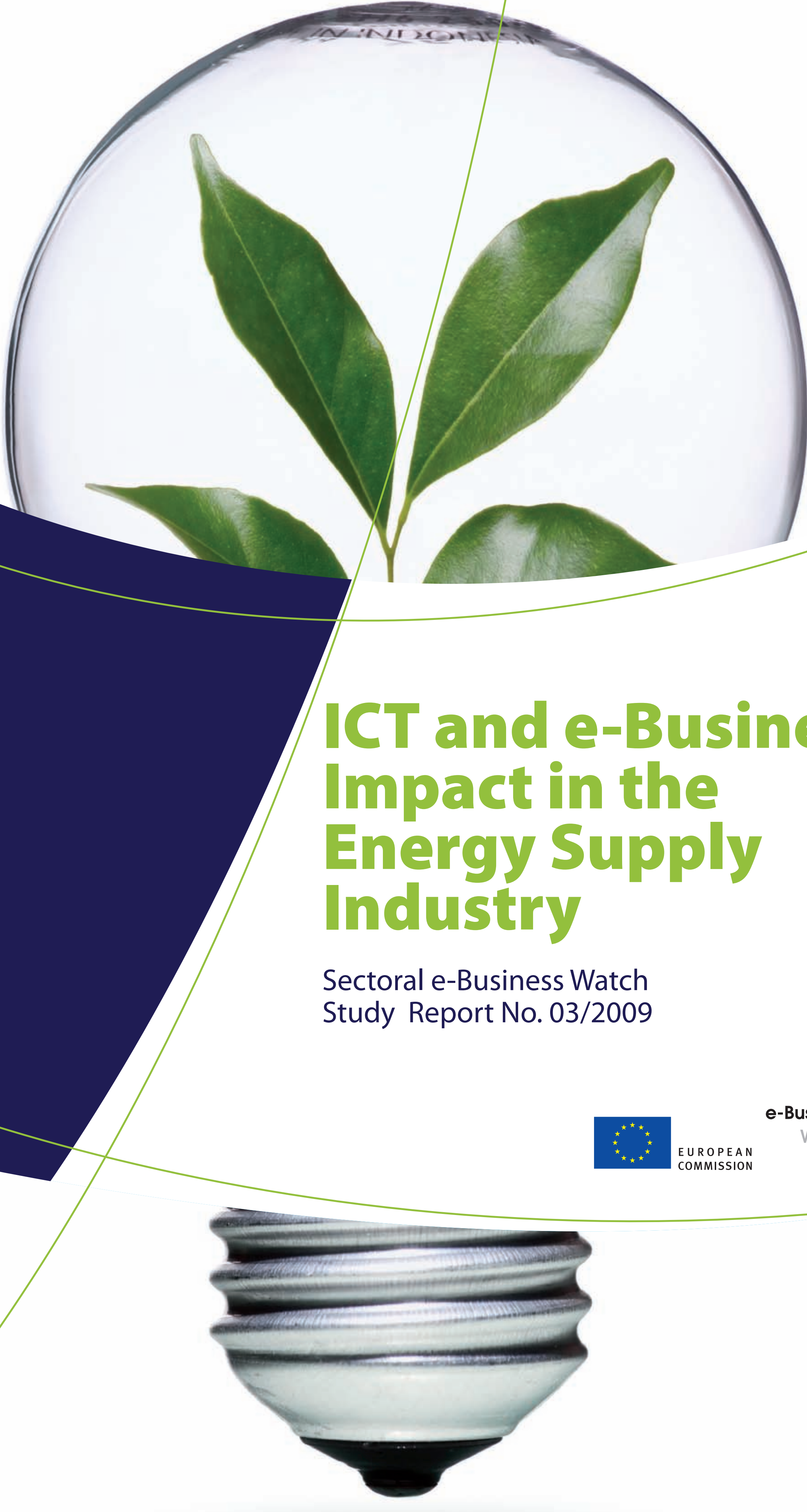

ICT and e-Business Impact in the Energy Supply Industry

Sectoral e-Business Watch
Study Report No. 03/2009

EUROPEAN COMMISSION

e-Business W@tch

e-Business W@tch

European Commission, DG Enterprise & Industry

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ICT and e-Business Impact in the Energy Supply Industry

A Sectoral e-Business Watch study by

IDC EMEA

Final Report

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This report was prepared by IDC EMEA on behalf of the European Commission, Enterprise and Industry Directorate General, in the context of the "Sectoral e-Business Watch" programme. The Sectoral e-Business Watch is implemented by empirica GmbH in cooperation with DIW Berlin, IDC EMEA, Ipsos and GOPA-Cartermill based on a service contract with the European Commission.

About the Sectoral e-Business Watch and this report

The European Commission, Enterprise & Industry Directorate General, launched the Sectoral e-Business Watch (SeBW) to study and assess the impact of ICT on enterprises, industries and the economy in general across different sectors of the economy in the enlarged European Union, EEA and Accession countries. SeBW continues the successful work of the *e-Business W@tch* which, since January 2002, has analysed e-business developments and impacts in manufacturing, construction, financial and service sectors. All results are available on the Internet and can be accessed or ordered at the SeBW website (www.ebusiness-watch.org).

This is a final report of a sector impact study, focusing on electronic business in the energy supply industry. The study describes how companies use ICT for conducting business, and, above all, assesses implications thereof for firms and for the industry as a whole. The findings are based on an international survey of enterprises on their ICT use, an econometric analysis of ICT impact on greenhouse gas emissions in the sector, case studies, expert interviews and literature evaluation.

Disclaimer

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Executive summary

Key findings

Supply of energy requires complex interactions of generation, transmission and distribution facilities, which can be greatly facilitated through information and communication technology (ICT). Smart metering, smart grids, demand management, intelligent power plants are currently some of most prominent issues in the energy supply industry (ESI).

The level of adoption of smart metering is low but increasing. Plans for investments in smart metering represent the unique positive exception in the investment plans examined in the SeBW Energy Supply Survey 2009. Barriers related to interoperability and regulations still need to be addressed.

Health, safety & environment systems and carbon management systems have not yet a widespread diffusion. The ESI is not fully exploiting the potential of ICT in contributing to the reduction of environmental impacts.

An econometric analysis conducted for this report found that greater ICT capital intensity significantly decreased emissions per output in the energy supply sector across all sample countries.

About this study

This study provides insights into current trends of ICT and e-business activity in the energy supply industry (ESI). It explores to which extent companies in the ESI sector use such ICT systems for managing their processes and the potential they attribute to ICT in these areas. Most importantly it provides a detailed analysis of the most innovative and promising area that will affect ESI evolution in the upcoming years, depicting the role and the impact on ICT.

Industry background – the sector at stake

The ESI as defined for the study is included in NACE Rev. 2 Group 35 (in the following short: NACE 35), “electricity, gas, steam and air conditioning supply”. Thus this study focuses on the value chain of the utility business that includes: production, transmission, distribution and trading of energy as well as its supply to final consumers (Section 2.1).

The EU-27 ESI is an economically important sector: about 31,000 firms employed nearly 1.6 million people and generated a turnover of 932 billion euros in 2006. Moreover, the energy industry is pivotal to any other industrial and private activity (Section 2.2).

Trends and challenges

A competitive, reliable and sustainable energy sector is essential for the EU, which is presently coping with a vast array of challenges. The EU is highly dependent on imported products and is subject to volatility of prices. The national markets lack integration, as indicated by the absence of price convergence and the low level of cross-border trade.

There are still large differences in market structure, competitiveness, public service and customer protection between European countries. The EU is also mandating to fight against climate chance, and the European energy supply industry is aiming to shift towards decarbonised power. The deployment of smart grids, including the pilot and rollout of smart metering, is a key strategic element in order to meet these challenges.

To stay competitive, ESI companies would benefit from increased process efficiency along the entire value chain. Integrating infrastructures and migrating systems to more cost-effective platforms, both for electricity and gas (Section 2.3) would also be beneficial.

ICT for corporate processes

Among the solutions supporting enterprise business processes, Enterprise Resource Planning (ERP) currently have the widest adoption within this industry. ERP is used by two thirds (67%) of firms in the industry’s employment, followed by computer-aided design systems (CAD, 63%) and document management (DMS, 61%). Supply Chain Management systems are less diffused (15%) (Section 3.2.1). It appears that ESI companies reach a fairly good degree of automation in single processes, while they have still a way ahead before reaching cross process integration.

