UK (accounting for 14% of respondents), France (7%), Germany (5%), Italy (7%), Spain (5%) and Poland (2%). A large share of respondents came from Greece (12%). All in all, the sample is balanced with regard to countries of origin.

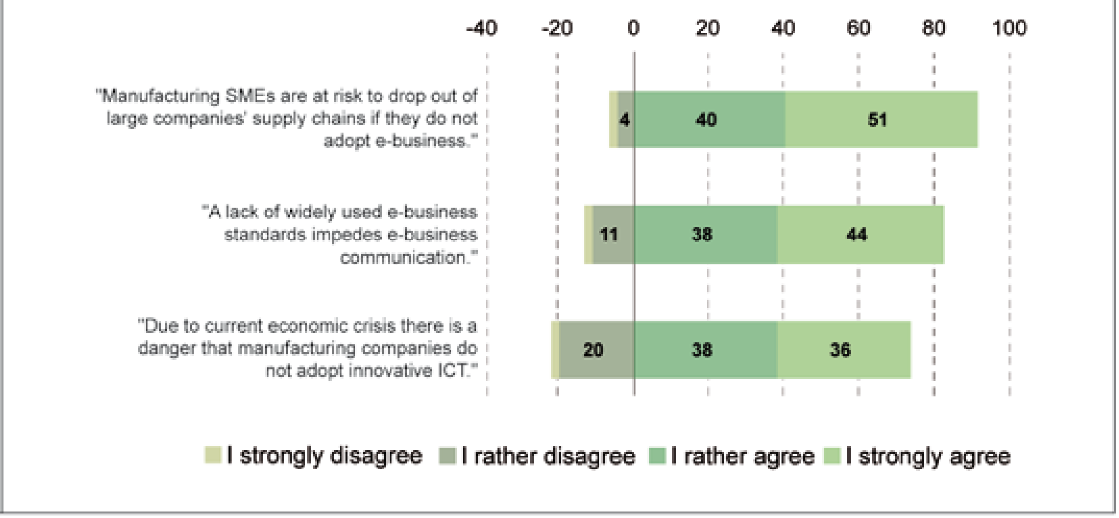
EXHIBIT 4.1-6: EXPERTS' ASSESSMENT OF THE SITUATION IN EUROPEAN ICT R&D&I IN 2009 (IN %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

EXHIBIT 4.1-7: ASSESSMENT OF THE CURRENT SITUATION OF ICT AND E-BUSINESS DIFFUSION (IN %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

Current situation of ICT research, development and innovation

Experts were first asked whether they agreed that "Europe is sufficiently strong in ICT R&D to maintain **ICT hardware manufacturing** industries". The share of respondents disagreeing with this statement was larger than the share agreeing (see Exhibit 4.1-6): 47% answered "I rather disagree", 4% "I strongly disagree" versus 33% "I rather agree" and 9% "I strongly agree". 7% did not answer this question. The large share of pessimistic respondents may reflect the currently difficult competitive situation of the European hardware industry. When asked about **software**, the respondents were more optimistic. Two thirds of the respondents agreed that "Europe is sufficiently strong in ICT R&D to maintain ICT software industries" (58% "I rather agree", 13% "I strongly agree"). Only a minority disagreed (24% "I rather disagree", 4% "I strongly disagree"). Among the individual statements there was one that "the future of Europe lies in software and services". This reflects the common view that European software production is more competitive than hardware production.

There was even stronger agreement that the economic crisis was decreasing investment of ICT-producing companies in product innovation: 60% rather agreed, 27% agreed strongly, and only 13% rather disagreed. This indicates that there is widespread fear that the European ICT-producing industries may lose ground to competitors in the economic crisis.

One of the respondents stated that one should "make a distinction between R&D and innovation. They are not necessarily linked!" This view is also expressed in the Commission's Communication on key enabling technologies of September 2009: "the EU has very good research and development capacities in some key enabling technology areas; however it is not as successful in commercialising research results through manufactured goods and services".[1] Another respondent said that "research, innovation etc. is not what will sustain ICT manufacturing industries in Europe. Low cost economies surely will be the driver for locating these firms". Two other respondents pointed to a lack of venture capital.

Current situation of ICT and e-business diffusion

The majority of respondents agreed with the following three questions related to ICT and e-business adoption in manufacturing companies (see Exhibit 4.1-7):

- 40% rather agreed and 51% agreed strongly with the statement that "manufacturing SMEs are at risk of dropping out of large companies' supply chains if they do not adopt e-business".
- 38% rather agreed and 44% agreed strongly that there is a "lack of widely used e-business standards that impedes e-business communication". One expert stated that "standards alone will not solve the problems"; there is a need for "better mapping between standards in use, good stories on implementations (not just case studies) and other actions to increase willingness to risk new approaches".
- 38% rather agreed and 36% agreed strongly that "due to the current economic crisis there is a danger that manufacturing companies do not adopt innovative ICT".

One of the experts said that "e-business and e-business standards are not the main barriers to growth in this sector". This statement is a reminder that ICT and e-business may be of minor importance for companies' and industries' competitiveness, while other aspects such as production technology may be crucial.

Competitiveness of ICT-producing companies

There was almost unanimous agreement among the survey respondents that ICT R&D and innovation in Europe needs to be improved – see Exhibit 4.1-8. The agreement was strongest for the statement that "ICT R&D in companies needs to be improved": 51% of the respondents rather agreed and 47% agreed strongly; no one disagreed. Experts also saw a need for improvement of ICT R&D in research institutions, of co-operative R&D on national and European levels, and of market introduction of new ICT. For all these items, more than 90% of the respondents agreed.

The statement leading to most discord was that "legislation ensuring that ICT companies can sell to customers EU-wide needs to be improved" (29% each for "I strongly agree" and "I rather agree"; 27% rather disagreed). For this statement, the share of respondents providing no answer (16%) was the second highest in the whole survey. Possibly the importance of the single market for the ICT companies' ability to sell their products is less well understood than the importance of ICT research, development and innovation.

Two individual statements pointed out the need for cooperation on a European level: "Europe cannot overcome USA, Japan and China competition without a united approach" and "Framework [Programme] 7 is a major opportunity". Another expert pointed to the marketing aspect of innovation: "Good products generate customer demand. R&D organisations should set more challenging and higher-impact goals and engage stronger multi-disciplinary teams beyond technology/engineering/ science expertise alone."

Competitiveness of ICT-using manufacturing companies

A large majority of respondents agreed about the need for more ICT-using manufacturing companies in Europe to

[1] European Commission (2009b) p. 3.

EXHIBIT 4.1-8: ASSESSMENT OF COMPETITIVENESS OF ICT-PRODUCING COMPANIES (IN %)

n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Online Survey 2009

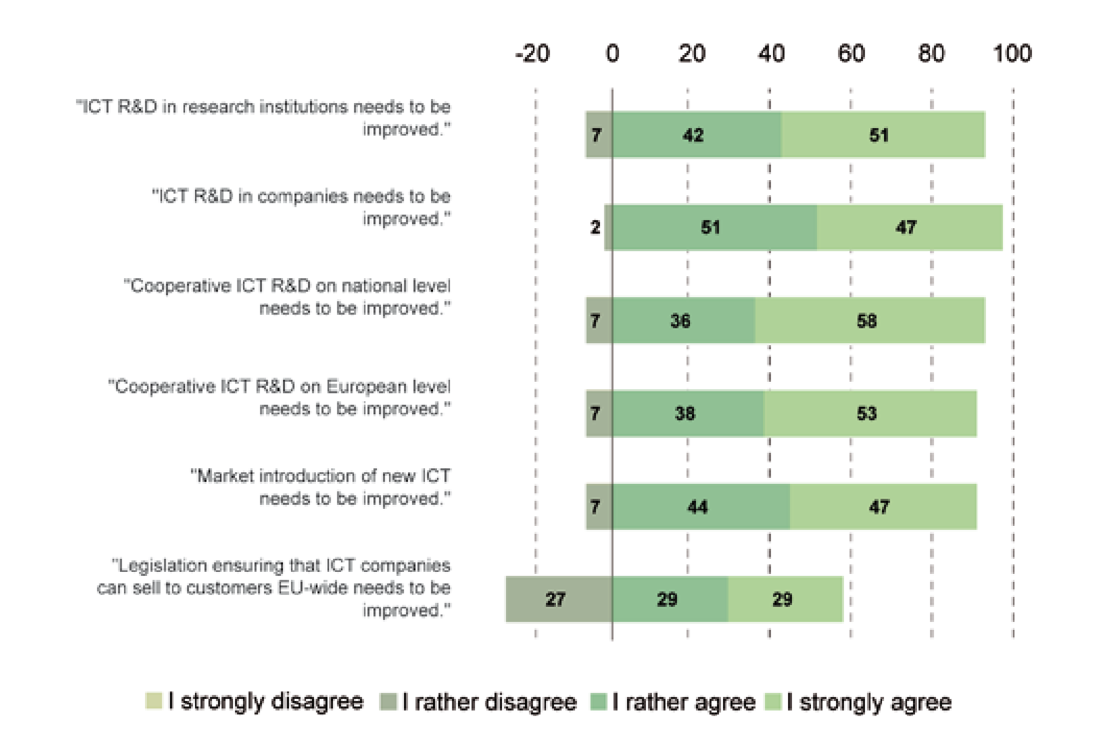
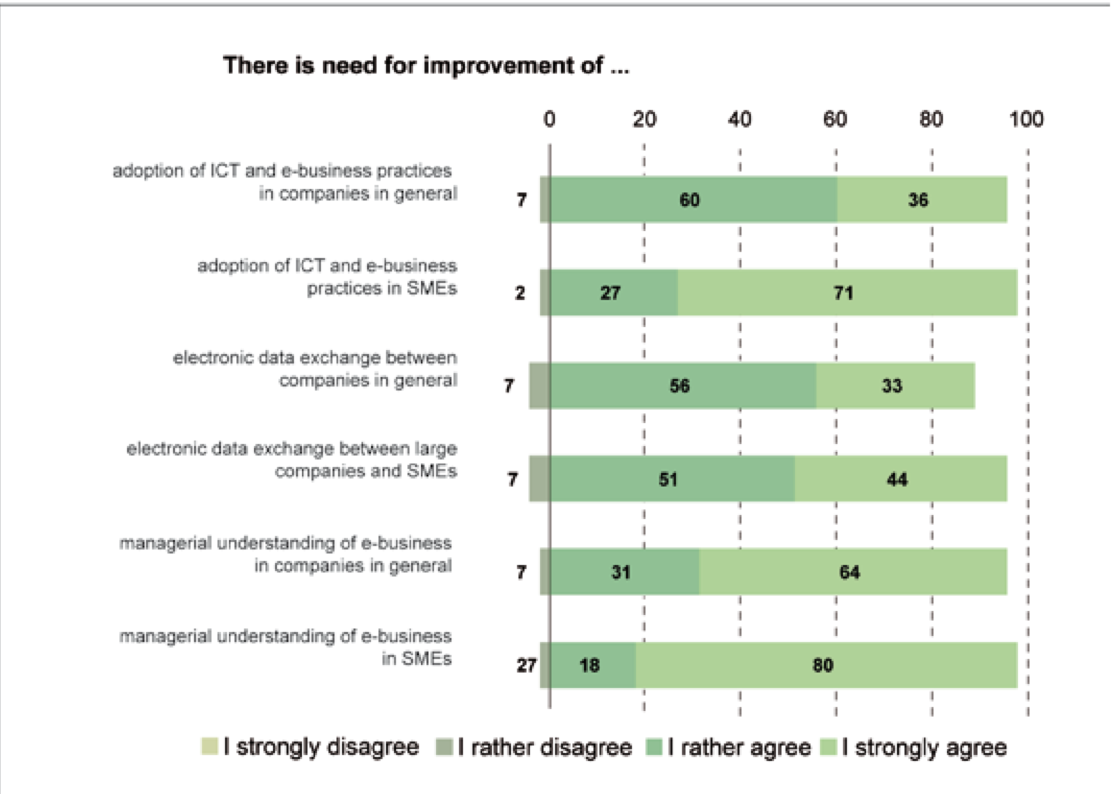


EXHIBIT 4.1-9: ASSESSMENT OF COMPETITIVENESS OF ICT-USING MANUFACTURING COMPANIES (IN %)

n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009



adopt e-business: more than 85% agreement was recorded for all statements related to this issue (Exhibit 4.1-9). This may be expected considering the purpose of the eBSN and the mindset of its members. One expert stated that it is "difficult to disagree with any of the previous statements, which are somewhat self-evident". However, these unequivocal assessments may be useful for decision makers who are not necessarily experts in the field and will have to decide about issues related to ICT and e-business adoption.

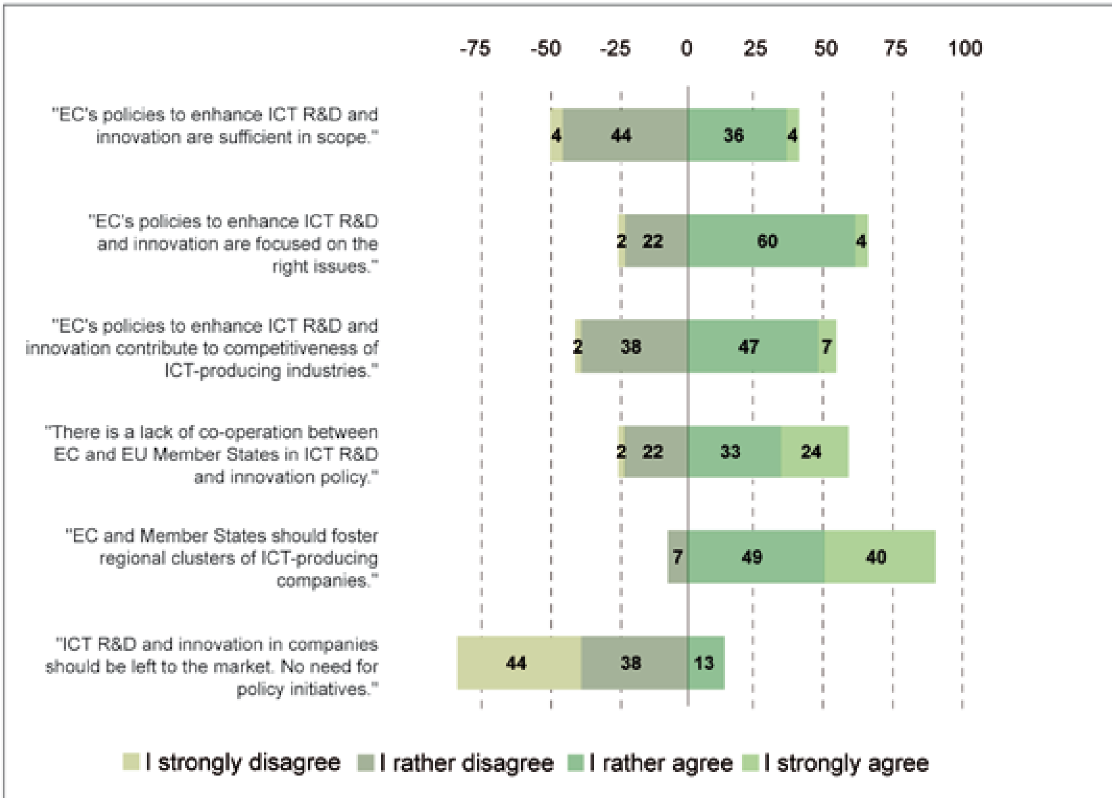
It is useful to look more closely into how answers are shared between strong agreement and some agreement. The highest levels of strong agreement were recorded for respondents asked about the need for improvement of "managerial understanding of e-business in SMEs" (80%) and "adoption of ICT and e-business practices in SMEs" (71%). Experts appear to believe that these are the most important areas in which SMEs need to catch up, while the improvement of "electronic data exchange between large companies and SMEs" is less urgent (44% "agree strongly"). On the other hand, the levels of strong agreement were much smaller for "electronic data exchange between companies in general" (33%) and "adoption of ICT and e-business practices in companies in general" (18%).