ICT skills requirements

Survey findings indicate that out of the companies currently employing ICT practitioners, 46% had job openings for ICT practitioners in the past 12 months and about half of them experienced difficulties in finding qualified people for open positions. Companies representing 91% of employment stated that demands on employees regarding their computer/software skills have noticeably increased. This is obviously related to the overall increased importance of ICT in this sector. Many of them also experience insufficient computer skills; this, however, for most companies affects only a minor part of their employees (Section 3.8).

Virtual Power Plant: ICT to integrate DER

A virtual power plant (VPP) is the distributed and co-ordinated operation of several small generation units, acting virtually as a single power plant. A VPP may be an effective approach to energy generation as it may significantly enhance the efficiency and reliability of production processes, bring environmentally interesting options and make it possible to deliver value added services to customers. The survey found that ICT solutions for managing distributed energy generation units (monitoring, forecasting and dispatching energy) are in place in a percentage of companies representing from 40 to 52% of total employment. Still many companies generating energy through distributed units run these units as “islands” of activity rather than in an integrated way. Leading edge pilot projects, like the one depicted in the RWE case study (Section 5.2), have been implemented in the EU. However, it is not yet possible to illustrate a standard architecture, nor is there consensus about costs and benefits of such implementations (Section 3.2).

ICT for transmission grids

European transmission systems are ageing and massive investments will be necessary in the next years both to replace assets and to solve congestion problems. Key ICT technologies for transmission grid management include tele-measures and tele-controls systems, aimed at supporting sector-specific functionalities related to real time measurement, analysis, forecast and monitoring of operations

ICT enablement of smart grids

Presently, ESI companies are fairly well equipped with systems supporting management and control of their activities in energy transmission and distribution although smaller companies slightly lag behind. Companies representing 71% of the industry’s employment said they have adopted systems for energy network automation and control. Plans for further investments, however, indicate that a low percentage of companies (firms representing 3% of employment) that presently do not have these solutions plan to adopt them. There is evidence that further enablement of smart grids, a pillar of the EU energy policy, would need to be supported by adequate ICT (Section 3.3).

Smart metering

Companies representing about half the employment in the sector reported that they are either installing or testing smart meters and further 21% said they plan to do so in the next two years. These plans for investment represent the unique exception in the investment plans examined in the SeBW Energy Supply Survey 2009: no other application or technology is regarded with the same attention. However, companies representing 36% of employment that implement or test smart metering reported to face barriers related to the interoperability of the devices and systems and 37% indicated that they need to cope with regulation deficiencies. These challenges are to be met in order to fully exploit the potential for energy savings, process efficiency and new value added services (Section 3.4.1).

Demand side management

On the supply side, companies installing, controlling, managing and monitoring energy distribution grids can use ICT for purposes such as remote meter reading and advanced metering infrastructure solutions. On the demand side, ICT may have a potential to increase energy efficiency among businesses and private households. The potential benefits of ICT for demand side management have been demonstrated in various pilot projects (see, e.g. business examples about SINTEF’s, ADDRESS and GridWise in Section 3.5.2). These benefits are also clear to ESI companies, as about three out of four of the surveyed companies perceive the potential of ICT in increasing efficiency of business customers as high or medium. However, companies representing only 19% of the EDI industry's employment stated to have ICT solutions to support demand response programmes. The set up of real time communication channels with end users is, instead, becoming a more common practice (firms representing 38% of employment, for instance, use web portals to inform their customers about consumptions). Outsourcing services are offered by companies representing 41% of employment.

ICT for environmental impact: untapped potential

The transition towards a more climate-friendly energy sector is supported by a range of ICT solutions that respond to changing regulatory, safety, and security requirements, while enhancing value chain visibility and ensuring continuity of operations. Overall, the SeBW Energy Supply Survey 2009 found that the diffusion of ICT solutions for monitoring and reducing environmental impact is low, if compared with the general market trends in the ESI and the regulation in place. Health, safety & environment systems that maximise compliance for electric utility industry facilities, have been adopted by companies, representing 50% of employment, and corresponding to only 32% of firms. Carbon management systems have been adopted by companies, representing 25% of employment. It appears that a relevant share of firms still do not fully exploit the potential of ICT in contributing to the reduction of environmental impacts. For instance companies representing 41% of employment said that ICT has no or little potential for reducing greenhouse gas emissions in the ESI.

ICT is an enabler of innovation

The entire ESI sector is undergoing profound changes leading closer to the vision of the "intelligent utility" to which users can actively participate. Innovation in smart grids, smart metering, demand response require enhancing and upgrading of existing infrastructures and implementing new ICT. It is therefore not surprising that within this industry ICT is perceived as a major innovation enabler. Companies representing 53% of this industry's employment said they introduced new products or services in the past twelve months, and 76% introduced new processes. The vast majority of these innovators said that the new products or services have ICT components (Section 3.5.2).

ICT impact on greenhouse gas emissions

An econometric analysis was carried out to determine the impact of ICT on greenhouse gas emissions in the ESI (Chapter 4). This analysis assesses the relationship between the ICT capital intensity of production and GHG emissions per output in the European energy supply sector.

Key findings from the analysis are that greater ICT capital intensity is found to significantly decrease emissions per output in the energy supply sector across all sample countries, with significant differences in the magnitude and form of this impact depending on whether new EU Member States are considered in the analysis. This suggests that there has been both a strong development of ICT innovations that reduce emissions and a sector-wide implementation of these innovations in the ESI among older EU Member States.

The role of e-business: a mixed picture

ESI firms largely recognise that ICT can provide a relevant contribution (for instance for reducing greenhouse gas emissions) and that its impact on energy management will increase in the future. The majority of companies, however, also indicate that presently most of their processes are only partly managed as e-business. According to the opinion of the interviewees, the main constraint to a wider adoption of e-business is that business partners along the value chain are not prepared for e-business. Costs, the second problem, lag far behind. Larger players apparently do not act as a driving force to broaden the adoption of ICT technologies (Section 6.2).

An outlook on ICT investments

The economic crisis has largely affected the decision for investments in ICT in 2009. Companies representing 52% of the industry's employment said they decreased their ICT budgets in 2009. 42% indicated that the economic crisis has an impact on ICT investment plans and out of these 51% actually cut or cancelled their ICT projects.

One of the most striking results from the SeBW Energy Supply Survey 2009 is the very low percentage of companies that plan investments in sector specific ICT applications that they do not have currently. For instance, firms representing only 4% of employment declared that they plan to introduce renewable energy information systems. Similarly low figures were found for systems for energy network automation and control (planned by 3%) and outage management systems (planned by 1%).

Investments in more sector-specific devices and applications, such as smart handheld devices, electronic billing and integration monitoring and control systems with business systems continue to receive attention by ESI, due to their relevance for competition (Section 6.3)

Implications for technological developments

Findings of this study suggest that there are technological developments that may be particularly helpful in supporting the ESI.

There is a need for need to better and further conceptualise, design and demonstrate technical architecture and commercial implications of Distributed Energy Resources (DER) and VPP. Further research would be needed for ICT for planning monitoring and control of the decentralised units. Further efforts are needed for the standardisation of the interfaces.

Improving energy efficiency on the demand side calls for actions in the areas of: standardisation, i.e. open and agreed standards for integration of devices, harmonisation of regulatory framework and the development of business models demonstrating the benefits for the various stakeholders involved.

The enablement of smart grids, a pillar of the EU energy policy requires the widespread adoption of ICT for monitoring, and control. There is a need for open and agreed standards for integration of different tools and devices in place. It is also necessary to improve architectures for integrating the data communications networks and the intelligent equipment in place. Besides mere technology, there is also a need for methods and tools that can assure interoperability, flexibility, effective security and expandability of the systems. Decision support systems to increase predictive reliability would also be needed. As smart grids involve various players along the value chain, this calls for coordination and harmonisation both at technical and at regulatory level.

The picture of smart metering in the EU leads to recommendations for actions addressing technical standards that may support interoperability between different systems and devices, and the definition of the required functionalities.

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

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 achieving the goals of a competitive, reliable and sustainable energy sector. The Edison Consortium case study and PHEVs technologies and standardisation (see Sections 3.4.2 and 5.3) suggest that there is a need for multidisciplinary and cross-sectoral cooperation including industry, scientists, academia, public administrations and the consumers (both business and final consumers).

Increased visibility and awareness of the benefits that can be achieved through the usage of ICT could be an important pillar of energy policies. This should lead to a deeper engagement of the demand side. Various actions could be recommended, including the development and dissemination of ICT-based platforms and users' tools. The availability of user-friendly and easily accessible tools of this kind may significantly impact on behaviour changes and, ultimately, on the level of consumptions. Another implication arising from this report is that more research may be helpful for establishing and disseminating knowledge and good practices for the most innovative technologies, such as VPP and smart metering for which a clear business case has not been established yet. Finally there is a need for continuing support of education and training activities especially in the areas where ICT can enable energy efficiency.

1 Introduction

1.1 About this report

Objectives, sources and addressees

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 firm performance in a context of global 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 an econometric analysis of the relationship between ICT investment and greenhouse gas emissions as well as on literature, interviews with industry representatives and experts, and company case studies.

In contrast to many other recent studies in the field of ICT and energy, this study does not focus on a narrow selection of issues for energy specialists but it provides a birds-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.

Study structure

The study is structured into **six main sections**. Chapter 1 explains the background and context *why* this study has been conducted: it introduces the Sectoral e-Business Watch (SeBW) programme of the European Commission, a conceptual framework for the analysis of e-business, and the specific methodology used for this study. Chapter 2 provides general information and key figures about the energy supply industry (ESI) in Europe. Chapter 3 describes relevance and trends of ICT and e-business use in this industry, focusing on specific ICT-related issues that were found to be particularly relevant to this sector. It includes results from the SeBW Energy Supply Survey 2009. Chapter 4 assesses the impact of ICT on greenhouse gas emissions based on an econometric analysis. Chapter 5 presents company case studies. These have been selected as practical examples and evidence for the issues discussed in Chapter 3. Chapter 6, finally, presents conclusions and an outlook of possible developments and policy implications related to ICT and e-business that could arise from the observed developments.

Combining descriptive and analytical approaches

The study approach is exploratory, descriptive and explanatory, applying a broad methodological basis: A **qualitative** case study approach (Chapter 5) is combined with a descriptive presentation of **quantitative** survey data (Chapter 3) and an **economic analysis** of ICT adoption and its impacts (Chapter 4). This threefold approach is meant to produce an in-depth understanding of current ICT and e-business application in the industry, while also assessing the economic effects of this application, for instance on firm productivity, innovation and greenhouse gas emissions. While the results from these different approaches are presented like self-sustained pieces of research in separate chapters, they are intertwined and cross-referenced.

1.2 About the Sectoral e-Business Watch

Mission and objectives

The "Sectoral e-Business Watch" (SeBW) studies the adoption and impact of ICT and 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 policy in the fields of ICT and e-business. The SeBW is based on a Framework Contract and Specific Contract between DG Enterprise and Industry and empirica GmbH.

Within the European Commission, DG Enterprise and Industry has the mission to help improve Europe's economic standing by ensuring that businesses are competitive and that they can compete openly and fairly. In ICT-related fields, DG Enterprise and Industry targets six policy fields: competitiveness of the ICT producing sector, ICT uptake in ICT using sectors, legal issues related to ICT uptake, ICT standardisation, e-skills and disruptive ICT.[1]

The services of the SeBW are expected to contribute to policies in these fields. The SeBW's mission can be broken down into the following main objectives:

- to assess the **impact of ICT** on enterprises, industries and the economy in general, including the impacts on productivity and growth, and the role of ICT for innovation and organisational changes;
- to highlight **barriers for ICT uptake**, i.e. issues that are hindering a faster and/or more effective use of ICT by enterprises in Europe;
- to identify and discuss **policy challenges** stemming from the observed developments, notably at the European level;
- to engage in **dialogue with stakeholders** from industry and policy institutions, providing a forum for debating relevant issues.

By delivering evidence on ICT uptake and impact, the SeBW is to support informed policy decision-making in policy domains also beyond ICT, including innovation, competition and industrial policy.

Policy context

The initial *e-Business W@tch* programme was rooted in the **eEurope Action Plans** of 2002 and 2005. The eEurope 2005 Action Plan had defined the goal "*to promote take-up of e-business with the aim of increasing the competitiveness of European enterprises and raising productivity and growth*".[2] The **i2010 policy**[3], a follow-up to eEurope launched in 2005, also stresses the critical role of ICT for productivity and innovation, stating that "*the adoption and skilful application of ICT is one of the largest contributors to productivity and growth throughout the economy, leading to business innovations in key sectors*" (p. 6). This policy rationale for the Sectoral e-Business Watch is still valid.

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1 See http://ec.europa.eu/enterprise/ict/index_en.htm#policy for more details.

2 "eEurope 2005: An information society for all". Communication from the Commission, COM(2002) 263 final, 28 May 2002, chapter 3.1.2.

3 "i2010 – A European Information Society for growth and employment." Communication from the Commission, COM(2005) 229 final.

Also in 2005, in consideration of globalisation and intense international competition, the European Commission launched a **new industrial policy**[4] to create better framework conditions for manufacturing industries in the coming years. Some of the policy strands described have direct links to ICT usage, recognising the importance of ICT for innovation, competitiveness and growth. In a **mid-term review** of the new industrial policy in 2007, the EC identified three particular challenges: intensified globalisation and technical change as well as climate change. In 2009, the EC will issue a Communication related to the role of high technology and industrial policy in the **economic crisis**.

The SeBW is one of several policy instruments used by DG Enterprise and Industry in this context. Other key instruments include the following:

- the e-Business Support Network (**eBSN**), a European network of e-business policy makers and business support organisations,
- the **eSkills Forum**, a task force established in 2003 to assess the demand and supply of ICT and e-business skills and to develop policy recommendations,
- activities in the areas of **ICT standardisation**, as part of the general standardisation activities of the Commission.[5]

In parallel to the work of the SeBW, the "**Sectoral Innovation Watch**" (see www.europe-innova.org) analyses sectoral innovation performance and challenges across the EU from an economic perspective.

Scope of the programme

Since 2001, the SeBW and its predecessor "e-Business W@tch" have published e-business studies on about **30 sectors** of the European economy, annual comprehensive synthesis reports about the state-of-play in e-business in the European Union, statistical pocketbooks and studies on specific cross-industry ICT issues. All publications can be downloaded from the programme's website at www.ebusiness-watch.org. In 2009, the main studies of the SeBW focus on the following five sectors and specific topics:

No.	Type of study and leader	Sector / topic
1	Sector study (NACE Rev.2 Division 35)	ICT and e-business impacts in the energy supply industry
2	Sector study (NACE Rev. 2 Division 23.1-6)	ICT and e-business impacts in the glass, cement and ceramic industry
3	Thematic study (cross-sector)	ICT impacts on greenhouse gas emissions in energy-intensive industries
4	Thematic study (cross-sector)	An economic assessment of ICT-related industrial policy
5	Thematic study (cross-sector)	e-Skills demand developments and challenges in manufacturing industries

ICT and e-business use in companies as well as related policy approaches have become increasingly sophisticated in recent years. For the SeBW this implies that there is also a need for **increasingly specific analyses**, conclusions and policy implications.

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4 See European Commission (2005a).

5 Larger recent activities include a workshop on "IPR in ICT standardisation" in November 2008, and a conference on "European ICT standardisation policy at a crossroads" in February 2008. See http://ec.europa.eu/enterprise/ict/policy/standards/ict_index_en.htm for details.

1.3 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 1-1). Compared to 2008, the European ICT market has experienced a decrease of minus 2.2%. For 2010, EITO expects the ICT market to stabilise and to decrease by only 0.5% to 714 billion €.

Exhibit 1-1: European ICT market (sales volume) in 2009

Market segment	Products / services included	EU market value estimates (2009)	Development to 2008
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:[6] 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

6 Cf. Bresnahan/Traijtenberg (1996) and Jovanovic/Rousseau (2005).

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".