Policies for ICT-producing companies

Six questions about policies to support ICT-producing companies were asked. Answers were mixed, as shown in Exhibit 4.1-10. Asked whether "the European Commission's policies to enhance ICT R&D innovation are **sufficient in scope**", the majority disagreed (4% strongly and 44% rather disagreed). A smaller share (40%) agreed with this statement (36% somewhat and 4% strongly). Thus, considering that ICT R&D&I investment in the EU is below that in the US and Japan, these results may encourage the European Commission to extend its ICT R&D&I efforts.

There was agreement with the statement that "the European Commission's policies to enhance ICT R&D and innovation are **focused on the right issues**": 60% rather agreed

EXHIBIT 4.1-10: ASSESSMENT OF POLICIES FOR ICT-PRODUCING COMPANIES (IN %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009 and 4% agreed strongly, while 22% rather disagreed and 2% disagreed strongly. Thus, according to the majority of respondents, there is no pressing need for the EC to realign the focus of ICT R&D&I support. However, one respondent added a statement about what he perceived to be the downsides of the EC's R&D&I policies: "By their fruits shall you know them. EU policies are not working as intended. Projects do not have sufficient impact on real products, there is little building on existing knowledge research, there are also strong nationalistic determinants in ensuring local benefits rather than pan-European community wide benefits; a way through this could be to encourage regional-based community clusters. Policy initiatives are essential, but they must be effective and structured in a way to ensure the best from the community of interest."

Contribution to competitiveness: Half of the respondents also believe that the EC's policies to enhance ICT R&D and innovation contribute to the competitiveness of ICT-producing industries (44% rather agreed, 7% agreed strongly). However, there was also a considerable share of respondents who believed the opposite (35% rather disagreed, 2% strongly disagreed). One expert stated that "the word decisively is crucial in explaining my answer. Has contributed, but not decisively." Another expert stated: "Regarding the competitiveness of the ICT industry, the knowledge transfer or exploitation of research results should be more supported (although the best solution is research on demand). Possibly, each project should have WP for exploitation and transfer, and employ a specialist for selling ideas." Knowledge transfer is also a key issue of concern in the European Commission's Communication on key enabling technologies.[2]

The majority of respondents agreed with the statement that "there is a lack of **cooperation between the EC and EU Member States** in ICT R&D and innovation policy" (33% "rather agree", 24% "strongly agree"). However, there was also a large share of respondents who gave no answer (18%), in fact the largest share in the whole survey, which indicates that this is a difficult question.

The clearest majority was found for the statement that "EC and Member States should foster **regional clusters** of ICT-producing companies": 49% rather agreed, 40% agreed strongly, and only 7% rather disagreed. In turn, one may conclude that there is apparently widespread comprehension that the ICT R&D&I landscape in the EU is too fragmented, as the European Commission points out in its recent Communications on key enabling technologies[3] and on ICT R&D&I[4]. One of the respondents commented on the type of clustering: "Be careful, we do not need to support only 'one way' of doing something. In the case of ICT clusters, for instance, we need to focus the adoption of standards for e-business through all the different types of actors and solutions (ERPs, ASP services, ...)".

Reflecting the previous answers that indicated broad appreciation of the European Commission's policies, there was clear disagreement with the statement that "ICT R&D and innovation in companies should be left to the market; there is no need for policy initiatives". 44% disagreed strongly, 38% rather disagreed, and only 13% rather agreed.

Policies for ICT-using manufacturing companies

The last set of questions concerned policies for ICT and e-business adoption in ICT-using manufacturing companies. As in the case of policies for ICT-producing companies, a range of answers was recorded – see Exhibit 4.1-11. Two thirds of the respondents (65%) disagreed with the statement that "the European Commission's policies to enhance ICT and e-business adoption in companies are sufficient in **scope**". 9% disagreed strongly, 56% rather disagreed. A minority of 27% rather agreed. The level of disagreement was higher than for the similar question for ICT-producing industries. This may reflect that the eBSN members among the respondents see a particular need for extending policies in their field of expertise. One respondent pointed out that extending the scope of e-business policies should not neglect quality: "The European Community needs to be able to better facilitate more integrated economic R&D and the application of interim and final results across communities of interest. Look again at mechanisms to review projects and terminate ones that are not delivering as expected and agreed. Use the money saved on more important and effective programs."

Many participants also disagreed with the statement that "the EC's policies to enhance ICT and e-business adoption contribute to the **competitiveness** of ICT-using manufacturing industries" (51% "rather disagree", 5% "strongly disagree"). This may refer to the assessment that the EC's policies are not sufficient in scope, or it may

[2] European Commission (2009b), pp. 7-8.
[3] European Commission (2009b).
[4] European Commission (2009a).

EXHIBIT 4.1-11: ASSESSMENT OF POLICIES FOR ICT-USING MANUFACTURING COMPANIES (IN %)

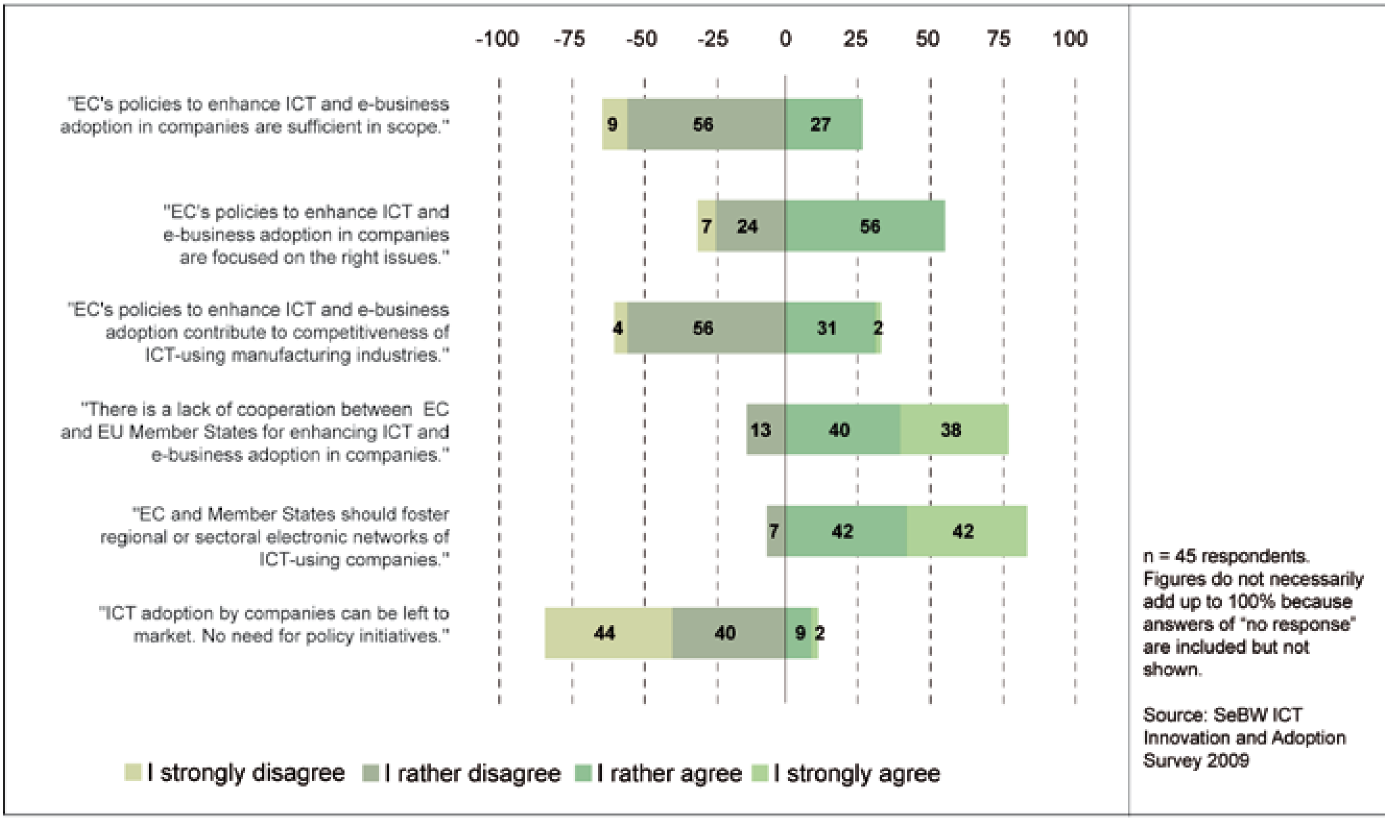
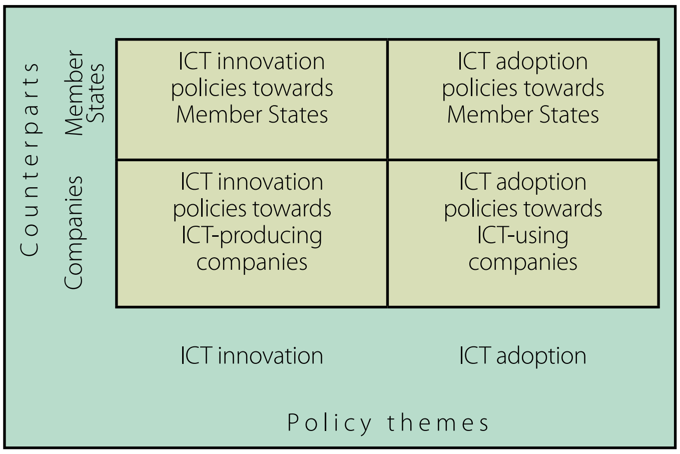


EXHIBIT 4.1-12: MATRIX OF ICT-RELATED INDUSTRIAL POLICY OF THE EUROPEAN COMMISSION



Source: empirica

indicate that e-business adoption is not crucial for the competitiveness of manufacturing industries.

There was also large disagreement with the statement that "ICT adoption by companies can be left to the market; there is **no need for policy initiatives**". 81% of the respondents disagreed with this; 44% strongly and 37% rather disagreed. Only 9% agreed. One of the respondents stated "I strongly disagree, especially with regard to SMEs".

On the other hand, half of the respondents (51%) rather agreed with the statement that the "EC's policies to enhance ICT and e-business adoption in companies are **focused on the right issues**". This can be taken as a confirmation of the focus on electronic value system enhancement, e-business standards adoption and e-skills development. As regards standards, one respondent pointed to shortcomings on the part of the European Commission: "EC activities partially fail in standards promotion; nevertheless something new is appearing recently in the right direction (DG enterprise and sectoral standardisation and harmonisation)." Taken together, the answers to these four questions confirm the EC's e-business policies are well received, but encourage the EC to go further in its efforts.

The respondents would also appreciate more **cooperation between the EC and Member States** for enhancing ICT and e-business adoption in companies. Almost four fifths (78%) agreed that there is "a lack of co-operation between EC and EU Member States for enhancing ICT and e-business adoption in companies" (40% weak and 38% strong agreement). An even higher share of respondents (84%) agreed that "EC and Member States should foster **regional or sectoral electronic networks** of ICT-using companies." This is in line with the current eBSN focus to foster electronic data exchange between companies.

4.1.6 POLICY IMPLICATIONS

A proposed matrix for ICT-related industrial policies of the EC

The study suggests a concept for developing more refined ICT-related industrial policies of the European Commission, that distinguishes between policy themes and counterparts. The two principal themes are policies for ICT product innovation and policies for e-business adoption. The two principal counterparts are companies and Member States. Taking these themes and target groups together leads to a matrix with four distinct fields of ICT-related industrial policy of the EC, as depicted in Exhibit 4.1-12.

This matrix may be considered as a starting point for further, more complex breakdowns of themes and target groups, depending on the specific objectives of policy makers. For example, ICT-producing companies can be broken down into hardware- and software-producing companies; Member States can be broken down into regions or subdivided into groups of countries with diverging interests.

A note about assessing the implications

The following implications are drawn largely from theoretical arguments. They are therefore on a highly abstract level of argumentation. From a practitioner's point of view, the implications may not sufficiently consider practical policy making and institutions existing in real life. One could also argue that there are competing theories which may lead to other results. One may also object that the implications are on a very high level of aggregation, considering the EC, companies and Member States as fairly unified entities. This may not sufficiently consider the complexity of interaction between the EC, Member States and companies and the diverging interests of different companies and Member States. These objections are correct. However, the following implications may nevertheless provide insights and guidance as valuable "food for thought" or a "rubbing surface" for current policy practice.

European Commission ICT innovation policies towards companies

Appropriability as an argument for public support of companies' R&D&I

ICT research, development and innovation (R&D&I) raises a general problem of appropriability. It is difficult for companies to appropriate the returns from the creation of new knowledge due to external effects. Creating and using knowledge may imply that others learn from it, without having to pay for it. ICT product innovation implies the creation of new knowledge. This implies that the firms' incentives to innovate may tend to be inefficient from a societal perspective – there tends to be underinvestment in R&D&I. More specifically, there may be underinvestment in ICT R&D&I in the current economic crisis. In the expert survey conducted for this study, 87% of the experts agreed with the statement that "the economic crisis decreases investment of ICT-producing companies in product innovation". The respondents also agreed unanimously with the statement that "ICT R&D in companies needs to be improved".

> **Policy implication 1:**
> **The appropriability problem is a general argument for public support of ICT R&D&I**
> Problems to appropriate the returns from newly generated knowledge and from product innovations imply that there is underinvestment in ICT R&D&I from a societal perspective.

Possible revision of contributions to commercialisation costs

The European Commission believes that Europe is not as successful in commercialising research results as it is in conducting R&D. As regards ICT R&D&I, difficulties in capitalising on research results may be related to special features of ICT, including short innovation cycles and smaller investments for R&D but higher investments for commercialisation. High investment requirements for commercialisation and marketing activities may imply that companies do not commercialise new ICT products because of a lack of information about potential demand. This problem is aggravated by standardisation and compatibility issues between existing and new ICT products as well as competitors imitating innovations - often at a low cost. It could be worthwhile for policy makers to think about revising public funding schemes so as to increase the contribution to costs of individual commercialisation activities.

Furthermore, the characteristics of short innovation cycles, high commercialisation costs, compatibility issues and imitation risks favour large ICT-producing companies. Short innovation cycles imply that large firms have at least two advantages vis-à-vis small firms when R&D&I is considered: a large established customer base, and reputation with regard to product quality. Furthermore, large firms offering established ICT products with large customer bases can easily leverage their market power such that they become dominant on the markets for new and compatible components too. Large firms may also be especially willing to imitate the ICT innovations of small firms to prevent competition for customers.

However, any revision of funding schemes in the way described should be designed very carefully in order to prevent windfall profits for companies and to prevent market distortions caused by favouring one technology over others.

Policy implication 2:
Rethink the percentage of public contribution to commercialisation costs
Considering the high commercialisation costs and relatively low R&D costs of innovative ICT products, it could be worthwhile to increase the maximum percentage of public contributions to the commercialisation of ICT-producing companies. As large firms were found to have advantages over SMEs with regard to ICT product innovation, the percentage of contributions could be higher for ICT-producing SMEs.

Prevent inefficient collusion between firms in R&D&I joint ventures

The SeBW ICT Innovation and Adoption Survey 2009 found that cooperative ICT R&D on national and international levels needs to be improved. The theoretical analysis in this report suggests that research joint ventures may lead to higher R&D&I investments when firms share information which have positive spill-over effects. However, cooperation may also have downsides: asymmetric joint ventures increase the large firms' incentives to invest, lead to more intense competition vis-à-vis potential competitors, and may thus prevent market entry. Large firms may also use R&D&I joint ventures with small firms to control their innovations and to try to slow down the innovation race.

Policy implication 3:
Prevent inefficient collusion – restrict the scope of agreements in joint ICT R&D&I
R&D&I policies which encourage joint ventures without restricting the scope of the respective agreements may thus not only spur innovations, but facilitate inefficient collusion between firms. Policy makers should thus consider the possible downsides of R&D&I joint ventures carefully when enacting policies to promote them.

Prevent free-riding and self-serving behaviour in joint R&D&I programmes

Joint European R&D&I programmes, for example European Technology Platforms, foster technological innovation in the Community. A game theory analysis of such programmes suggests that the European Commission should seek ways to prevent companies from either joining late or leaving early. This means that, first, firms that did not participate in the basic research stage of a joint programme are not allowed to join the platform in later stages. Second, there need to be instruments to prevent strategic behaviour in later stages of the game: firms must not have an incentive to leave the platform and to perform their own research programmes with insights they gained in public programmes. Such self-serving behaviour will be difficult to prevent if firms anticipate large economies of scale or scope and large first-mover advantages. An indirect measure in this respect may be to prevent national governments from subsidising national firms that participate in joint European research programmes.

Policy implication 4:
Prevent companies joining joint R&D&I programmes late or leaving them early
In order to prevent free-rider behaviour in the first

stage or self-seeking behaviour in later stages, R&D&I programmes should prevent companies from late joining or early leaving.

European Commission ICT innovation policies towards national governments

Coordination of national ICT R&D&I policies and grants

The European Commission sees a critical need for enhanced cooperation between the Community and the Member States in R&D&I, in order to create critical mass and to prevent inefficient duplication of efforts. The majority of respondents of the SeBW ICT Innovation and Adoption Survey 2009 (57%) agreed with the statement that "there is a lack of cooperation between the EC and EU Member States in ICT R&D and innovation policy". Such coordination problems may apply to dispersed R&D&I activities in any region, as the example of the US Networking and Information Technology Research and Development programme shows.

From a theoretical point of view, there is a basic argument in favour of coordinating the ICT R&D&I policies of different countries. National R&D&I grants are driven by the ambition of national governments to strengthen their domestic industries in order to foster competitive advantages and national growth. These strategic incentives can lead to an equilibrium in which countries spend more on grants separately than they would have if they had coordinated their grants. Coordination of national governments' R&D&I policies and grants through the EU can help overcome inefficiencies of national grants. However, coordination in dedicated joint R&D&I programmes would have to be binding (it would imply sanction mechanisms), as national governments may have an incentive to use national grants in addition to what has been agreed internationally. One should also consider that coordination is not efficient per se because there may also be beneficial effects of competitive R&D&I.

Policy implication 5:
The European Commission could coordinate national ICT R&D&I grants
Coordination of national R&D&I policies and grants through the EU can help overcome inefficiencies, but coordination in joint R&D&I programmes would have to be binding.

Balance number of countries in R&D&I joint ventures

The theoretical analysis suggests that the number of participants in international joint ventures is a critical factor for their effectiveness and efficiency. If the right number of countries participate in joint programmes, governments have an incentive to subsidise the joint venture, as their domestic companies are likely to gain a competitive advantage. If the number of participants is too low, however, grants may be inefficiently high. If too many countries participate, the risk of high transaction costs and free-rider problems with respect to investments in basic R&D&I increases.

Policy implication 6:
Balance the number of countries in R&D&I joint ventures
With regard to spill-over effects and national grants, the efficiency of international joint ventures tends to increase with the number of countries participating. However, transaction costs and free-rider problems increase too. Policy makers should consider this.

Prevent national programmes competing with EU programmes

In the early stages of a joint R&D&I programme, i.e. in basic research, there should be explicit rules for national governments not to establish national research programmes that compete with joint European R&D&I programmes, because this would be inefficient and prevent companies from participating. In later stages of the game, national governments must not be induced to leave the platform and pursue their own research programmes.

Policy implication 7:
Prevent Member States from establishing competing national programmes
R&D&I programmes competing with joint European R&D&I programmes in the basic research stage as well as later on would be inefficient and prevent companies from participating in the EU programme.

European Commission e-business adoption policies towards companies

Identifying e-business adoption barriers

While policy makers may tend to focus on the benefits of e-business applications for industries or regional economies, one needs to be aware that, from an economic point of view, it may make sense for individual companies not to invest in e-business. The theoretical analysis indicates several possible reasons for not adopting e-business. For example, firms may have an incentive to forego actual cost savings by delaying their investment in order to save money on lower prices and better technologies in the future. Another example is that small companies that trade only with one or a few large companies may refrain from relation-specific e-business investments because they cannot be sure about the behaviour of the large company and the future benefits of these investments.

Policy implication 8:
Consider the reasons why companies may not choose to invest into ICT
The first step of policy making towards e-business adoption should be a clear understanding of the barriers to e-business adoption.

Defining the level of industry specificity

A large share of respondents of the SeBW ICT Innovation and Adoption Survey 2009 (84%) agreed that "EC and Member States should foster regional or sectoral electronic networks of ICT-using companies". This is in line with the current focus of the European e-Business Support Network to foster electronic data exchange between companies. From a theoretical point of view, policy makers should consider market structures carefully when designing ICT-related industrial policy, i.e. market concentration and the power of large companies compared to that of SMEs. The theory of industrial organisation suggests a close relationship between market structure, the conduct of companies and the performance of companies. Barriers related to incomplete contracts, coordination failures and asymmetric market structures may be interpreted as market failure due to imperfect competition and incomplete information. They may thus justify political activity.

Policy implication 9:
Consider market structures in policies that support electronic value systems
In particular, policies should carefully consider the level of industry specificity in activities to enhance value systems.

Small versus large companies

In the SeBW ICT Innovation and Adoption Survey 2009, 91% of respondents agreed with the statement that "manufacturing SMEs are at risk to drop out of large companies' supply chains if they do not adopt e-business". The survey also found that there is a need to improve the adoption of e-business processes in European companies. Industrial organisation theory and game theory can help to predict whether a small firm makes a relation-specific investment vis-à-vis a large partner. The small firm knows that even if it invests, its larger partner may later terminate the business relationship. Thus, the small firm may decide not to invest. However, if the large firm is able to credibly commit not to exploit the small firm, for example by signing long-term contracts with the small firm, the payoff of the small firm in the subgame in which it invests can be larger than in the subgame in which the firm does not invest. In market economies such decisions are left to companies; public policy may intervene only indirectly, if at all. For example, political agencies such as the CARS initiative for the automobile industry in the Stuttgart region may support communication between large and small companies and help find credible commitment solutions.

Policy implication 10:
Support credible commitments of large firms versus SMEs
Policy makers should seek to support credible commitments of large firms versus small suppliers or customers in situations where small firms are expected to invest in relation-specific e-business solutions.

Policies to support e-business standards

In the SeBW ICT Innovation and Adoption Survey 2009, 82% of respondents agreed that there is a "lack of widely used e-business standards that impedes e-business communication". There was also almost unanimous agreement that electronic data exchange between companies needs to be improved in general (89% agreement) and that electronic data exchange between large companies and SMEs also needs to be improved (96%). Economic theory suggests that there may be a lack of commitment among ICT-using companies for aligning adoption decisions about e-business standards and potential compensation payments. Efficient adoption decisions cannot be expected. As regards policies related to e-business standards adoption, policy makers need to be aware that the ICT-using companies involved have strategic incentives to hide relevant information in order to reduce the costs they will incur from implementing a new standard or to receive direct grants. It may thus be more efficient for the state to leave standards adoption to the companies and focus on an earlier stage, namely, the support of standards development in standardisation committees.

Policy implication 11:
Do not foster e-business standards adoption but standards development
Policies for standards adoption should take account of the hidden intentions of companies involved. Public policy should foster institutions like standardisation committees that do not rely on direct payments.

European Commission e-business adoption policies towards national governments

In the SeBW ICT Innovation and Adoption Survey 2009, almost four fifths of the respondents (78%) agreed that there is "a lack of cooperation between EC and EU Member States for enhancing ICT and e-business adoption in companies". From a theoretical point of view, there is a risk that national governments promote specific e-business standards that are prevalent within their country. However, the large Member States with the strongest power to promote their standards may not necessarily have the best standards from a European perspective. Furthermore, if two or more different national standards compete on international markets, there are uncertainties about which standard may turn out to be most successful. Thus, companies may hesitate to invest in related ICT, in order to avoid being locked in an unsuccessful standard later on.

Policy implication 12:
Coordinate e-business standard adoption on EU level – prevent national standards
The European Commission should seek to coordinate the adoption of e-business standards on a European level, thereby considering related developments beyond Europe, in order to prevent competing national standards that may reduce the incentives for ICT-using companies to invest in e-business systems.

4.1.7 SELECTED REFERENCES

European Commission (2009a): A Strategy for ICT R&D and Innovation in Europe: Raising the Game. Communication from the Commission to the European Parliament, the Council, the European Economic ans Social Committee and the Committee of the Regions. COM(2009)116, {SEC(2009)289}. Brussels, 13.3.2009.

European Commission (2009b): Preparing for our future: Developing a common strategy for key enabling technologies in the EU. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, COM(2009) 512/3.

Acknowledgements

This study was conducted by **empirica GmbH** (http://www.empirica.com), an information society consultancy based in Bonn, Germany, and **DIW Berlin**, a large economics research institute. The study authors are Stefan Lilischkis (empirica) and Pio Baake (DIW). The study was accompanied by an Advisory Board, consisting of Antti Eskola (Finnish Ministry of Employment and the Economy), Paul Heidhues (University of Bonn), Philipp Köllinger (University of Rotterdam), Paula Swatman (University of South Australia). The full study report can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

4.2 e-Skills demand trends and policy implications

A study by empirica GmbH. Study author: Hannes Selhofer

A lack of ICT-related skills ("e-skills"), in particular a shortage of ICT professionals, could hamper the competitiveness of European enterprises. This study explored the current and anticipated demand for different types of e-skills, covering ICT practitioner skills, ICT user skills and e-business skills.

Demand for ICT practitioner and e-business skills

There is no evidence of a general quantitative shortage of ICT professionals in 2009/10. However, case studies indicate that specific skills and competencies (or combinations thereof) are sometimes not sufficiently developed among professionals or university graduates. Interviewees mentioned, in particular, the following points:

- ICT practitioners often lacked communication and presentation skills.
- The general understanding of business requirements is very important for many positions, including in particular know-how in business process design. Graduates with a specialisation in ICT often have excellent technical skills but lack the business background.

- University programmes should include more practical modules, such as training in standard business software systems. With regard to specific functions and occupations, ICT services companies reported challenges in finding university graduates with the right mix of qualifications for their consulting branches. ICT-using companies mentioned difficulties in finding ICT systems & process architects and specialists in developing open source software solutions.

ICT user skills: few problems in companies

A majority of survey respondents felt that the demands on employees regarding their computer and software skills "have noticeably increased" in the past few years. However, it appears that the vast majority of employees can cope well with the (rising) requirements. ICT user skills were not reported to represent a significant problem.

4.2.1 STUDY OBJECTIVES AND APPROACH

Why e-skills matter – the study rationale

A shortage of people in the labour market who possess the ICT-related qualifications required by companies (whether in ICT-producing or in ICT-using industries) poses a risk to economic development. This shortage can be quantitative, in terms of the number of people trained in ICT, or a competence shortfall between current and needed competence levels of (employed) personnel.

The growth potential of the ICT industry may not be optimally exploited if demand for products and services surpasses capacity (due to unfilled vacancies), and ICT-based innovation processes in user industries can be slowed down, with negative implications for productivity growth and competitiveness. Moreover, as ICT and e-business are developing rapidly, e-skills need to be constantly updated, and the demand for individuals with higher-level conceptual e-skills increases. Viewed from an opportunity perspective, the adequate supply and use of ICT-related skills ("e-skills") represents a relevant input factor to create comparative advantage.

Against this background, policy has dealt with the ICT skills gap since the late 1990s, typically in the broader context of economic policy and information society policy. DG Enterprise and Industry has been explicitly addressing the issue for years, with the objective of improving framework conditions in Europe for the provision of a "world-class e-skilled workforce" to achieve stronger productivity and economic and social benefits.

A key challenge for policy is that there are no easy fixes to adjust demand and supply through ad-hoc short-term measures, simply because of the cyclic and longer-term nature of the issue. DG Enterprise and Industry has therefore stressed the importance of a coherent e-skills policy framework with a longer-term policy strategy. This was documented in the Communication on "e-Skills for the 21st Century: Fostering Competitiveness, Growth and Jobs" (2007),[1] which presented a long-term e-skills agenda and included five major action lines at the European level. This Communication was a milestone in the e-skills policy of DG Enterprise and Industry. The effectiveness of its implementation is going to be evaluated in 2010.

Study objectives and approach

Against this background, the main objective of this study is to contribute to a better understanding of current and expected e-skills requirements of companies. It focuses on the demand side, and applies a micro-perspective (case studies, company surveys). This is in contrast to most of the existing market studies on e-skills, which focus on providing aggregate figures about the skills shortage, but do not look at the challenges of individual enterprises.

The study is embedded in the e-skills policy framework of the European Commission's DG Enterprise and Industry. It applies as a central conceptual framework an e-skills definition which was developed by the e-Skills Forum in 2004: this definition distinguishes between "ICT practitioner skills", "ICT user skills" and "e-business skills".[2] The study considers all three dimensions, but focuses on the requirements for ICT practitioners. ICT practitioner skills are the capabilities required for researching, developing, designing, strategic planning, managing, producing, consulting, marketing, selling, integrating, installing, administering, maintaining, supporting and servicing ICT systems.

The main data sources were company case studies and representative surveys conducted by Eurostat (in 2007) and by the Sectoral e-Business Watch (in 2009) among ICT decision makers. The case studies are based on semi-structured interviews with IT and human resources managers both in the ICT services and in ICT-using companies. Exhibit 4.2-1 provides an overview of the interviews and case studies conducted. As some of the information is confidential, interviewees requested that their companies should not be named in the study.

The study addresses mainly policy makers and those stakeholders who are directly affected by a shortage or mismatch of e-skills. These are, in particular, the ICT industry, IT managers in companies from user industries, and people involved in planning and implementing curricula for ICT training programmes.

4.2.2 ICT PRACTITIONER SKILLS

Aggregate demand for ICT practitioners

A recent study by IDC / empirica (2009)[3] estimated the total demand for ICT practitioners in the EU in 2010 at about 3.9 million, according to a narrow definition of "ICT practitioners", and at about 4.9 million according to a broader definition.

[1] Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. COM(2007)496 final. Brussels, 7 September 2007.
[2] European e-Skills Forum (2004). E-skills in Europe: Towards 2010 and beyond. Synthesis report of September 2004 of the European e-Skills Forum, established by the European Commission, DG Enterprise and Industry.
[3] IDC / empirica (2009). Monitoring e-skills demand in Europe: Foresight Report (2009). Study conducted for the European Commission, DG Enterprise and Industry, October 2009.