Exhibit 1-2: Process components of transactions

Pre-sale / pre-purchase phase	Sale / purchase phase	After sale / after-purchase phase
• Request for offer/proposal • Offer delivery • Information about offer • Negotiations	• Placing an order • Invoicing • Payment • Delivery	• Customer service • Guarantee management • Credit administration • Handling returns

Source: Sectoral e-Business Watch

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. 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). [7] 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

7 These definitions remain useful today. For recent developments in definitions related to e-commerce and e-business see OECD (2009), pp. 41-48.

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 documents by electronic exchanges (machine-to-machine). Advanced automatic machine-to-machine exchanges are just unfolding their technical and economic potential and may lead to new applications and services with profound impact on business and society. Such developments are related to what is called the "Future Internet", comprising the "Internet of Things" and the "Internet of Services".[8]

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.

Definition of key terms for this study

- ***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 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 processes such as joint online design processes which are not directly transaction focused.*

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.[9] 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*".[10] 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.[11] This focuses on

8 See European Commission: Internet of Things – An action plan for Europe. COM(2009) 278 final. Brussels, 18.6.2009; and European Commission: Communication on future networks and the internet. COM(2008) 594 final, Brussels, 29.09.2008.

9 See Porter, Michael E. (2004); original published in 1985.

10 See Porter (2004), p. 48.

11 See SCOR Supply-Chain Council: Supply-Chain Operations Reference-model.

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. Companies that exploit the innovative potential of ICT even in times of economic crisis could emerge from the crisis stronger and more competitive.

1.4 Study objectives and methodology

Research objectives

The study focuses on topics related to ICT and e-business along the energy supply chain. The focus is on the issue how ICT and e-business can contribute to an efficient supply and consumption of energy. For each topic the study provides a problem-oriented analysis with a certain scheme including ICT use, drivers and barriers, impacts, and policy implications:

- **ICT use**: What types of ICT are available for supplying and consuming energy more effectively, and what is their development stage? What is their level of use between energy supplying and consuming companies?
- **Drivers and barriers**: What are the drivers and barriers of ICT use in energy supply? Major drivers may typically include cost savings and regulation, and barriers may typically be investment costs and dominant market positions of some players.
- **Impacts**: What are the impacts of ICT on energy market effectiveness, structure, business models, competitiveness and sustainability? What are the impacts on the economy at large, e.g. in terms of energy supply and saving?
- **Policy implications**: What implications arise from the analysis of ICT in energy supply for decision makers in the European Commission, national governments and industry associations? The study investigates the extent to which ICT allows to better meet the three key objectives of modern energy policy: efficiency, environmental protection and security of supply.[12]

The study deals with energy consumers, i.e. with the demand side, which may be businesses or private households, from a supply side perspective. This means that consumers' activities have only been examined to the extent that energy suppliers and consumers conclude specific agreements about energy provision and use. The study does not investigate the consumers' side independently.

The SeBW's methodological framework builds upon the one established for the preceding *e-Business W@tch*. It has been adapted to the new focus of activity, progressing from monitoring "e-readiness" and "e-activity" to the evidence-based **analysis of "e-impact"**.

Data collection and analysis

The study is based on a selected set of data sources and methodologies, including primary data collection, desk research and case studies. More specifically, information were collected from the following sources:

Sectoral e-Business Watch Survey (2009): The energy supply sector is one of two sectors besides glass, cement and ceramic covered by the SeBW Survey. The SeBW Survey is the main source for analysing the state of play in ICT adoption, B2B process integration and automation in this Final Report.

Case studies: Five case studies describing the e-business strategy of companies from the sector have been conducted. They were selected to match the topics in focus, and

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[12] See for instance the third legislative package of the EU commission on energy markets (http://ec.europa.eu/energy/electricity/package_2007/index_en.htm).

with a view to achieve a balanced coverage of countries, business activities (sub-sectors) and company size-bands.

Interviews: interviews have been conducted with firm 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 held.

Analytical statistical methods: Econometric methods were used to gain better evidence on the impact of ICT in reducing greenhouse gas emissions. This analysis, which is mainly presented in Chapter 4, focuses on links between ICT capital and GHG emissions. It is a macro-data analysis using the EU-KLEMS Growth and Productivity Accounts as well as Eurostat data.

Sources of industry association: Annual reports and position papers of industry associations were used, notably from the following federations: The Union of the Electricity Industry, Eurelectric, (http://www.eurelectric.org); European Smart Metering Industry Group, Eurogas (www.eurogas.org), International Gas Union (www.igu.org), World Energy Council (www.worldenergy.org).

Validation of results – the advisory board

The study is being conducted in close consultation with an Advisory Board, consisting of the following experts (in alphabetical order):

- Mr. Bernard Aebischer, Centre for Energy Policy and Economics (CEPE), ETH Zürich.
- Mr Maher Chebbo, SAP AG, Vice President of Utilities Industry for Europe, Chairman of the EU SmartGrids Demand and Metering.
- Mr. Iiro Rinta-Jouppi, Head of Development of Vattenfall Distribution Nordic
- Mr. Miguel Angel Sánchez Fornié, Chairman of the European utilities Telecommunications Council and Director of Control Systems and Telecommunications of Iberdrola.
- Mr. Thomas Theisen, Head R&D, RWE Energy.

Two on-site meetings of the Advisory Board were held, in addition to informal exchanges with the members and to their contributions on specific sections of the study. The first meeting was held on 20 May 2009 in Milan, to discuss the draft interim report and preliminary results of the survey. The second meeting took place on 24 September 2009 in Brussels. In this second meeting, the final survey results and a first draft of the final report, including the main findings and the implications for policy were discussed.

2 Context and background

2.1 Sector definition – scope of the study

Business activities covered

The energy supply industry (ESI) as defined for this study is included in NACE Rev. 2 Group 35 (in the following short: NACE 35), “electricity, gas, steam and air conditioning supply” (see Exhibit 2-1). Thus the study focuses on the value chain of the utility business, which includes production, transmission, distribution, and trading of energy as well as its supply to final consumers:

- **Production** of electricity and steam from any type of primary source – i.e. 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 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. The power or gas exchange operators (market operators) will not be included in the analysis.
- Energy **supply to final consumers**, which may be industrial, commercial, agricultural or residential.

Exhibit 2-1: Business activities of the energy supply industry (NACE Rev. 2 and 1.1)

NACE Rev. 2			NACE Rev. 1.1			Business activities
35			40			Electricity, gas, steam and air conditioning supply
	35.1			40.1		Electric power generation, transmission and distribution
		35.11			40.11	Production of electricity
		35.12			40.12	Transmission of electricity
		35.13			40.13	Distribution of electricity
		35.14			40.13	Trade of electricity
	35.2			40.2		Manufacture of gas; distribution of gaseous fuels through mains
		35.21			40.21	Manufacture of gas
		35.22			40.22	Distribution of gaseous fuels through mains
		35.23			40.22	Trade of gas through mains
	35.3			40.3		Steam and air conditioning supply

The study excludes the activities concerning extraction and processing of materials used for energy generation that are included in other NACE Divisions and Groups.[13]

The energy supply industry has not yet been included in previous e-Business Watch studies. In 2007/8 SeBW conducted a study about ICT and energy consumption, i.e. about the other side, the demand side of the energy market. Study 3 of the SeBW 2008/9 deals with energy intensive industries and will thus be partly complementary to the study about the energy supply industry.