EXHIBIT 4.2-1: OVERVIEW OF CASE STUDIES AND INTERVIEWS CONDUCTED FOR THIS STUDY

Company	Type of company	User / service provider
A	Large stock-listed European manufacturing company (category 5,000-10,000 employees), with international operations, in a traditional manufacturing sector. - Interview A1: Head of IT infrastructure department - Interview A2: Head of e-business department	ICT-using company (manufacturing sector)
B	Multinational, stock-listed European manufacturing company (category 20,000-100,000 employees), global operations. - Interview B1: Head of the e-business unit - Interview B2: Senior manager in IT infrastructure governance	ICT-using company (manufacturing sector)
C	Large ICT service provider (category 1,000-5,000 employees), subsidiary of a manufacturing company that provides services mainly to its parent company, but also on the market. - Interview C1: Head of Department, Senior IT Manager	ICT service provider
D	Large European manufacturing company (category 20,000-100,000 employees), with global operations, in a high-tech industry. - Interview D1: Head of Information Systems	ICT-using company (manufacturing sector)
E	Large European software company (category 1,000-5,000 employees), with an international presence. - Interview E1: Head of Human Resources	ICT service provider (software industry)

Whether narrowly or broadly defined, ICT practitioner skills are required both by ICT service providers and in user industries. Therefore, it is crucial to distinguish between "ICT professionals" and the "ICT sector". According to the Eurostat Labour Force Survey 2007, about 40% of computer professionals (and associated professionals in ISCO-88 codes) were employed in the computer services sector, and 60% in user industries.

Due to the economic crisis, the shortage experienced during the growth period of 2004-2007 has almost completely disappeared. Aggregate demand and supply are estimated to be broadly in balance in most countries. The study offers five scenarios how demand and supply could develop in the next five years, depending mainly on the assumptions concerning the overall economic framework conditions. Estimates are that aggregate demand will increase to 4.1-4.6 million in 2015 (narrow definition, depending on the scenario) and 5.1-5.7 million if the broad definition of practitioners is applied. In the mid-range scenarios, a shortage in the supply of practitioners of about 8% of demand is forecast. The general assessment is substantiated by survey results. Eurostat asked companies in 2007 whether they had job had vacancies for ICT staff in the preceding 12 months, and if they had experienced difficulties in finding qualified people for any of these positions. In total, only about 3% of all companies (18% of the large ones) reported difficulties in finding qualified people in the preceding 12 months.

These figures indicate that most companies are, currently at least, not directly affected by a shortage of ICT practitioners. On more detailed inspection, however, the picture is more complex, as the case studies show. Companies in the ICT services industry certainly experience challenges, for example in hiring ICT consultants. An important point is that qualitative issues matter, and they may be obscured when looking only at aggregate figures.

Case study: Company A

In Company A, a stock-listed European manufacturing company, the corporate IT services department is located at the company headquarters and has a staff of about 50 employees. In addition, there are one or two ICT professionals at each of the 36 production sites which the company operates in different locations and countries for the maintenance of the local ICT infrastructure.

Company A has on average about five job openings for ICT specialists per year. Some of these positions are replacements, and others have been new jobs resulting from the growth of the company. The recruitment of new staff is often triggered by specific projects, as the IT department is highly project-driven. The recruitment procedure for ICT practitioners is managed by the IT department and not by Human Resources. Company A uses different channels to announce job openings, depending on the position. In most cases, the initial announcement is limited to online channels, which include special IT forums and online career portals. "We find most of our people by announcing job openings online," said Interviewee A2, and gave as reasons: "In those forums, one gets immediately an excellent picture of the specific experience and skills of a candidate." Traditional employment ads in print media are placed only as a second measure if the search via online channels is not successful. Sometimes, in particular for international recruitment activities, agencies are used. Salary requests from applicants were not experienced as a problem (with some exceptions): "Most of our applicants have very realistic expectations about their salary," said Interviewee A2.

The main challenge in recruiting, according to the interviewed IT manager, was to find people who had a broad background in ICT ("generalists") in addition to their specific qualifications in a given area. The company prefers to hire people with generalist ICT skills rather than pure specialists. In terms of specialisations, the most acute shortage in the market was seen in the domain of network specialists with network development skills. Ideally, the company would need network specialists with a perfect knowledge of the existing "of-the-shelf" systems, but who also had the skills and creativity to develop specific components themselves, to make the solution better and more cost efficient.

Asked about recommendations for ICT training, the IT manager said that there was an increasing demand for ICT practitioners with special skills in open source software development. However, it was difficult to find qualified people in this domain, not only due to a lack of skills in the market, but also because of a lack of formal criteria to specify the requirements. Currently, open source skills are often self-taught; university or college degrees or certifications of ICT vendors are therefore not a useful indicator or search criterion. He said it would make it easier for companies to work creatively with open source if there were more certified specialists.

Case study: Company B

Company B is a global manufacturing company maintaining operations in all continents. The central IT department at the company headquarter is responsible for IT governance, a corporate governance function that focuses on planning the company's information systems in the broadest sense and monitoring their performance and risk management. In total, about 120 employees are directly employed in one of the five units of IT governance. In addition to IT governance, Company B has about 120 information managers working either at the company's headquarter (about two thirds of them) or at other company sites in Europe. They must possess a good knowledge of ICT issues, but they need not be ICT specialists in the narrow sense, as they are not implementing technology themselves. Information managers are working "at the interface between business and IT" (Interviewee B1). They are employed in different functions and departments of Company B but are not part of the IT governance department from an organisational perspective. Thus, the company's total ICT headcount is relatively small in relation to the size of this multinational company. The reason is that Company B has nearly completely outsourced IT operations to external IT service providers, most of them to a service provider which is a 100% subsidiary of Company B. The staff directly employed by Company B focuses on IT governance and strategy development and manages the contracting and cooperation with external service providers. User support and help desk functions have also been outsourced to the service company. The recruitment of ICT practitioners for the IT governance team is not a big issue in Company B, due to the relatively small number of people and low staff turnover.

The skills requirements differ for staff who actually develop and implement technologies (e.g. programmers, developers) and for ICT and e-business managers (e.g. in IT governance), who have to understand the business potential of the technology rather than the technical details. Asked about relevant skills for practitioners, Interviewee B1 stressed the importance of communication, negotiation and project management skills, i.e. competencies that are complementary to ICT skills in the strict sense. He observed that most employees had excellent technical skills: "If there is a skills gap, it's not so much the ICT part, but the communication skills." He recommends that such skills should receive more attention in the ICT curricula of universities and colleges.

Case study: Company C

Company C is a large ICT service provider with more than 1.000 employees, focusing on clients in the process manufacturing industry. It is organised along the "plan, build, run" model, with three main areas (business solutions, development centre, ongoing services). In a second layer, there are two marketing divisions aiming at the acquisition of new customers in support of the service divisions. Within the main services divisions, about 60% of the employees work in the ongoing / managed services division, and about 20% in each of the other two divisions. In contrast to IT-using companies (such as Companies A, B and D), where relatively few ICT practitioners are employed, at Company C most of the employees (about 90%) are ICT professionals. The other 10% include secretarial assistants of managers or work in support functions such as administration and control.

The company had about 10 job openings at the time the case study interview was conducted. In 2008, there were about 30 job openings for a division which employed about 440 people; but the number differs significantly from year to year. Most job openings concern IT consultants, in particular with a strong background in business processes: "We concentrate our recruitment activities much more on the consulting skills than on the purely technical skills", said Interviewee C1.

At Company C, the expected formal education level and the expected job experience clearly depend on the specific position. However, there is a marked difference between positions in the consulting domain and other areas. In the consulting area, a university degree is required for about 70% of the positions. For help-desk functions or PC maintenance, there are few positions where higher education is required (fewer than 10%). In the consulting branch, the Company D had a strong demand in particular for SAP advisors.

Asked about vocational training for IT practitioners, Interviewee C1 provided figures for a division which employs about 440 people. He said that about 75% of the staff would attend at least one external training scheme within a 12-month period, for example one of the trainings offered by large software companies such as SAP. In addition, Company C offers internal training opportunities in different skills domains, for instance project management.

Case study: Company D

Company D is a global manufacturing company from the transport sector. It is an intensive user of ICT, in particular to support its advanced supply-chain and logistics system. Company D's ICT division has five main organisational units: governance (responsible for resource and competence management), horizontal operations, and three units for specific functional areas (purchasing, sales, and finance). In total, more than 1,000 ICT practitioners work in these divisions. In addition to the primary structure, there is a secondary structure which describes the content of the work rather than the functional area: about 700 ICT professionals work in the area of "business applications", about 300 on business projects, and the rest (about 100) in corporate management.

The company had about 120 open positions for ICT practitioners at the time the interview was conducted. This corresponds to more than 10% of the total ICT workforce. For these positions, the company planned to recruit about 70 externally, while about 50 positions were planned to be filled internally with existing staff. The situation was substantially influenced by the company's strict cost reduction programme adopted in response to the economic crisis. In some countries, the management imposed a freeze on further recruitment until the cost reduction programme has been fully implemented. In 2008, the total recruitment balance was a net loss of 10 ICT practitioners: the company lost about 95 ICT practitioners and hired about 85 new ones. Interviewee D1 stressed the difference between standard staff turnover and unforeseen events for planning the recruitment activities: "We can cope very well with the standard turnover, as we can anticipate the demand and plan in advance; what makes the whole business difficult are internal restructuring activities, mergers & acquisitions and fast changes in the economic environment, such as the current crisis."

Countries differ also with regard to the typical recruitment paths. In Germany, the company would typically hire university graduates from relevant ICT programmes, while in France the predominant recruitment process would be to hire external consultants who have already been working for the company for some time on a specific project. Company D aims to position itself as a preferred employer to attract young ICT practitioners. This is seen as an important objective with a view to the next 5-10 years, when a significant number of senior staff will have to be replaced.

Like all other companies studied, Company D barely uses ads in print media to announce open positions, preferring online career portals. Moreover, many ICT practitioners are directly hired from university. To this end, Company D maintains close cooperation with universities at their production sites.

Company D makes a basic distinction between ICT professionals with mostly technical ICT skills and those which combine ICT skills with business & management skills. In terms of qualifications and job profiles, Company D has defined three focus areas for the career development of its ICT staff: project management, ICT architecture, and services management. Service managers are responsible for smooth cooperation with the external IT service providers. For Company D, these include in particular IBM and Hewlett-Packard, with whom the company has significant contracts.

Typical career paths in Company D would start either as systems developers or systems administrators, i.e. to support the ongoing operations, for a period of 3-5 years. Then the ICT practitioners would increasingly be charged with planning and management functions, such as specifying the company's ICT architecture requirements for a specific unit, and managing the interface between the company's internal users and the external service providers. According to Interviewee D1, this perspective would gradually substitute the former static job profile categories such as "database administrator" or "system administrator". Technical levels (such as systems implementation and maintenance) would increasingly be taken care of by the external ICT service providers; the critical task for the ICT practitioners employed by Company D was to manage the requirements and the contracts & cooperation with the service providers.

Interviewee D1 said his company experienced a general lack in the supply of trained ICT staff with a university degree. However, he said that the situation differed between countries. A specific skills shortage in the market, according to Interviewee D1, concerns systems architects and process architects. The company still uses IT platforms that were set up in the 1970s and had then been transformed ("reengineered") into newer architectures. This is a complicated process, and the knowledge of the older platforms often lies with only a few people in the company, typically older engineers. When these people leave the company, problems arise.

Asked about internal training activities, Interviewee D1 stressed that training was an absolute priority at Company D. It is also planned to further strengthen cooperation with universities in vocational training. About 90% of the ICT training in which ICT practitioners take part is product-specific, typically provided by the respective solution provider (e.g. Cisco, Oracle, SAP). In addition, the company offers specific training programmes in IT project coordination. Currently, about 50 employees are attending this programme.

Company D cooperates closely with a university in the region of the company headquarters. The objective is to innovate and adapt curricula. A group of CIOs specified skills requirements; together with the university, these were translated into curricula for a new study programme, which starts in autumn 2009. The longer-term objective behind this commitment is to train young people to become a new generation of IT managers. Interviewee D1 expects increasing demand for graduates who were trained both in technical ICT skills and in management skills.

Asked about general trends and requirements in ICT training, the interviewee argued that programmes that train students for positions in ICT services companies should be different from those that train students for positions in ICT user companies: "I do not think that it will work in the future to train information scientists in a uniform way, who will only at the end of their studies decide whether they work for SAP [i.e. for an ICT service provider] or for a car manufacturer [i.e. for a user company]. We must make a difference between 'producers' and 'consumers'. The skills requirements are fundamentally different." He conceded, however, that his vision of differentiated programmes was from the perspective of (very) large companies, and that he could not say to what extent this would also apply to SMEs from user industries.

Case study: Company E

Company E is a large ICT service company with offices in more than 50 countries. It provides services to business customers from different sectors, focusing on software for enterprise integration. About a quarter of the employees are based in the country of the headquarters. The business activities of Company E can be divided into two main fields: software development, and IT consulting services. Most of the employees in these primary business functions are ICT practitioners; about 1,500 practitioners work in software development, about 600 in the consulting division. In addition, ICT practitioners work in support functions (back-office support, finance) and – to a lesser extent – in marketing & sales.

In 2008, the company issued about 100 job openings for ICT practitioners in total (worldwide). Of those, about 95% could be filled with qualified practitioners. About 60% of the positions were in the consulting branch. At the time of the interview, the company had about 40 open positions, corresponding to about 2% of its total ICT practitioner workforce. The Head of Human Resources said that the market situation (the supply of e-skills) was quite good. The company was satisfied with the results of its recruiting activities; for instance, only very few of the newly recruited people left the company during the trial period. The economic crisis had a significant impact on the demand and subsequently on recruitment activities. Currently, the company focuses mainly on its consulting activities and on marketing its products and services. Most of the 40 current positions are for jobs in these domains. There are few positions open for software developers. Staff turnover among ICT practitioners in the main market is very low, according to the HR manager; however, there were considerable differences between countries.

In the consulting branch of Company E, a university degree is required for about 80% of the positions. ICT consultants are often hired directly from university and then trained on the job. For management positions in consulting (project management, team leaders), working experience is required as well, the amount depending on the position. Managers in the consulting branch are preferably recruited internally. Important skills include business process management. In software development, proof of practical (software-related) skills is more relevant than a formal education. For many positions, working experience (ideally of at least 4-5 years) is required. Important ICT skills for many positions in Company E include expertise in programming with Java (Java EE / J2EE) and SOA (Service Oriented Architecture) expertise.

In general, Company E is quite satisfied with the supply of ICT practitioners with regard to their ICT competencies. The HR manager said that applicants for open positions, notably university graduates, had typically very good ICT skills which complied with the company's requirements. The company had not experienced a shortage of talent in this respect, at least in its major markets in Europe. The challenge was rather that applicants often lacked soft skills, which is a problem in particular for ICT consultants. "We often interview candidates who have excellent ICT skills, but with major deficits in their communication and social skills." The main shortcomings observed are difficulties in expressing oneself properly, a lack of self-confidence, or even bad manners (such as receiving and answering calls on the mobile phone during a job interview).

According to the interviewee, a major challenge for HR managers in companies operating internationally was the lack of comparability between university degrees in Europe, in particular from different countries. A "bachelor" or "master" in information sciences from one university can often not be compared to the same degree from another university with an apparently similar programme, not only in terms of the quality of the education, but also in terms of curricula. This lack of transparency is a challenge not only for the hiring companies, but also for students when making decisions in their study plans. There is no easy solution to the problem; but any initiative at the European level to increase the transparency of how different programmes can be compared would be appreciated.

The HR manager of Company E also stressed the importance of practical experience from internships, in part due to the fact that the degree as such does not tell much about the qualification of an applicant: "We look carefully at the practical experience of a graduate, for example in which companies he did an internship during his study. A graduate, even a good one, without relevant practical working experience is much more difficult to integrate in the company."
Finally, Interviewee E1 recommended that universities should also train their students in communication and presentation skills of, as this is an important aspect in many professions besides the technical skills (see above).

4.2.3 ICT USER SKILLS

ICT user skills and "PC workers"

While there are comparatively few ICT specialists in most companies, many jobs require computer and software user skills. This covers a wide spectrum of activities and intensity of use. Some employees will only occasionally use computers, for example sales representatives who spend most of their time meeting customers, and who may only use CRM software to manage their customer contacts. Office staff, on the other hand, are mostly working at their desk in front of a computer screen ("PC workers").

An IT manager from a large manufacturing company with about 8,000 employees interviewed for this study said that about 2,500 of them (i.e. about 30%) were mainly "PC workers", i.e. they spend a significant proportion of their working time (if not most of it) at their desk, processing information with the support of computer systems. Most of them use mainly basic office applications such as text editing and spreadsheet calculation, communication tools (e-mail) and the web. Depending on the department they work in, they may also be users of specific applications such as the ERP or CRM system or the procurement system. There is no special education or training needed to use these systems if the employee is "digitally literate", i.e. has learned how to use a computer in principle. A few people work with more advanced software tools, for example CAD/CAM programmes, which require more experience and special expertise.

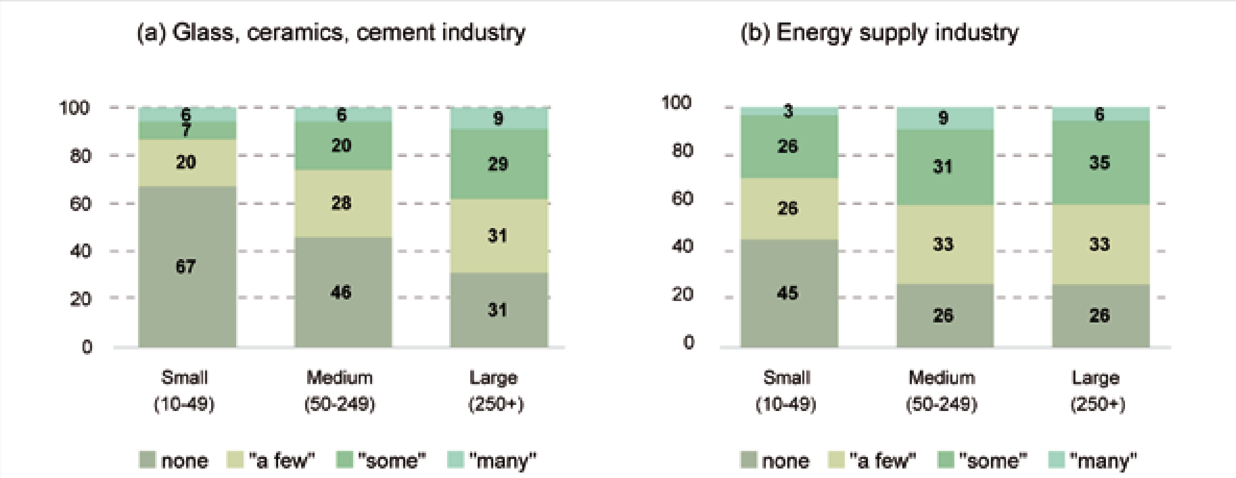
Rising demands – but no major difficulties experienced

In an e-Business Watch survey among companies from the glass, ceramics and cement industries, more than 50% of the survey respondents felt that the demands on employees regarding their computer and software skills "have noticeably increased" in the past few years. Interestingly, this view is more widespread the larger the company is. In the energy supply industry, which is more ICT-intensive than the SME-dominated manufacturing sector, this feeling is even more pronounced. Here, even among SMEs, 70-80% of the interviewees confirm this perception. At the same time, however, most of the interviewees said that either no or only a few employees had problems in their job because of insufficient computer and software skills (see Exhibit 4.2-2). Even among the large companies interviewed, where more employees might be concerned, only few respondents (6-9% in the two sectors) said that "many" of their employees had problems because of insufficient computer skills. About a quarter of the companies in the glass/ceramics/cement industry and a third in the energy supply industry reported that "some" employees were challenged; the rest felt that this was not a problem or only for few employees.

Specific ICT user skills

The survey in the glass, ceramics and cement industry also explored whether it was difficult for companies to find personnel with specific, advanced ICT user skills, for example for operating design programmes such as CAD/CAM. In total, only 6% of the companies interviewed (representing 15% of the sectors' employees) had job openings for such positions within the 12 months prior to the interview (see Exhibit 4.2-3). Among large firms, close to 30% said that they looked for new staff with such skills. In total, about a third of those firms that wanted to hire staff reported difficulties in finding people with the required user qualifications. Thus, the figures are quite similar to those for

EXHIBIT 4.2-2: % OF COMPANIES OBSERVING THAT MANY / SOME / A FEW EMPLOYEES HAVE PROBLEMS BECAUSE OF INSUFFICIENT COMPUTER SKILLS (2009)



Source: e-Business Watch Surveys (2009)

ICT practitioners. All in all, there is no evidence of a major, systemic problem in this area.

In summary, these results suggest that the majority of the workforce in these sectors (and probably in other manufacturing sectors as well) is sufficiently digitally literate and has no major difficulties in using the software applications that they need in their daily work routines. There are certainly cases where individual workers have difficulties in adapting to new systems and working routines; but these are the exceptions and do not present a pressing business need that demands attention. Companies can handle such situations themselves – for example by offering ICT training to employees.

Companies' approaches to ICT training

The need to train employees in their ICT user skills can be broken down into three main categories:

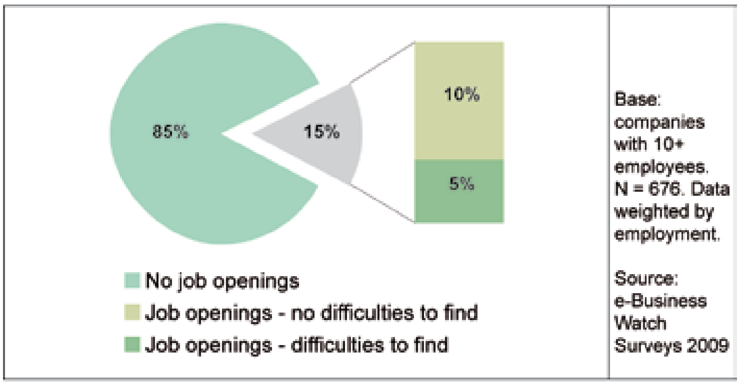
(1) Updating skills: the continuous update of ICT skills is seen as a requirement for many (or all) employees in the information society. Attending ICT training is one possibility to do so (besides self-learning, learning on the job).

(2) Specific improvements needed: this concerns employees with good basic computer skills, but who want or need to improve their skills in specific applications which are important for their job (e.g. spreadsheet calculation in MS Excel). This is the ideal situation for specific ICT training programmes. In most cases, these skills gaps can easily be addressed.

(3) Absolute lack of digital literacy: in very few cases, employees have no computer skills at all. This concerns mostly older people. They have never used computers or the internet in their job, but are suddenly required to do so. One of the case interviewees mentions as anecdotal evidence a case where his company had hired a senior sales representative with more than 30 years working experience, but neglected in the recruitment process to ask him about his computer skills. It turned out that this person had never used a computer in his previous positions – a skill mandatory for sales representatives at the company. In this special case, a lack of ICT user skills was a real problem. However, such cases are exceptional.

All the companies interviewed had internal service centres that offered a broad range of training programmes, including ICT training. Employees are encouraged to make use of the offer and can register for selected programmes as part of their career development. One of the interviewees explained how this was managed in his company: The offer is typically available on the intranet and employees can register there, provided that his/her superior has authorised the training. Asked whether employees make voluntarily use of this offer or rather have to be "pushed" by their superiors to participate, the interviewee said that it was mostly "bottom-up", i.e. the initiative comes mainly from employees. He also said that the offer currently exceeded the demand, which he attributed to the general workload: "I am the best example. I have perfect opportunities to attend exciting management seminars which we organise, but make way too little use of it – there is always something 'important' to do in our day-to-day business, and the seminar becomes a 'second priority'."

EXHIBIT 4.2-3: % OF GLASS/CERAMICS/CEMENT COMPANIES WITH JOB OPENINGS REQUIRING SPECIAL ICT USER SKILLS (2009)



Anticipated trends and challenges

The case studies indicated some upcoming trends with implications for ICT user skills in companies.

Web 2.0 for information sharing. The Services unit in the ICT department of one of the case companies set up an internal Wiki for information sharing and informal exchanges among employees. About 800 employees have registered. This platform has never been officially announced in the company, but has gradually evolved. The success of this platform indicates the potential of Web 2.0 applications within enterprises, not only for knowledge management, but also to strengthen the company culture. Another company studied uses social networking tools internally for team-building and communication purposes. A special platform has been developed for this purpose. However, neither company sees any major skills implications stemming from these developments. They regard this as an evolutionary development.

Use of new communication tools. A specific challenge for the future which was mentioned by several interviewees will be to find the right approach and balance in using new web-based communication tools (such as chat and messenger functions) and Web 2.0 applications. It is a difficult trade-off between ensuring ICT security ("security awareness") and avoiding discouraging employees' creativity. The younger generation of employees has grown up with these communication tools (e.g. Skype, MSN) and wants to use them in their work for internal and external communication. However, it can be difficult to align this with the privacy and security requirements of a company. One of the interviewees confirmed that security issues were important, but felt that it was equally important to take a progressive and active approach. "We are very active in this field and believe that it will be part of how we communicate in the future." The company believes that Web 2.0 is important both for internal and external communication.

4.2.4 E-BUSINESS SKILLS

e-Business skills refer to the managerial understanding of e-business opportunities, and the capabilities needed to exploit them. This study analysed the organisational approach which companies studied have chosen for their e-business activity, as well as the resulting skills requirements and the trends they expected in this field.

Organisational set-up of e-business units and the general role of e-business

In Company A, the e-business unit is named "Services" and represents one of six units within the "Corporate IT Services" department. 13 people work in the Services unit (out of 50 in total who work in Corporate IT Services). The main responsibility of the e-business unit is to ensure that the company's ICT systems support marketing and sales activities in the best way possible. The key systems in this respect are the ERP systems and the extranet portal. The unit has the task of monitoring and analysing the functions of these systems, identifying new opportunities for their application, tracking difficulties, and continuously optimising the systems and processes accordingly. They do not have to deal with the technology itself, but have to describe the functional requirements and oversee the process. In addition to planning and developing the functionalities in general, the unit provides help-desk support for users of these systems and manages security tasks (setting user privileges, i.e. who is authorised to use which functions of the system).

Interviewee A1 explained that advanced e-business exchanges are possible only with a few customers (mainly the large companies). However, these account for a significant share of his company's business, thus the volumes are substantial. The ERP system (in use since 1999) is the backbone for this part of the company's e-business.

Many of the other customers are small companies, however, typically operating in a very traditional way. As a service to these customers, the company has set up an extranet portal that provides structured information about the status of their orders. Many of these companies do not have IT systems themselves which would be able to provide this analytical overview. In total, this portal has about 1,600 registered users (from about 1,000 companies). On average, about 200 users per day log in to actively access their customer account ("pull" mode). Many users have made use of the opportunity to register for an automatic report about the status of their orders ("push" mode).

Company B, a multinational manufacturing company, is among the most advanced users worldwide of e-business in its sector. Since 2000, the company has made a massive investment in building a comprehensive infrastructure of e-business solutions to support its global business activities. e-Business is regarded as a central aspect of how global companies operate in the information society, going beyond purely transactional aspects (i.e. not just as an "additional" sales channel). Electronic transactions account for a significant proportion of trade already. The company uses different e-channels, including a highly sophisticated extranet portal for customers. The functions are similar to those provided by the extranet of Company A (see above). The principal dichotomy is also between doing business with other large companies and with small companies on the other hand. Thus, many of the observations on the role of industry structure apply here as well, although Company B is in a different manufacturing sector.

The e-business activities of Company B are planned and managed by a global unit with highly strategic objectives within the information systems division (Corporate IT

Governance). Worldwide, the e-business unit has a staff of about 60, of which 30 work at the company's European headquarters, and another 30 at the main sites of the North America, Asia/Pacific and South American branches. Out of the staff working at the headquarters, six employees are responsible for the marketing of the solutions, i.e. "to bring e-business to our customers, whether internal or external customers" (Interviewee B1). The remaining 25 take care of the technical aspects, i.e. planning, implementing and maintaining the functionalities.

Skills and competencies required

In sharp contrast to most other units within the ICT department, where technical ICT skills are central, staff working in e-business units may have a background in marketing and sales rather than in engineering disciplines. The percentage of marketing people versus engineers depends on whether the unit is responsible for implementing its systems itself or not. This is an organisational issue which is closely linked with the size of the company and the unit.

In Company B, which has a much larger central e-business unit with 30 people, about 20 of them are ICT specialists, five have an affinity to ICT as they graduated from university or college programmes which combine ICT, economics and management skills, and five do not have an IT background at all. The head of the e-business unit is an engineer (but not in an ICT domain) and has an MBA.

In Company A, with a total staff of 13, the situation and tasks are quite different. First, there is a wide gap between the high-level competencies and responsibilities of the e-business manager(s) heading the department and most of the staff members who perform primarily help-desk functions. The e-business managers need not necessarily come from a technical background (this applies to Company B as well). They have moved into this function from a position in marketing and sales. Requirements are excellent management skills, a thorough understanding of the company's strategy and its operations, and practical experience with e-business software such as ERP systems. Typically, there are only few positions in a company with this profile (no more than one or two), even in large companies. There are often close links with supply chain management. Therefore, according to the interviewees, it would not make sense to develop training programmes specifically for e-business managers.

EXHIBIT 4.2-4: POLICY ISSUES ARISING FROM THE E-SKILLS CASE STUDIES AND SURVEYS

Issue	Domain concerned	see Section
Making a clear distinction between skills and occupations (job profiles) in an e-skills policy framework	ICT practitioner skills (framework)	III.1
Considering different requirements of ICT services and ICT using sectors in an e-skills policy framework		III.1
Differentiating between personal skills (i.e. skills and competencies of individual employees) and company skills (i.e. the capabilities of the company as a whole)	ICT practitioner skills (framework)	III.1
ICT user skills: making a distinction between "digital literacy" at large and ICT user skills of employees; policy initiatives should focus on specific groups (risk groups)		III.2
Strengthening complementary competencies ("soft skills") in ICT training such as communication, presentation and project management techniques	ICT practitioner skills (framework)	III.2
Strengthening practical experience (with business software) and business process know-how in ICT studies	ICT user skills (support measures)	III.2
Supporting Human Resources managers in assessing how different ICT studies compare to each other	ICT practitioner & e-business skills (training)	III.2

Interviewee A1 (head of the e-business unit in Company A) describes the typical job profile of staff working in his team (12 employees). A typical applicant is a young person of about 18-25 years with high school graduation and some job experience in marketing or sales. A university degree is not necessary; on the contrary, university graduates are overqualified. Neither is it necessary to have experience in the sector in which the company operates when starting the position. The interviewee stresses the importance of "common sense" and the ability of applicants to perform tasks in an efficient way.