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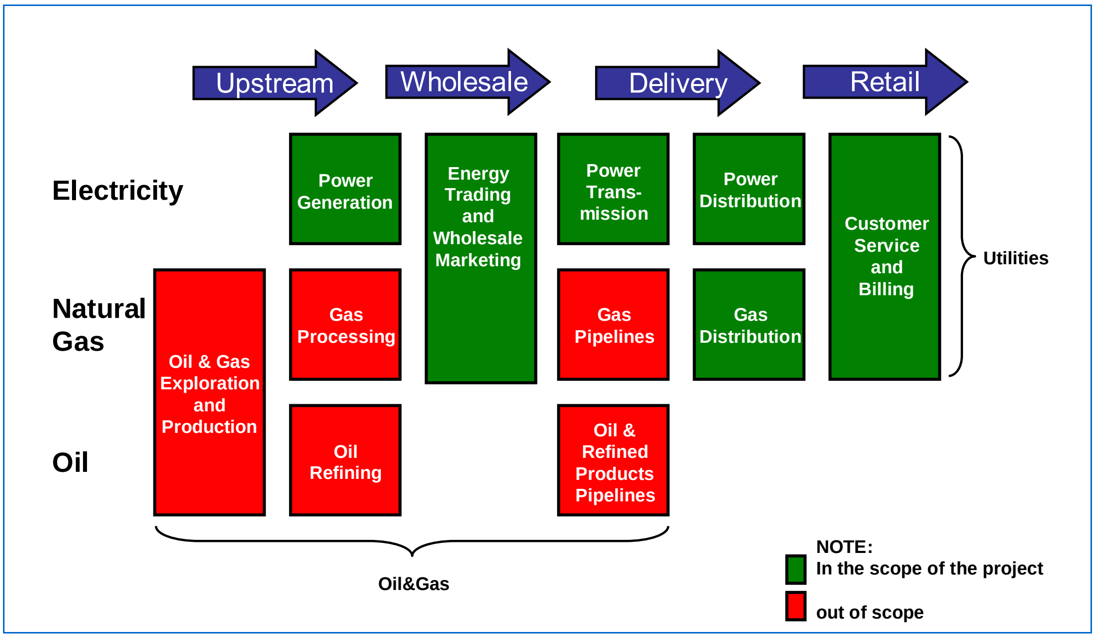
[13] Extraction and processing includes the mining and quarrying of energy producing materials and the manufacture of coke, refined petroleum products and nuclear fuel.

The supply chain of the energy supply industry

The ESI value chain is illustrated in the following figure, which also highlights the scope of the present Study Report. Although delivery of gas through pipelines is not part of this study and it is not extensively analysed, a brief description of the relevance of ICT for pipelines is provided in Section 3.7.

Exhibit 2-2: ESI supply chain and scope of the study



Source: IDC Energy Insights 2009

Power generation and wholesale

Power generation include activities to produce electric energy from sources such as fossil fuels (coal, gas and oil), nuclear, hydroelectric, geothermal energy, wind energy, solar, ocean. This segment also includes the selling of energy at the wholesale level. Players may operate on a regional, national or global level to match the geographic scope of their processing facilities. Business strategies rely on economies of scale, high volumes, cost/quality leadership, operations efficiency, R&D investments.

Delivery: transmission and distribution

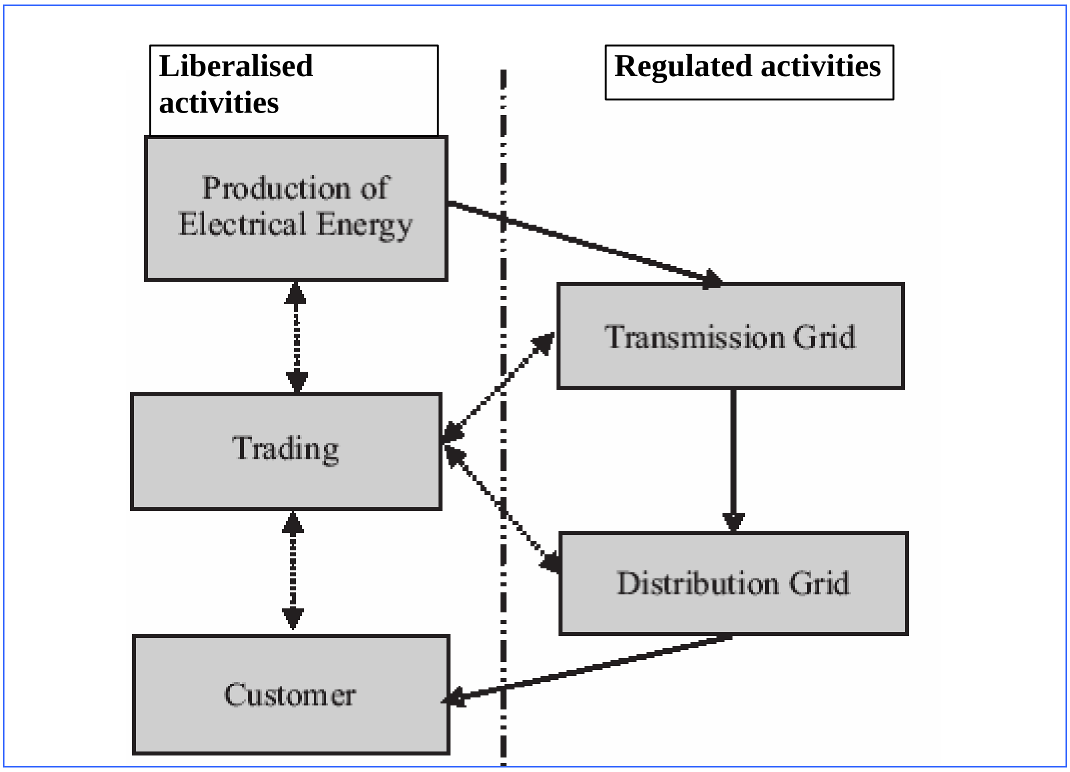
Electricity networks comprise both transmission and distribution infrastructure. Transmission is focused on transporting and transforming electricity on the interconnected high- and extra-high-voltage grids, the distribution segment is focused on the local network of pipers and wires delivering electricity and natural gas from the transmission system to the end users, and includes electric and gas distribution companies. Transmission and distribution are to be considered as distinct businesses.

Critical success factors in transmission and distribution are operational excellence, asset management and business process efficiency.

A more and more important technical challenge for the distribution operators is the emerging of “distributed generation” technologies and renewable energy sources. The increase of small and distributed generation units has a significant impact on the distribution networks both in technical and economical terms.

It should be pointed out that in the market for electricity, transmission and distribution remain regulated activities, as the European Electricity Market Directive currently in force clearly states operational and legal separation (unbundling) of network activities from the competitive segments of the industry This means that businesses which generate power and supply gas are not allowed to control the electricity grid or pipeline networks and are forced to either sell transmission networks or lease them to new operators.

Exhibit 2-3: Electricity market in EU: liberalised and regulated activities



Source: Elaborated from Acta Polytechnica N.3/ 2008, Czech Technical University

Retail

Retail activities focus on the marketing and selling of energy commodities and related services to customers. These may be energy intensive industrial users for whom energy is a significant percentage of the cost of goods sold. They are typically sophisticated energy users that not only need commodity energy but also have requirements for high power quality or other premium energy services. Other large user's market segments are large commercial and institutional end-users. The remaining market segment is the mass-market, consisting of small industrial and commercial and residential customers. In all segments, critical success factors include building customer loyalty and satisfaction, as well as and product leadership (for instance, green power).

A broad range of ICT systems is available for supporting ESI companies in their supply chain activities. A synopsis of these systems and the link with the various supply chain activities is provided in Exhibit 3-2.

2.2 Industry background

Overview of industry background

The EU-27 ESI is an economically important sector, providing employment to over 1.2 million people and generating a turnover of approximately 885 billion Euros in 2006. This industry comprises over 31 thousands firms representing 0.1% of the total number of enterprises in the non-financial business economy.

Exhibit 2-4: Profile of ESI in EU27, 2006

	Number of firms	Employment	Value added (billion Euros)	Turnover (billion Euros)
ESI EU-27	31,378	1,227,400	180	885

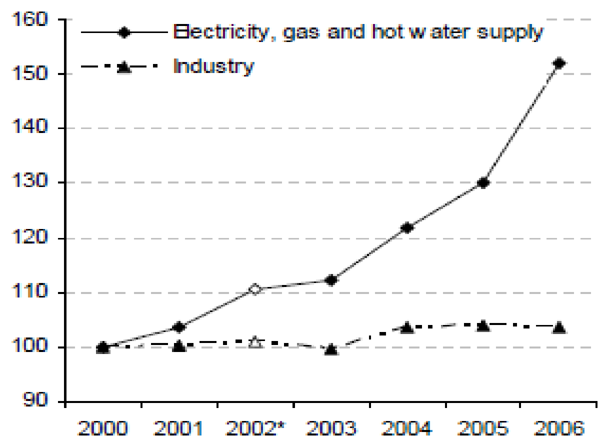
Source: Eurostat, Energy sector in Europe (SBS) 2009

Number of firms and employment

Historically, ESI has been a restricted sector operated by state monopolies in most countries. Since the 1990s, political trends in EU have brought forward liberalisation and deregulation, under the rationale that competition would be positive for efficiency and prices. While liberalisation of markets and competitiveness has been ruled at EU level, at the national level the pace at which this process has being achieved varies remarkably. Energy production firms are both privately and publicly owned. In many countries energy transmission and distribution are public utilities and in any case are regulated business. Ownership and control of the energy grid have been traditionally either fully public or at least dominated by public interests.

By and large, the structure of ESI, with large incumbents in the various sub-sectors is still in place. National markets in the EU-27 are characterised by structural differences of large and smaller firms, but also by an increasing role of companies operating in new energy technologies. Across the EU 27 countries there are also fundamental structural differences when it comes to how and from which sources energy is produced. This explains the variability in the number of enterprises and related employment across countries and over the observed period of time, as illustrated in the following tables.

Exhibit 2-5: ESI growth of the number of enterprises in EU 27, 2000-2006



Source: Eurostat, Energy Sector in Europe, 2009

The total number of enterprises in the energy sector increased by 52% between 2000 and 2006 (*Exhibit 2-5*). This growth includes both 'real' enterprise births and entries into the population due to mergers, break-ups, split-offs or other forms of reconstruction of the existing population of enterprises. More specifically, the number of enterprises in the energy sector increased by 30% in the EU-27 between 2000 and 2005 and grew even more rapidly in 2006.

The number of persons employed has remained fairly stable in recent years – see Exhibit 2-6. The overall number in EU-27 was approximately 1.6 million in EU-27 in 2005 and 2006. In some countries, such as Germany, France, Italy and Poland, the number of persons employed has been slightly declining; in others such as Spain and the UK it has been slightly increasing.

Exhibit 2-6: ESI, number of persons employed 2005-2007

Countries	2005	2006	2007
EU (27 countries)	1,600,000 (e.u.)	1,598,100	n.a
EU (25 countries)	n.a.	n.a	n.a
Germany	277,710	276,226	272,464
Spain	65,768	69,653	n.a
France	195,862	195,113	n.a
Italy	117,867	114,856	n.a
Poland	205,717	204,353	n.a
United Kingdom	131,498	136,666	n.a
Legend: n.a.=not available; e=Estimated value; p=Provisional value; c=Confidential; U=unreliable/uncertain			
Note: The number of persons employed is defined as the total number of persons working in the industry: employees, non-employees (e.g. family workers, delivery personnel) with the exception of agency workers.			

Source: Eurostat (SBS) 2009

Data broken down by enterprise class (defined in terms of the number of persons employed) show that large enterprises dominate in this industry, as the energy supply activities are characterised by relatively high minimum efficient scales of production – see Exhibit 2-7.

Exhibit 2-7: ESI, persons employed by enterprise size-class, 2006 (% of sectoral total)

	250 or more	50-249	10-49	1-9
ESI EU-27	79.3	13.6	4.9	2.2

Source: Eurostat (SBS) 2008

Despite the dominant role of large firms and high entry barriers, those countries that first implemented the mandates towards liberalisation and/or shifted towards distributed power generation, witness a lower degree of concentration in the electricity generation activity. The situation is illustrated in the following table that provides the current concentration of electricity generating firms within the EU. While in Greece, Cyprus and Malta the market share of the largest generator is around 100%, in Poland or the UK is around 20%.

Exhibit 2-8: ESI, market share of the largest generator in the European electricity market, (EU27 and Norway), 2004-2006 (%of the total)

Countries	2004	2005	2006
Austria	n.a	n.a	n.a
Belgium	87.7	85.0	82.3
Bulgaria	n.a	n.a	n.a
Cyprus	100.0	100.0	100.0
Czech Republic	73.1	72.0	73.5
Denmark	36.0	33.0	54.0
Estonia	93.0	92.0	91.0
Finland	26.0	23.0	n.a
France	90.2	89.1	88.7
Germany	28.4	n.a	n.a
Greece	97.0	97.0	94.6
Hungary	35.4	38.7	41.7
Ireland	83.0	71.0	51.1
Italy	43.4	38.6	34.6
Latria	91.1	92.7	95.0
Lithuania	78.6	70.3	69.7
Luxembourg	80.9	n.a	n.a
Malta	100.0	100.0	100.0
Netherlands	n.a	n.a	n.a
Poland	18.5	18.5	17.3
Portugal	55.8	53.9	n.a
Romania	31.7	36.4	31.1
Slovakia	83.7	83.6	70.0
Slovenia	53.0	50.1	51.4
Spain	36.0	35.0	31.0
Sweden	47.0	47.0	45.0
UK	20.1	20.5	22.2
Norway	*31.2*	*30.0*	*n.a*
n.a.=not available			

Source: Eurostat (SBS) 2008

Turnover, production and value added

The total turnover generated by ESI in 2006 was around 932 billion euros, recording an annual growth of about 17% over the previous year. Data for 2007 are only available for Germany, where turnover recorded a growth of about 12% over 2006. Data about turnover broken down by country not surprisingly reflect the geographical size and population across Europe. Germany leads with about 28% of totals turnover generated in Europe[14], followed by Italy, UK and France.

[14] Data about the 27 European countries are provided in Annex, Exhibit A9.

Exhibit 2-9: ESI, turnover in EU27 and main European countries, 2005-2007 (million Euros)

Countries	2005	2006	2007
EU27	800000(eu)	932431.0	n.a
EU25	n.a.	n.a.	n.a
France	75967.7	84328.7	n.a
Germany	225394.6	267616.7	298905.5
Italy	115786.8	142465.9	n.a
Poland	29379.1	32935.7	n.a
Spain	53250.9	59177.4	n.a
United Kingdom	90673.6	108213.7	n.a
Legend: n.a.=not available; e=estimated value; p=provisional value; c=confidential; u=unreliable/uncertain			

Source: Eurostat (SBS) 2009

The total production value of ESI in EU27 was about 802 billion Euros in 2006, with a remarkable growth of about 15% compared to previous year (700 billion Euro in 2005) and to 2004 (€600 billion).

An analysis of the sub-sectors of energy supply identifies the supply of electricity as the largest in value added terms, as it contributed for 85% of the sector's value added in 2006. The manufacture of gas and distribution of gaseous fuels through mains sub-sector contributed to 12% of the sector value added and the steam and hot water supply sub-sector around 5%.

Exhibit 2-10: ESI, value added at factor costs[15] by sub-sector in EU27, 2006 (million Euros)

Sub-sectors	Million Euros	% of the total ESI sector
Production and distribution of electricity	139,718	85
Manufacture of gas; distribution of gaseous fuels through mains	19,000	12
Steam and hot water supply	7,081	5
Total ESI	165,799	100

Source: Eurostat (SBS) 2008

2.3 Trends and challenges

Introduction

A competitive, reliable and sustainable energy sector is essential for any economy. This has been spotlighted in recent years by a number of issues. The volatility in oil prices and interruptions to energy supply from non-member countries have highlighted the vulnerability of the European sector. Blackouts have been aggravated by inefficient connections between national electricity networks, hampering cross-border exchanges, and by the difficulties that new suppliers face in accessing the gas and electricity markets.