4.2.5 CONCLUSIONS

The following conclusions aim to put the empirical evidence presented in this study in a policy context. Possible implications for an e-skills policy agenda and for ICT-related training (in particular for bachelor and master programmes of universities) are presented. The limited evidence base and scope of this study do not allow for detailed recommendations for specific actions. Instead, issues are suggested that may deserve further discussion among stakeholders, as part of general reflections about improving the framework conditions for the development of e-skills in Europe. Exhibit 4-2-4 provides an overview of these issues.

These issues are not addressed to a specific group of actors. It will require close cooperation among all stakeholders, involving policy makers, industry representatives, the educational sector and professional associations (such as CEPIS[4]) to effectively address them and – provided that they are supported and considered relevant – translate them into concrete actions. European e-skills policy could play an important role in this context as a facilitator, by initiating the deliberation on such issues among stakeholders and by coordinating resulting actions.

General implications for an e-skills policy framework

The study interviews demonstrated that the basic e-skills framework (practitioner skills / user skills / e-business skills) is still useful to structure the debate about the issues at stake. Indeed, the challenges and issues identified with regard to the demand for ICT practitioner skills are completely different from those concerning ICT user skills.

Practitioner vs. e-business skills: The distinction between ICT practitioner skills and e-business skills is not as straightforward as the one between practitioners and users, because the categories overlap. It works quite well for large companies which have a dedicated e-business unit, headed by an e-business manager and staffed with a team that plans and implements the e-business strategy of the company. However, the organisational level should not be confused with the individual skills level. An e-business unit typically comprises staff with e-business skills as well as typical "ICT practitioners", in particular if the unit is responsible for running and maintaining ICT systems itself. The two e-business managers interviewed for this study, on the other hand, are perfect examples of the very model of experts with "e-business skills". Neither has their main background in ICT (it was in marketing), nor would they consider themselves "ICT practitioners". An e-skills framework should therefore clearly differentiate between personal skills (i.e. skills and competencies of individual employees) and company skills (i.e. the capabilities of the company as a whole). The concept of "e-business skills" can be applied to both layers, but the issues are quite different in each case.

How to classify ICT practitioners: An important aspect of an e-skills framework is how to structure the key category of ICT practitioners, and their skills. It is important to understand that these are different analytical levels: a segmentation can be made on the basis of people by referring to their function and occupation in companies, or on the basis of skills and competencies, irrespective of the occupations these are associated with. For structuring occupations, the ISCO-08 classification (which came into force in 2008) or job profiles developed by the e-Skills Career Portal (http://eskills.eun.org/web/guest/careerprofiles) could be used. A new, different classification other than those is probably not necessary, as it would not facilitate policy making.

For ICT practitioner skills (as opposed to occupations), there are two dimensions that have to be considered: the technical skills and expertise; and other competencies such as communication and presentation skills. This study has clearly shown the importance of the second dimension, i.e. competencies which are not directly ICT-related. Interviewees pointed towards deficiencies among ICT practitioners and university graduates in this respect.

Reflecting these considerations, a practical framework for structuring ICT practitioners and their skills could be composed as a simple four-field-matrix (see Exhibit 4.2-5): the first dimension considers in which sectors and companies the practitioners are needed and employed, with a basic differentiation between ICT-using and -producing industries.

[4] CEPIS, the Council of European Professional Informatics Societies, is a non-profit organisation seeking to improve and promote a high standard among informatics professionals.

EXHIBIT 4.2-5: ICT PRACTITIONER SKILLS MATRIX (SUGGESTION)

	ICT services industry	ICT consultants (in particular in the area of enterprise solutions)
«PLAN» External consulting / information management / managing external service providers	• ICT consultants (in particular in the area of enterprise solutions)	• Internal information managers • Information systems analysts and systems architects • e-Business managers / e-commerce specialists • Business intelligence
«BUILD» Product development	• Software and applications developers • Web designers • Multimedia developers	• Systems developers • System integrators
«RUN» Internal infrastructure maintenance and back-office support	• ICT security specialists • ICT operations and user support technicians • Systems and network administrators • Database management • Web technicians	

The second dimension considers the function within the company based on the plan-build-run model. Different skills and their profiles (such as those developed by the e-Skills Career Portal) can then be positioned within this matrix.

Setting the right focus in promoting ICT user skills

In the domain of ICT user skills, e-skills and social inclusion policies have placed great emphasis on promoting ICT skills in Europe to help closing the digital divide. The e-Skills Communication, for example, refers to the "persistence of digital illiteracy" and defines "fostering employability and e-inclusion" as one of the five key components of the long-term e-skills agenda (European Commission, 2007b, p. 5). In this context, it is very important to make a clear distinction between the digital literacy of the population at large, and the ICT user skills of employees. For the latter, all evidence presented in this study indicates that the vast majority of the workforce (at least in the companies studied) is sufficiently digitally literate and does not experience major difficulties in using the software applications which they need in their daily work routines. In other words, for people who are already in employment, ICT user skills are rarely a significant problem.

This finding does not challenge the validity of social and employment policies to advance and improve ICT skills among specific target groups, such as unemployed people with a lack of ICT skills, or young people living in low-income households which cannot afford to provide them with computers and internet access. Broad and unspecific measures to promote ICT user skills in general could, however, be critically questioned.

Implications for ICT training

Several interviewees both from ICT-using and ICT services companies recommended that specific competencies should receive more attention in the training of ICT practitioners. They argued that the main shortcoming they experienced among practitioners was typically not the core ICT skills themselves, but rather complementary skills and competencies which are needed to apply their ICT skills in an effective and efficient way. In particular, the following competencies were mentioned as particularly important:

- Communication and presentation skills. Interviewees said that ICT practitioners often had difficulties in presenting their technical concepts and solutions to users in the right way. It is difficult to specify user requirements and translate them into solutions if the users and technicians speak "different languages".
- Project management skills were also seen as a very important competency for ICT practitioners with scope for improvement.
- Business processes. An issue that came up repeatedly in the case interviews was the understanding of business

processes. This was seen as a very important competency for many ICT practitioners, for example in ICT consulting, but also in ICT-using companies (so as to properly specify user requirements and plan solutions accordingly). Interviewees suggested that ICT studies should pay due attention to business process design and teach their students to use the respective methods and tools (as for project management).

Case study interviewees, in particular from the ICT services sector, expressed the wish that university studies should include more practical training in working with the most common business software systems so that students gain a better understanding of how these systems are practically used in enterprises when they start their job. They suggested that such practical hands-on training for specific systems could be provided in cooperation between universities and the ICT industry. They argued that there was high demand for ICT graduates who had acquired, in addition to their broad ICT skills, practical know-how with specific solutions from the main providers.

Finally, an issue related to ICT training which came up in interviews was the lack of transparency about how different ICT studies (as offered by universities and colleges) compare to each other. Human resources managers, when hiring university graduates on an international basis, are confronted with the challenge that they cannot assess the actual qualifications of a graduate just from the name of the programme or from the degree (such as "bachelor" or "master"). One of the interviewees stressed how much it would be appreciated if unbiased, structured information was available that provides an overview of the different programmes and how they compare to each other (e.g. on an internet platform).

Acknowledgements

This study was conducted by **empirica GmbH** (http://www.empirica.com), a research and consulting company in Bonn focusing on information society developments. The study manager and main author is Hannes Selhofer, Senior Consultant at empirica. The full study report can be downloaded from the e-Business Watch website (http://www.ebusiness-watch.org).

Annex

Annex I Methodological notes: the e-Business Surveys 2009

Background and scope

The Sectoral e-Business Watch has been collecting data relating to the use of ICT and e-business in European enterprises by means of representative surveys since 2002. In 2009, two e-Business Surveys were conducted: one among companies from the glass, ceramics and cement industries (676 interviews), and another one in the energy supply industry (351 interviews). Both surveys covered six EU countries (France, Germany, Italy, Poland, Spain, UK). Interviews were carried out with ICT decision-makers in the company in March 2009, using computer-aided telephone interview (CATI) technology.

EXHIBIT A1-1: POPULATION COVERAGE OF THE E-BUSINESS SURVEYS 2009

No.	Sectors covered	NACE Rev. 2 activities	Population definition	No. of interviews conducted
e-Business Survey in the glass, ceramics and cement industries				
1	Glass and glass products	23.1	Companies using computers and having at least 10 employees	159
	Refractory products	23.2		20
	Clay building materials	23.3		75
	Other porcelain and ceramic products	23.4		60
	Cement, lime and plaster	23.5		25
	Articles of concrete, cement & plaster	23.6		337
	TOTAL			**676**
e-Business Survey in the energy supply industries				
2	Electricity	35.1	Companies using computers and having at least 10 employees	212
	Gas	35.2		69
	Heating / cooling	35.3		70
	TOTAL			**351**

Questionnaire

The questionnaires were structured into the following modules:

- Use of ICT systems and e-business software
- Automated data exchange with suppliers and customers
- Special computer systems for energy supply (energy survey only)
- Innovation activity and the role of ICT
- ICT skills requirements
- ICT investments
- ICT, energy efficiency and emissions (glass, ceramics and cement only)
- Background information about the company

EXHIBIT A1-2: STRATA BY COMPANY-SIZE

Size-bands	Quota (target vs. achieved)		
	Target	Achieved (GCC sectors)	Achieved (energy supply)
Small companies (10-49 employees)	up to 55%	54% (365)	46% (160)
Medium-sized companies (50-250 employees)	at least 35%	34% (227)	38% (133)
Large companies I (250-999 employees)	at least 10%	10% (71)	11% (40)
Large companies II (1000+ employees)	as many as possible	2% (14)	5% (18)

Some of the questions were the same or similar to those used in previous surveys, partly to enable comparisons with other sectors. Other questions were newly introduced or substantially modified, in order to reflect recent developments and priorities. A special focus in the survey of the glass, ceramics and cement industry was to assess the degree of process automation in companies, i.e. to what extent paper-based and manually processed exchanges with business partners had been substituted by electronic data exchanges. The survey on the energy industry focused instead on the use and experienced impact of ICT systems that are special to this sector.

Some questions were filtered, for example follow-up questions which were only relevant for companies depending on their answer to the entry question. No open questions were used.

The survey questionnaire (as well as those used in previous e-Business Watch surveys since 2002) can be downloaded from the project website (www.ebusiness-watch.org/about/methodology.htm).

Population and sampling frame

The survey population was defined as companies that had at least 10 employees, used computers, were active within the national territory of one of the six countries covered, and which had their primary business activity in one of the sectors covered (see Exhibit A1-1). The survey was carried out as an enterprise survey: data collection and reporting focus on the enterprise, defined as a business organisation (legal unit) with one or more establishments.

The sample drawn was a stratified random sample of companies from the population in each of the six countries, with the objective of fulfilling minimum strata with respect to company size-bands per country-sector cell (see Exhibit A1-2). The target quota were mostly achieved.

Samples were drawn locally by fieldwork organisations based on official statistical records and widely recognised business directories. Dun & Bradstreet was used in France, Italy, Spain and the UK, Heins und Partner Business Pool in Germany, and Hoppenstedt Bonnier in Poland.

Fieldwork

Fieldwork was coordinated and conducted by the German branch of Ipsos GmbH (http://www.ipsos.de), in cooperation with local partner organisations in some of the countries covered (see Exhibit A1-3) on behalf of the Sectoral

EXHIBIT A1-3: INSTITUTES THAT CONDUCTED THE FIELDWORK OF THE E-BUSINESS SURVEYS 2009 AND NUMBER OF INTERVIEWS CONDUCTED PER COUNTRY

Country	Institute conducting the interviews	No. of interviews conducted	
		GCC sectors	energy
France	Ipsos GmbH, 23879 Mölln, Germany	87	20
Germany	Ipsos GmbH, 23879 Mölln, Germany	180	149
Italy	Demoskopea S.p.A., 20123 Milan, Italy	101	50
Poland	IQS and Quant Group Sp.z.o.o, 00-610 Warszawa, Poland	120	60
Spain	Ipsos Spain, 28036 Madrid, Spain	125	58
UK	Ipsos GmbH, 23879 Mölln, Germany	64	14
TOTAL		**677**	**351**

e-Business Watch. Pilot interviews prior to the regular fieldwork were conducted with about 25 companies in Germany in February 2009, in order to test the questionnaire (structure, comprehensibility of questions, average interview length).

Non response: In a voluntary telephone survey, in order to achieve the targeted interview totals, it is always necessary to contact more companies than just the number equal to the target. In addition to refusals, or eligible respondents being unavailable, any sample contains a proportion of "wrong" businesses (e.g. from another sector), and wrong and/ or unobtainable telephone numbers. Exhibit A1-4 shows the completion rate by country (completed interviews as percentage of contacts made) and reasons for non-completion of interviews. Higher refusal rates in some countries, sectors or size bands (especially among large businesses) inevitably raises questions about a possible refusal bias. That is the possibility that respondents differ in their characteristics from those that refuse to participate. However, this effect cannot be avoided in any voluntary survey (be it telephone- or paper-based).

Feedback from interviewers

No major problems were reported from the fieldwork with respect to interviewing (comprehensibility of the questionnaire, logical structure). The overall feedback from the survey organisations was that fieldwork ran smoothly and that the questionnaire was well understood by most respondents. The main challenge was the fulfilment of the quotas in the larger size-bands. More specific comments from fieldwork organisations, which point to difficulties encountered in the local situation, are available in the detailed field-report from Ipsos, which can be downloaded from the e-Business Watch website.

Weighting schemes

Due to stratified sampling, the sample size in each size-band is not proportional to the population numbers. If proportional allocation had been used, the sample sizes in the 250+ size-band would have been extremely small, not allowing any reasonable presentation of results. Thus, weighting is required so that results adequately reflect the structure and distribution of enterprises in the population of the respective sector or geographic area. The Sectoral e-Business Watch applies two different weighting schemes: weighting by employment and by the number of enterprises.[1]

Results weighted by employment: Values that are reported as employment-weighted figures should be read as "enterprises comprising x% of employees" (in the respective sector or country). The reason for using employment weighting is that there are many more micro-enterprises than any other firms. If the weights did not take into account the economic importance of businesses of different sizes in some way, the results would be dominated by the percentages observed in the smallest size-band.

Results weighted by the number of enterprises: Values that are reported as "x% of enterprises" show the share of firms (as legal units) that use a certain technology or activity, irrespective of their size, i.e. a small company and a large company both count equally.

The use of filter questions in interviews

In the interviews, not all questions were asked to all companies. The use of filter questions is a common method in standardised questionnaire surveys to make the interview more efficient.

The results for filtered questions can be computed on the base of not only those enterprises that were actually asked the question (e.g. "in % of enterprises buying supplies online"), but also on the base of "all companies". In the study, both methods are used, depending on the variable and the issue to be analysed. The base (as specified in footnotes of tables and charts) is therefore not necessarily identical to the set of companies that were actually asked the underlying question.

Statistical accuracy of the survey: confidence intervals

Statistics vary in their accuracy, depending on the kind of data and sources. A 'confidence interval' is a measure that helps to assess the accuracy that can be expected from data. The confidence interval is the estimated range of values on a certain level of significance. Confidence intervals for estimates of a population fraction (percentages) depend on the sample size, the probability of error, and the survey result (value of the percentage) itself. Further to this, variance of the weighting factors has negative effects on confidence intervals.

Exhibit A1-5 gives some indication about the level of accuracy that can be expected for totals of the two surveys (based on all respondents), depending on the weighting scheme applied. The confidence intervals[2] differ depending on the respective value. For the survey on the glass, ceramics and cement industries, on average, it is 3-5 percentage points (in both weighting schemes) for the sector total. Confidence intervals are higher for sub-sectors and specific break-downs

[1] In the tables of this report, data are normally presented in both ways, except for data by size-bands. These are shown in % of firms within a size-band, where employment-weighting is implicit.

[2] A confidence interval indicates how likely a specified interval is to contain the given parameter. This is determined by the (i) confidence level and (ii) the selected confidence coefficient. In Exhibit A1-5, the "90% confidence intervals" has been calculated for specific percentage values and segments of the sample, which means that the actual value of the parameter is within the given interval with a likeliness of 90%.

(about 5 points for the cement industry, and up to +/- 10 points for the glass and the ceramics industries). For the survey on the energy industry, the confidence intervals are 5-10 percentage points.

The calculation of confidence intervals is based on the assumption of (quasi-) infinite population universes. In practice, however, in some countries the complete population of businesses consists of only several hundred or even a few dozen enterprises. This means that it is practically impossible to achieve a smaller confidence interval through representative enterprise surveys in which participation is not obligatory. This should be borne in mind when comparing the confidence intervals of e-Business Watch surveys to those commonly found in general population surveys.

EXHIBIT A1-4: INTERVIEW CONTACT PROTOCOL, COMPLETION RATES AND NON-RESPONSE REASONS

	Survey in the glass, ceramics and cement industry	DE	ES	FR	IT	PL	UK
1	**Sample (gross)**	**2301**	**2171**	**828**	**1001**	**847**	**943**
1.1	Telephone number not valid	251	0	41	51	40	114
1.2	Not a company (e.g. private household)	23	52	4	6	22	12
1.3	Fax machine / modem	4	0	5	1	0	1
1.4	Quota completed → address not used	438	557	0	37	0	0
1.5	No target person in company	217	34	155	41	68	72
1.6	Language problems	1	0	0	0	15	0
1.7	No answer on no. of employees → not used	1	3	0	1	1	0
1.8	Company does not use computers	0	9	0	1	0	0
1.9	Company <10 employees	38	152	10	5	15	24
	Sum 1.1 – 1.10	973	807	215	143	161	223
2	**Sample (net)**	**1328**	**1364**	**613**	**858**	**686**	**720**
2.1	Nobody picks up phone / answering machine	97	169	57	0	39	143
2.2	Line busy, engaged	0	0	0	0	5	0
2.4	Contact person refuses	504	721	322	561	287	236
2.5	Target person refuses	383	197	62	92	34	173
2.6	no appointment during fieldwork possible	1	0	7	15	58	28
2.7	open appointment	151	128	72	80	119	72
2.8	target person is ill / cannot follow the interview	1	0	0	0	0	0
2.9	Interview abandoned	11	24	6	9	26	4
2.10	Interview error (→ interview cannot be used)	0	0	1	0	11	0
	Sum 2.1 – 2.10	1148	1239	527	757	579	656
3	**Successful interviews**	**180**	**125**	**86**	**101**	**107**	**64**
	Completion rate (= [3]/[2])	**14%**	**9%**	**14%**	**12%**	**16%**	**9%**
	Average interview time (min:sec)	**14:23**	**15:57**	**15:06**	**16:57**	**17:24**	**14:54**
	Survey in the energy supply industry	**DE**	**ES**	**FR**	**IT**	**PL**	**UK**
3	**Successful interviews**	**149**	**58**	**20**	**50**	**60**	**14**
	Completion rate (= [3]/[2])	**15%**	**17%**	**29%**	**13%**	**18%**	**8%**
	Average interview time (min:sec)	**17:20**	**15:51**	**17:23**	**18 : 15**	**21:06**	**14:24**

EXHIBIT A1-5: CONFIDENCE INTERVALS

	Survey result	Confidence interval								
		if weighted as «% of firms»			if weighted by employment			Unweighted		
Glass, cement, ceramics (total)	10%	7.8%	-	12.8%	7.5%	-	13.2%	8.3%	-	12.1%
Energy (total)	10%	7.5%	-	13.2%	5.7%	-	17.1%	7.7%	-	13.0%
Glass, cement, ceramics (total)	30%	26.4%	-	33.9%	25.9%	-	34.5%	27.2%	-	33.0%
Energy (total)	30%	25.9%	-	34.4%	22.2%	-	39.2%	26.1%	-	34.2%
Glass, cement, ceramics (total)	50%	45.9%	-	54.1%	45.3%	-	54.7%	46.8%	-	53.2%
Energy (total)	50%	45.3%	-	54.7%	40.8%	-	59.2%	45.6%	-	54.4%
Glass, cement, ceramics (total)	70%	66.1%	-	73.6%	65.5%	-	74.1%	67.0%	-	72.8%
Energy (total)	70%	65.6%	-	74.1%	60.8%	-	77.8%	65.8%	-	73.9%
Glass, cement, ceramics (total)	90%	87.2%	-	92.2%	86.8%	-	92.5%	87.9%	-	91.7%
Energy (total)	90%	86.8%	-	92.5%	82.9%	-	94.3%	87.0%	-	92.3%

confidence intervals at α=.90

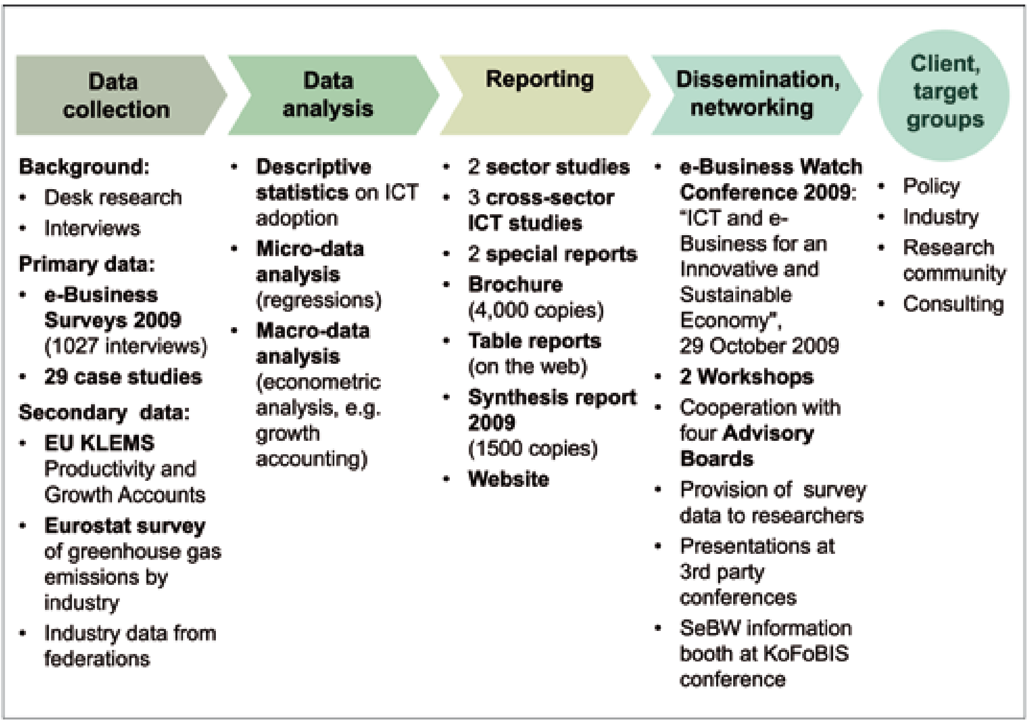
Annex II Sectoral e-Business Watch activities in 2009

This Annex summarises the activities of the Sectoral e-Business Watch over the period from December 2008 to December 2009[1]. Activities can be grouped into four categories, which constitute the main project phases (see Exhibit A.2-1): **primary data collection** (with the e-Business Surveys 2009 and the case studies as the cornerstones of this activity), **data analysis** (including micro and macro data analysis), **reporting**, i.e. the presentation of results in publications, and **dissemination and networking** activities, which include the organisation of events and cooperation with the Advisory Boards.

A2.1 DATA COLLECTION

The Sectoral e-Business Watch combines quantitative and qualitative methods to collect primary and secondary information about the sectors and topics studied (see Exhibit A2-2). Qualitative information, i.e. individual assessments of facts, stems from interviews (with sector experts, industry and company representatives) and from case studies. This evidence serves as contextual information and has a descriptive, explanatory and illustrative function. In addition to this, quantitative data gathered through

EXHIBIT A2-1: ACTIVITIES OF THE SECTORAL E-BUSINESS WATCH IN 2009



[1] The Sectoral e-Business Watch is based on a framework contract between DG Enterprise and Industry and empirica GmbH, running from January 2007 until the end of 2010. The second specific contract concluded under this framework contract comprised the services summarised in this Annex. It covered the period from December 2008 to December 2009.

EXHIBIT A2-2: MATRIX OF DATA SOURCES USED

	Quantitative data	Qualitative information
Primary data	• e-Business Survey 2009 • e-Policy expert survey	• Case studies • Expert interviews
Secondary data	• EU KLEMS • Eurostat databases • Data from industry federations	• Literature evaluation ("desk research") • Business examples (e.g. customer case studies by ICT service providers)

surveys and from secondary statistical sources delivers the indicators on ICT adoption and the basis for the economic analysis of ICT impact. Data collection is complemented by a literature review. Reports issued by industry federations are of particular importance as they deliver sector-specific data and background information, and present the industry's perspective on key issues and challenges.

The ICT and e-Business Surveys 2009

A good deal of the data presented in the Sectoral e-Business Watch studies and in this synthesis report are results of the ICT and e-Business Surveys of 2009, which are decision-maker surveys about the adoption of ICT and e-business among more than 1,000 companies from six EU countries. Interviews were carried out in March 2009 by Ipsos GmbH (http://www.ipsos.de) in cooperation with its local branches and partners, using computer-aided telephone interview (CATI) technology. Two separate surveys were conducted: (i) ICT and e-business in the energy supply industry, (ii) ICT and e-business in the glass, ceramics and cement industry. More information about the surveys is available in Annex I. Furthermore, for the study about ICT-related industrial policy, an expert survey was conducted, asking selected experts in the field to fill in an internet-based questionnaire.

Case studies

In 2009, the Sectoral e-Business Watch conducted 29 case studies in 13 countries. Case studies are examples of current e-business activity in firms from the sectors studied. The research objective is to complement the quantitative picture of e-business adoption from the e-Business Survey 2009 and from the economic analyses, and to illustrate the impact of ICT and e-business activity on enterprises and other organisations.

All case studies are based on personal interviews with representatives of the company or organisation, complemented by information such as annual reports, company brochures and information available on the company website or from other internet sources. The interviews were conducted face-to-face or by telephone (in cases where travel costs would have proven disproportionate), either by study team members or by local correspondents from the wider network of service providers. To this end, correspondents had received detailed guidelines how to identify and collect cases. The selection of cases was made by the study team responsible for the study, in coordination with DG Enterprise and Industry.

Case studies have been published as part of the study reports of 2009 and, in addition, on the case- study section of the website (www.ebusiness-watch.org/studies/case_studies.htm).

Secondary data sources

The Sectoral e-Business Watch collected comprehensive secondary data, particularly for analyses for the study about ICT impact on greenhouse gas emissions in energy-intensive industries, but also for the studies about the glass, ceramics and cement industry as well as the energy supply industry. The following principal data sources were used:

- **EU KLEMS**, an extensive database provided by the Groningen Growth Development Center. The EU KLEMS research project provides a database of measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all EU member states from 1970 onwards.
- **EUROSTAT**, the EU statistical office that collects data from national statistical institutes and other competent bodies to harmonise them according to a single methodology, was tapped for data about greenhouse gas emissions.

- The **United Nations Framework Convention on Climate Change** secretariat that compiles an international database of greenhouse gas emissions for participating countries and releases numerous publications on the topic of climate change.
- The **OECD** that collects harmonised data from member countries in addition to select non-member countries on a variety of relevant topics.

A2.2 DATA ANALYSIS

For data analysis, the Sectoral e-Business Watch used a combination of descriptive and analytical statistical methods in most of its studies.

Descriptive statistics

In the studies of the energy supply industry and the glass, ceramics and cement industry, the discussion of trends in ICT adoption and impact is mostly based on descriptive cross-tabular presentations of simple frequencies, typically percentages of enterprises (e.g. using a certain technology or performing a certain e-business activity). This constitutes the first and most basic step in data presentation. The requirement for this step is that micro-data have been aggregated and that weighting has been applied. Weighting is an important issue for data presentation, but it often confuses users. Weighting is necessary, as due to stratified sampling the sample size in each size-band is not proportional to the population numbers. If proportional allocation had been used, the sample size in groups of large companies (with more than 250 employees) would have been extremely small, and would have led to an unreasonable presentation of results.

Analytical methods

Descriptive presentation is limited in its power to explain ICT impact, as it can only deliver information about perceived impacts.[2] Analytical statistics, including macro data analysis (e.g. by means of growth accounting) and micro-data analysis (e.g. by means of regressions) were used to gain further insight into the economic impact of ICT in the studies of energy-intensive industries, the energy supply industry and the glass, ceramics and cement industry.

Theoretical analysis

A key component of the study of ICT-related industrial policy was the theoretical analysis that it conducted. This analysis did not use specific data directly but was built upon research findings from available literature. The overall objective of the theoretical analysis was to produce insights about strategies and behaviour of companies, Member States and the European Commission when interacting on issues of funding for ICT research, development, innovation and adoption, as well as of policy design.

A2.3 PUBLICATIONS OF 2010

All studies of the Sectoral e-Business Watch are published. The comprehensive study reports (typically with a scope of 100-200 pages) are published electronically on the SeBW website. Summaries of the studies are also available in printed format in various publications such as the brochure "ICT and e-business impact studies – 2009" and in this report.

Study reports

The main publications of the Sectoral e-Business Watch in 2009 – apart from this synthesis report – are five e business study reports, including two **sector studies** and three **thematic studies** on horizontal (cross-sectoral) issues. Summaries of these studies are presented in this report in Sections 2, 3 and 4. In addition, the Sectoral e-Business Watch has conducted two **special briefings** (i.e. studies with a smaller scope) on the following issues:

- the potential of Intelligent Transport Systems for reducing road transport related greenhouse gas emissions (see Section 2.3);
- metering facilities as enabling technologies for smart electricity grids in Europe (see Section 3.2).

All studies can be downloaded in full from the website (www.ebusiness-watch.org, under "eBiz studies"). Printed copies are not available.

Synthesis publications

The main synthesis publications of the Sectoral e-Business Watch in 2009 are this **Synthesis Report and the brochure** "ICT and e-business for an innovative and sustainable economy – 2009". Printed copies of these publications can be ordered from the Sectoral e-Business Watch or from DG Enterprise & Industry. In addition, **Table Reports** (in Microsoft Excel format) which summarise the CATI survey results are available on the website.[3] Charts or tables from

[2] Companies are directly asked to assess the impact of ICT or a certain activity on their business.
[3] http://www.ebusiness-watch.org/statistics/table_chart_reports.htm.

these reports can be freely used, provided that the sources are acknowledged.

Website

The Sectoral e-Business Watch website (www.ebusiness-watch.org) was launched back in 2002. It is continuously updated to include new results of SeBW research. The site is the **main archive** of the programme, providing users with free access to all publications and workshop proceedings available since the launch of the initiative. The website had an average of **8,500 visitors per month** in 2009, not including automatic accesses e.g. by search engines.