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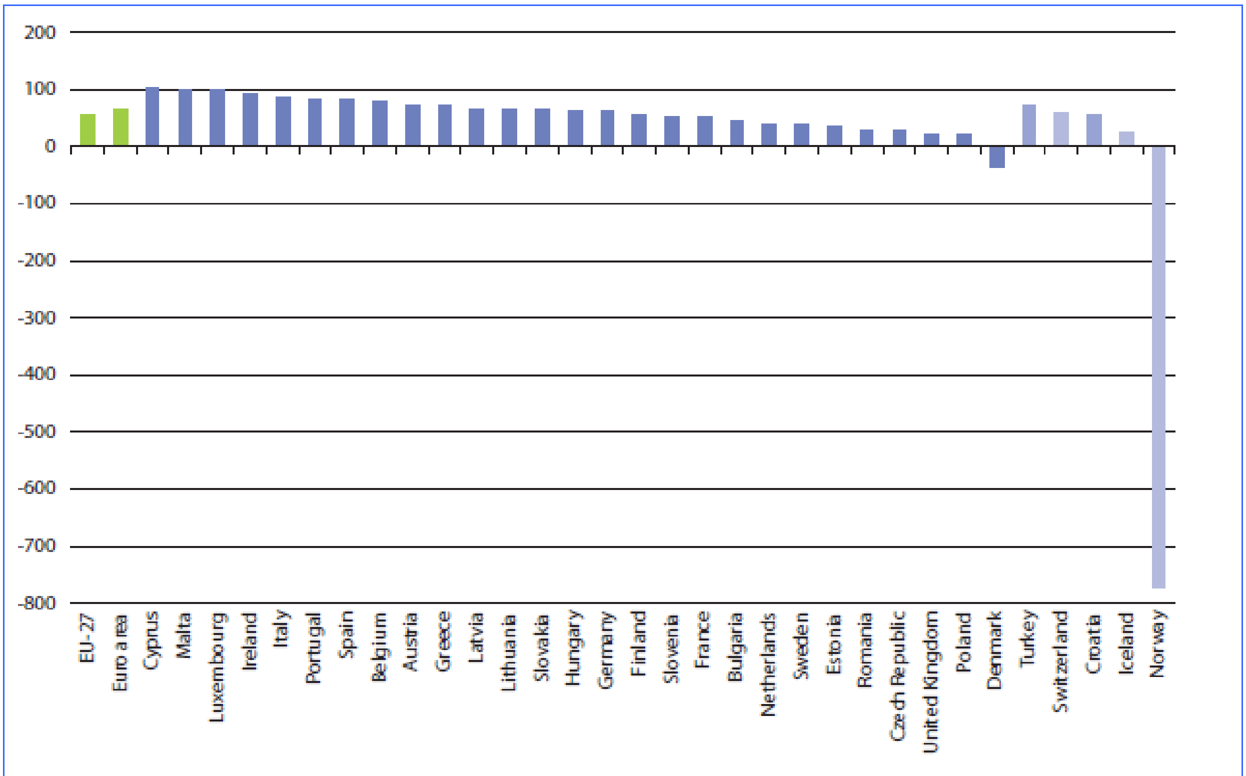
[15] In Eurostat SBS, value added at factor costs is defined as the gross income from operating activities after adjusting for operating subsidies and indirect taxes.

This section focuses on the main trends in this industry and on the challenges that the EU is going to face in order to achieve the goals of a more secure and sustainable sector. It also provides a brief summary of the regulation and climate mandates that are shaping the competitive scenario of the ESI in Europe.

Dependence of the EU in energy production

In almost all EU countries, internal primary energy resources cannot meet energy consumption requirements. In 2004, the dependency rate[16] recorded 50 and it reached 52.6 and 53.8 in 2005 and 2006 respectively. The highest dependency ratios were for crude oil and petroleum, although dependency for solid fuels and natural gas has been growing faster (see also the following section). Among the Member States, Denmark is the only net exporter; UK and Poland recorded the lowest dependency ratios. In Spain, Portugal and Italy, to mention only a few, dependency ratios were upwards of 80.

Exhibit 2-11: Energy dependency rate- all products 2006 (% of net imports in gross inland consumptions, based on tons of oil equivalent)



Source: Eurostat yearbook 2009

According to the Commission's Green Paper of 2006 on the security of energy supply, lacking measures to contrast these trends, in the next 20 to 30 years, 70% of the EU's primary energy requirements would need to be covered by imported products. It is also worth reminding that a large share of imports originates from politically unstable regions and, in the case of gas, reserves are concentrated in only a few countries.

Security of supply is determined by the availability of a wide range of fuel inputs from diverse sources, combined with adequate mix of the generation portfolio, including

[16] Eurostat defines the dependency rate as net imports divided by gross consumption, expressed as a percentage.

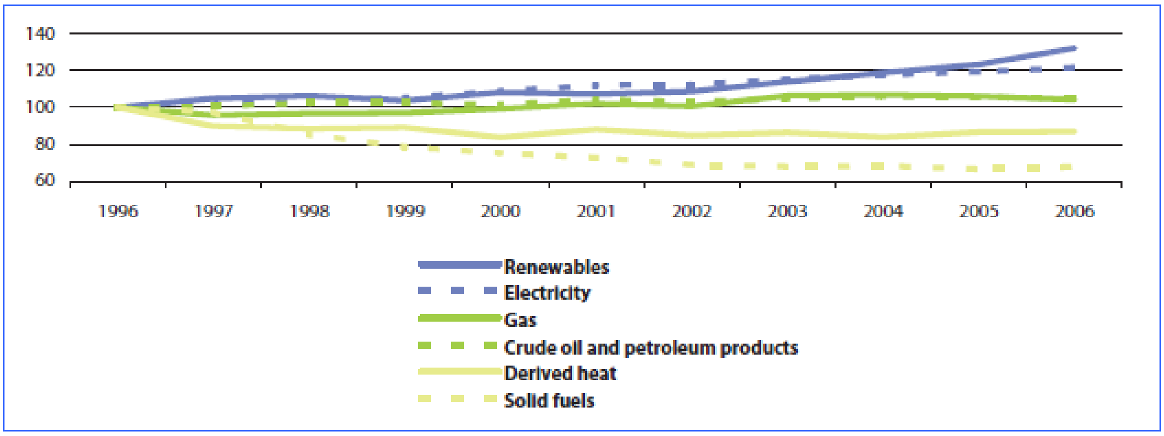
reserve capacity, and also adequate network infrastructure. This implies a stable framework, able to facilitate adequate investments and reward risk appropriately. Not least, in a context where consumers are demanding higher levels of stability and quality in their electricity supply, the whole system must be operated with paramount attention to reliability and operational security. Moreover, meeting the targets of security of supply and sustainability clearly implies reducing energy dependence, which, in turn, calls for actions to develop renewable sources, to increase efficiency in energy consumption and for technological developments and innovation along the ESI supply chain.

The challenge of reducing energy demand

The demand of energy by and large follows economic and demographic trends, it has therefore growing steadily for the past years and has been halted by the economic crisis: for the fist time, since the end of the Second World War, a decrease of global electricity demand is expected in 2009 The EU policies in place are nevertheless aimed at reducing energy demand in an attempt to decouple it more forcefully from the growth in economic activity. Initiatives in this field are illustrated in Section 2.3. Measures taken include a broad spectrum of actions addressing both businesses and households, such as the energy performance of buildings (private and public), lighting, transport, and manufacturing just to mention a few.

Final energy consumption in the EU-27 was equivalent to at 1,176 million toes in 2006. This level was only slightly higher than the previous two years, and over the ten years from 1996 to 2006 final energy consumption increased on average by just 0.5 % per annum. An analysis by main type of energy shows a shift in the energy mix between 1996 and 2006, most notably through a fall in the consumption of solid fuels (-3.8 % per annum) and an increase in the consumption of renewables (2.8 % per annum) and electricity (2.0 %).

Exhibit 2-12: Final energy consumptions in EU27, (1996=100)



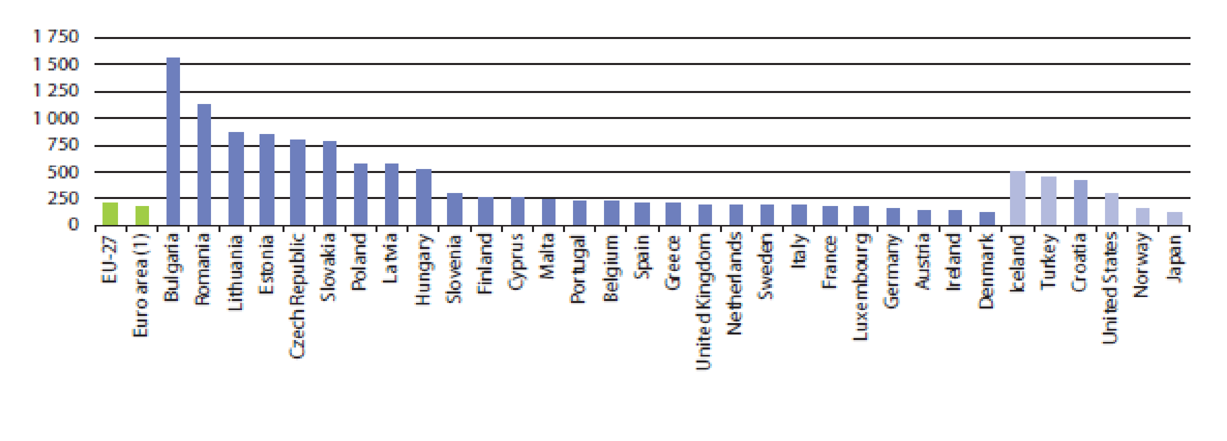
Source: Eurostat yearbook 2009

Energy intensity in EU-27 and other major economies is illustrated in the following graph. The energy intensity[17] ratio is determined by dividing the gross inland consumption by the GDP for a given calendar year. It measures the energy consumption of an economy and its overall energy efficiency. The gross inland consumption of energy is calculated as the

[17] Since gross inland consumption is measured in kgoe (kilogram of oil equivalent) and GDP in EUR 1 000 this ratio is measured in kgoe per EUR 1,000.

sum of the gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources. The graph shows that EU countries with the lowest energy intensity are Denmark, Ireland and Austria.