A2.4 DISSEMINATION AND NETWORKING ACTIVITIES

One of the objectives of the Sectoral e-Business Watch is to provide a **forum for debate** of ICT-related issues with stakeholders from industry and policy institutions, and thus to support policy formulation in this field. Therefore, dissemination and networking activities are an important part of its work. They constitute the next link in the "value chain" of the initiative after data collection, analysis and reporting (see Exhibit A2-1). To provide a forum for debate, the Sectoral e-Business Watch organised a full-day **conference** and two half-day **workshops** in 2009. Furthermore, the cooperation with **Advisory Boards** was continued. **Dissemination** activities included mailing e-newsletters, providing micro-data from e-Business Watch surveys to researchers for statistical analysis purposes, and presenting the project at third parties' events.

Workshops

In 2009, the Sectoral e-Business Watch organised two workshops to discuss interim study findings with stakeholders from industry, policy and research. The main objective of these events was to validate the research findings (typically on the basis of interim reports). Proceedings of the workshops, and a synopsis of main results and conclusions from the discussion with participants, are available on the website at www.ebusiness-watch.org/events/proceedings.htm.

e-Business Watch Conference 2009

The main event in 2009 was empirica's "ICT and e-business for an innovative and sustainable economy" conference, which was held on 29 October in Brussels. The conference was attended by 80 participants from across Europe, mostly e-business policy makers (at the European, national and regional level), industry representatives (from federations, ICT service providers or ICT using companies), researchers (notably economists), business advisors and consultants.

This conference was held to present the latest SeBW study results to stakeholders from the sectors covered, policy makers, researchers and representatives of the ICT industry. In the morning track, empirical evidence about the potential of ICT was presented. The afternoon track discussed the policy approaches needed to exploit this potential. The studies presented and discussed at the conference confirmed the enabling role of ICT for innovation. The e-Business Watch findings presented at the conference also suggested a significant link between ICT use and the intensity of greenhouse gas emissions, and identified important issues for industrial policy. Proceedings are available at the website.[4]

EXHIBIT A2-3: SECTORAL E-BUSINESS WATCH WORKSHOPS IN 2009

Date	Place	Workshop title and content
24-05- 2009	Milan	**ICT and e-business in the energy supply industry** Organised by IDC
22-09-2007	Brussels	**ICT impact in the energy supply industry and on greenhouse gas emissions in energy-intensive industries** Organised by empirica

[4] http://www.ebusiness-watch.org/conference2009/index.php.

EXHIBIT A2-4: ADVISORY BOARD MEMBERS OF 2009

Advisory board member	Company / organisation	Country
Energy supply		
Thomas Theisen	RWE Energy	Germany
Maher Chebbo	SAP	France
Bernard Aebischer	ETH Zurich	Switzerland
Iiro Rinta-Jouppi	Vattenfall	Finland
Miguel Sanchez Fornie	European Utilities Telecom Council	Spain
Glass, ceramic, cement		
Jean-François Mottint	CEMBUREAU	EU
Frédéric van Houte	CPIV	EU
Renaud Batier	Cérame-Unie	EU
Brigitte Preissl	Intereconomics Wirtschaftsdienst	Germany
Energy-intensive industries		
Enrico Gibellieri	European Steel Technology Platform	Italy
Pietro Evangelista	Consiglio Nationale delle Ricerce	Italy
Martin Wörter	ETH Zurich	Switzerland
Graham Vickery	OECD	France
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Cooperation with the Advisory Board

To validate study results, the Sectoral e-Business Watch seeks regular exchange and debate with international experts on ICT, e-business and from the sectors covered. For four studies conducted in 2009, an Advisory Board was established. This way, 18 representatives from industry, public authorities, research and consulting contributed to the work. They provided comments on interim reports and specific inputs to the research work. Their services are gratefully acknowledged.

Other dissemination activities

Members of the Sectoral e-Business Watch study team **presented findings** at various international events, for example at the kick-off meeting of the CEN eSME Focus Group on 2 April 2009 in Brussels, at the Microsoft Growth and Innovation Day on 5 March 2009 in Brussels, and the CEN conference "Electronic Invoices and Compliance" on 18 June 2009 in Brussels. In addition, the project was represented at an **information booth** during the Koblenzer Forum für Business Software (Koblenz Forum for Business Software, Germany) on 22 September 2009.

The Sectoral e-Business Watch aims to contribute to the **international debate on ICT and e-business measurement** and to working groups on ICT and e-business related issues, for example by participating in workshops on these issues and exchanging resources with related initiatives, such as interoperability initiatives. Examples of this exchange include the participation of Sectoral e-Business Watch representatives in a conference of the European e-Business Interoperability Forum (eBIF) on 8 December 2008 and in the meeting of the European e-Business Support Network in Prague on 13 May 2009.

The Sectoral e-Business Watch grants researchers and students **access to the micro-data** of the e-Business Surveys conducted since 2002 for research purposes, for instance for carrying out further empirical analysis on the economic impacts of ICT and e-business use in enterprises. In several cases, results of such research have been published in academic journals or PhD theses. Examples from 2009 include "Organizational Readiness and the Adoption of Electronic Business – The Moderating Role of National Culture in 29 European Countries" by Tobias Kollmann, Andreas Kuckertz and Nicola Breugst (The DATA BASE for Advances in Information Systems, Volume 40, Number 4, November 2009), and the PhD thesis "Prediction of Hybrid e-Commerce and Traditional Demand Evolution and the Assessment of its Impact on Production System Robustness" by Luca Canetta, École Polytechnique Fédérale de Lausanne. Members and former members of the Sectoral e-Business Watch study teams also use survey results as a source for further research and in articles they publish.

The Sectoral e-Business Watch sends out regular **electronic newsletters** to its subscriber base and to industry associations and federations across the EU. e-Newsletters provide information about new publications and forthcoming events.

The Sectoral e-Business Watch also frequently acts as a "**help desk**" for e-business related questions from all over the world. The number of such requests has steadily increased over the years, reflecting the growing recognition of e-Business Watch as an authoritative source of information on the issues it covers. Examples include requests for analysis from companies or business consultants, requests for background information (e.g. about surveys), questions on specific findings in reports, students who contact the Sectoral e-Business Watch in the context of their master or PhD thesis and orders for publications.

Annex III ICT and e-business - key terms and concepts

A definition of ICT

Information and communication technology (ICT) is an umbrella term that encompasses a wide array of hardware, software and services used for data processing (the information part of ICT) as well as telecommunications (the communication part). The European Information Technology Observatory (2009) structures the ICT market into three broad segments with an estimated total market value of about € 718 billion in 2009 (Exhibit A3-1).

EXHIBIT A3-1: EUROPEAN ICT MARKET (SALES VOLUME) IN 2009

Market segment	Products / services included	EU market value estimates (2009)	Change 2008-09
Information Technology (IT)	IT hardware, software, services	€ 299 billion	-2.6%
Telecommunications (TC)	TC end-user equipment, carrier services, network equipment	€ 361 billion	-0.7%
Consumer electronics	Examples: flat-screen TVs, digital cameras and navigation systems	€ 58.5	-8%
Total ICT market		***€ 718 billion***	***-2.2%***

Source: EITO 2009

ICT is a technology with special and far-reaching properties. As a so-called **general purpose technology** (GPT), it has three basic characteristics:[1] First, it is pervasive, i.e. it spreads to all sectors. Second, it improves over time and hence keeps lowering the costs for users. Third, it spawns innovation, i.e. it facilitates research, development and market introduction of new products, services or processes. One may argue that only electricity has been of similar importance as a GPT in modern economic development.

Companies in all sectors use ICT, but they do so in different ways. This calls for a **sectoral approach** in studies of ICT usage and impact. The following section introduces a framework for the discussion of ICT that has been applied in most studies of the Sectoral e-Business Watch.

A definition of e-business

In a maturing process over the past 15 years, electronic business has progressed from a specific to a broad topic. A central element is the use of ICT to accomplish **business transactions**. This means exchanges of goods – or, in economic terms: property rights – between a company and its suppliers or customers.

Transactions can be broken down into **three phases**, and related business processes (see Exhibit A3-2). First, the pre-sale (or pre-purchase) phase includes the presentation of (or request for) information on the offer, and price negotiations. Second, the sale or purchase phase covers ordering, invoicing, payment and delivery processes. Finally, the after-sale or purchase phase covers all processes after the product or service has been delivered to the buyer, such as repairs and updates. Practically each step in a transaction can be pursued either electronically ("online") or non-electronically ("offline"), and all combinations of electronic and non-electronic implementation are possible. Therefore it has to be decided which components must be conducted online for a transaction (as a whole) to be termed "electronic".

[1] Cf. Bresnahan/Traijtenberg (1996) and Jovanovic/Rousseau (2005).

EXHIBIT A3-2: PROCESS COMPONENTS OF TRANSACTIONS

Pre-sale / pre-purchase phase	Sale / purchase phase	After-sale / after-purchase phase
• Request for offer/proposal	• Placing an order	• Customer service
• Offer delivery	• Invoicing	• Guarantee management
• Information about offer	• Payment	• Credit administration
• Negotiations	• Delivery	• Handling return

Electronic transactions, i.e. electronic procurement or sales, constitute **e-commerce**. The suppliers or customers can be other companies ("B2B" – business-to-business), consumers ("B2C" – business-to-consumers), or governments and their public administration ("B2G" – business-to-government).

The OECD proposed two definitions of e-commerce - one narrow and one broad – and both remain useful today. While the narrow definition focuses on "internet transactions" alone, the broad definition defines e-commerce as "the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over ***computer-mediated networks***. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the goods or service may be conducted on- or offline" (OECD, 2001). The addendum regarding payment and delivery illustrates the difficulty in specifying which of the processes along the transaction phases constitute e-commerce. The OECD definition excludes the pre-sale or pre-purchase phase and focuses instead on the ordering process. The SeBW follows the OECD position on this issue, while fully recognising the importance of the internet during the pre-purchase phase for the initiation of business.

The OECD Working Party on Indicators for the Information Society proposes a definition of **e-business** as "automated business processes (both intra- and inter-firm) over computer-mediated networks", with the imperative conditions that "the process integrates tasks (i.e. a value chain) and extends beyond a stand alone / individual application" and that "the processes should describe functionality provided by a technology, not a specific technology per se" (OECD, 2003, p. 6). Using this definition, e-commerce is a key component of e-business, but not the only one. This wider focus on business processes has been widely recognised: e-business also covers the digitisation of **internal and external business processes** that are not necessarily transaction-focused. Internal business processes include functions such as research and development, finance, controlling, logistics and human resources management. An example of external cooperative or collaborative processes between companies would be industrial engineers collaborating on a design in an online environment.

In addition, the OECD proposed that e-business processes should integrate tasks and **extend beyond a stand-alone application**. Thus, simply using a computer in a company does not constitute e-business. The most rudimentary form of e-business may thus be to connect two computers in a local area network.

The term "automation" in the OECD definition refers to the substitution of formerly manual processes. This can be achieved by replacing the paper-based processing of

Definition of key terms
e-Commerce: the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over computer-mediated networks. (OECD) Participants can be other companies ('B2B' – business-to-business), consumers ('B2C'), or governments ('B2G'). This includes processes during the pre-sale or pre-purchase phase, the sale or purchase phase, and the after-sale or after-purchase phase.
e-Business: automated business processes (both intra-and inter-firm) over computer-mediated networks. (OECD). e-Business covers the full range of e-transactions as well as collaborative business processes, such as collaborative online design processes which are not directly transaction-focused.

documents by electronic exchanges (machine-to-machine). Such electronic exchanges require interoperability, i.e. the agreement between the participants on electronic **standards** and processes for data exchange. In a wide sense, standards are defined here as "technical specifications". Standards and standardisation remain a key issue in further sophistication of e-business.

e-Business and a company's value chain

Despite dating back 20 years to the pre-e-business era, Michael Porter's framework of the company value chain and value system between companies remains useful when describing the opportunities of e-business.[2] A **value chain** represents the main functional areas ("value activities") of a company and differentiates between primary and support activities. These are "not a collection of independent activities but a system of interdependent activities" which are "related by linkages within the value chain".[3] These linkages can lead to increased process efficiency and competitive advantage through optimisation and co-ordination. This is where ICT can have a major impact.

The term **value system** expands this concept beyond the single company. The firm's value chain is linked to the value chains of (upstream) suppliers and (downstream) buyers. The resulting set of processes is referred to as the value system. All e-business processes occur within this value system. Key dimensions of the value system approach are reflected in the **Supply Chain Management** (SCM) concept[4]. This focuses on optimising the procurement-production-delivery processes, not only between a company and its direct suppliers and customers, but also in terms of a full vertical integration of the entire supply chain. Analysing the digital integration of supply chains in various industries has been an important theme in most sector studies by the SeBW.

The importance of e-skills and company organisation

The optimisation of value systems with ICT requires employees with particular skills. ICT skills or "e-skills" comprise ICT practitioner skills, ICT user skills and e-business management skills. Furthermore, the successful use of ICT is not only a matter of implementing technology but also of adapting the company's organisation to the specific needs of an electronic value chain. Organisational changes may for example relate to a rearrangement of strategies, functions, and departments.

e-Business in times of economic crisis

While e-business had regained momentum as a topic for enterprise strategy in recent years, the situation and outlook of ICT investment has become much less favourable with the economic crisis since mid-2008. In its Information Technology Outlook, the OECD stated that in 2009 "ICT growth is likely to be below zero for the OECD, with considerable turbulence as the financial services sector restructures and the real economy experiences a deep economic downturn." (OECD, 2008, p. 15)

However, the economic crisis does not affect all ICT in the same way. The OECD expects that "IT services and software will generally grow, along with new internet and communications-related products and infrastructure, as they are an essential part of spending, and partly recession-proof" (OECD, 2008, p. 15). The OECD also expects that growth of the ICT industry is unlikely to suffer the collapse that accompanied the bursting of the "new economy" bubble in 2001 (p. 23). Furthermore, the development of ICT investment differs by industry. Industries exposed to deep demand cuts, such as the automotive industry, may have to reduce their ICT investment, while industries with more stable demand, such as energy suppliers, may sustain their ICT investment. In any case, the evolutionary development of e-business has certainly not come to an end with the economic crisis. "E-" elements have become an essential component of modern business, and trends such as "cloud computing" and "Web 2.0" are likely to intensify this process.

Increasing competitive pressure on companies, many of which operate in a global economy, has been a strong driver for ICT adoption. Companies use e-business mainly for three purposes: to **reduce costs**, to **increase revenues** and to **improve customer service**. In essence, all e-business projects in companies explicitly or implicitly address one or several of these objectives. Recently, the use of ICT to **save energy** and reduce greenhouse gas emissions emerged as a specific issue of cost reduction, one with wide impacts for the economy and society as a whole.

While cutting costs continues to be a key motivation for e-business activity, particularly in the current economic crisis, anticipatory firms exploit the **innovation** potential of ICT for key business objectives. They have integrated ICT in their production processes, quality management, marketing, logistics and customer services. These functions are considered crucial to improving the competitiveness of European economies. Competing in mature markets requires not only optimised cost and excellent quality of products or services; it also requires effective communication and cooperation with business partners.

[2] See Porter, Michael E. (2004); original published in 1985.
[3] See Porter (2004), p. 48.
[4] See SCOR Supply-Chain Council: Supply-Chain Operations Reference-model (available at: http://www.supply-chain.org).

Companies that exploit the innovative potential of ICT even in times of economic crisis could emerge from the crisis stronger and more competitive.

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