Exhibit 2-13: Energy intensity of the economy (kgoe per EUR 1,000 of GDP), 2006



Source: Eurostat yearbook 2009

Large variations in EU energy prices

The price of energy supplies, and of electricity in particular, is a key element of economies' competitiveness.

Prices for gas and electricity differ substantially across Europe, both at a wholesale and at a retail level. The price of electricity is influenced by the power generation mix; in other terms by the price of primary fuels, the type and level of incentives mechanisms created to support the development of specific energy sources, and more recently also by the cost of carbon dioxide (CO2) emission certificates.

The relationship between wholesale and retail prices is determined by a range of factors that vary from country to country, although price regulation exerts particular pressure and it is essentially a function of the government's political disposition.

There are strong variations, not only from country to country but also towards the various customer groups. While large industrial customers are in a position to negotiate personalised contracts, small consumers' contracts are normally set according to the amount of electricity or gas consumed, and a number of other characteristics that vary from one country to another; most tariffs also include some form of fixed charge.

In summary, there is no single price for electricity or gas in any EU country nor there is any evidence of forthcoming convergence. This, of course, may represent a challenge for the competitiveness of the various EU economies.

A concentrated and competitive sector

The overall European energy sector is quite concentrated (also refer to Exhibit 2-8) and the number and the size of players vary remarkably in the various countries.

Remarkable pan-European mergers and acquisitions over the past years have affected the map of players on the market, for instance the Scottish Power acquisition by

Iberdrola, Gaz de France acquisition of Electrabel, Enel acquisition of Endesa, and Vattenfall acquisition of Nuon.

The lesson learned from cross-border deals is that they absorb a great deal of time and effort (not just financial resources) in order to cope with a sort of "national" resistance. Even if some of these deals did not succeed (such as Enel's attempt to acquire Suez), cross-border mergers and acquisitions will continue to drain resources and reshape the sector.

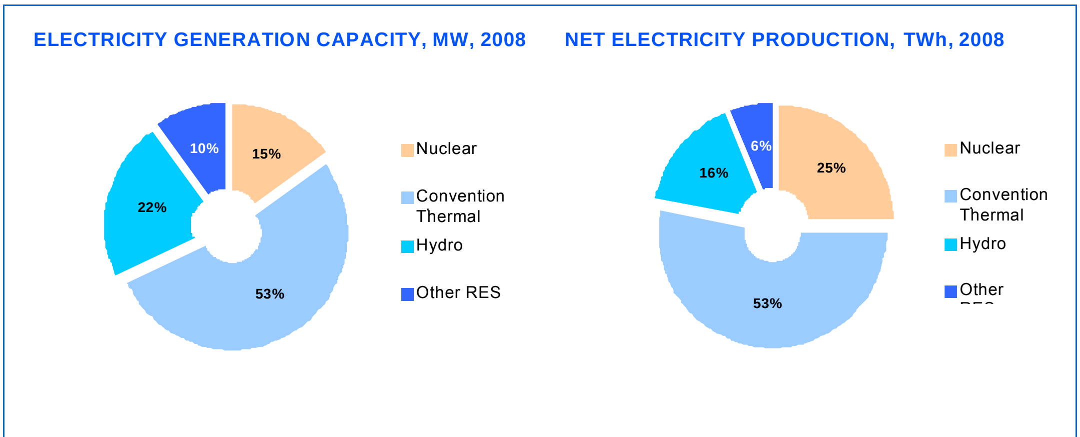
Even with some pressure on margins related to high fuel prices and incentive-based regulations, European utilities companies have been financially healthy, up to 2008, both in regulated and competitive businesses. It is not yet possible to evaluate the effects of the current crisis, although it can be envisaged that, in order to face the economic downturn, ESI players will have to further enhance their overall efficiency.

Sustainability: technological innovation and renewable energy sources

Technological innovation is essential for facilitating the transition from fossil fuels to renewable energy sources and for the development of clean coal and carbon capture and storage (CCS) technologies, with the goals to reduce dependence on fuel from non-members countries, decrease overall emissions and decouple energy costs from volatility of fossil fuel process.

In 2008, electricity generation capacity was 811,110 MW in the EU27, while total net electricity production reached 3,206.3 TWh. The relevance of the various energy sources differs between the two, for example "Other Renewable Energy Sources (RES)," which consists for example of wind power, photovoltaic power, biomass energy, and geothermal energy, makes up a 10% share of the total generation capacity, while it only contributes by 6% in net production. A very relevant renewable energy source, hydropower, in 2008, generated a 22% share of electricity capacity and produced a 16% share of electricity. Nuclear power has an opposite trend than the other RES described above, as its generation capacity contributes a smaller share than its net production, the former 16% and the latter 25%.

Exhibit 2-14: Electricity generation capacity versus net electricity production, EU27, 2008



Source: IDC Energy Insights redrawing of Eurelectric Key Statistics 2008

The development of renewable electricity generation implies relevant technological challenges and calls for changes along the entire ESI supply chain.

As renewable sources, in particular wind and sun, are variable that is to say they change over time due to weather conditions, their increased penetration requires careful analysis in terms of power system planning and operations, especially as regard reserve capacities. Although forecasting models of renewable generation have improved, there is still inherent operation uncertainty that needs to be addressed. Storage technologies have been proposed and tested but they are still far from being applied due to technical and cost reasons. Redundant capacity can be installed to compensate for unexpected reductions of renewable-based generation, but this represents extra-cost, which needs to be rebated to the customers.

The adoption of **demand management** is currently the most suitable solution to the problem of variable renewable electricity generation, as it supports in maintaining the supply-demand balance. It is also a tool for enhancing energy efficiency.

Another technological challenge related to the increased penetration of renewable energy sources is that some of them are typically organised as distributed energy resource systems, (e.g. solar panels on the roofs of buildings), and in order to be efficiently integrated they need to be controlled and, possibly, virtually bundled and managed as a single power plant. The management of **virtual power plants** requires co-ordination and the provision of additional services to the energy system. The role of ICT in facing this challenge is analysed in Section 3.3.

Moreover, as far as technology challenges are concerned, distributed generators installed need to be able to supply energy to their distribution network operator as well as to re-use it. Unfortunately, distribution networks were not designed for two-way flow and the changes in the performance of these networks with bi-directional energy flow has not been adequately addressed.

The need for more cross border integration

In the EU, there is a lack of integration of national energy markets, indicated by the absence of price convergence and the low level of cross-border trade.

Back in 2002, it was agreed that minimum interconnection levels would be increased between Member States to 10%. Till now, however, progress has not been as desired. Various factors hinder integration and, in turn, cross border competition:

- The energy mix, which differs substantially from country to country. The energy mix is primarily determined by geographical factors, by the availability of natural resources, as well as by political decisions, such as the phase-out of nuclear programmes or the implementation of specific policies to support renewable technologies. Energy mix in place may impact on each country's policies and priorities. In addition, the energy dependence on non-EU countries, as well as the diversity in the origin of such imports, can also impact on the definition of common energy policies among EU countries and, subsequently, on the sharing of infrastructures.
- Pricing is also a major issue, as illustrated in the previous section of this chapter
- Technical barriers – mainly dealing with the characteristics of energy – that strengthen the tendency towards regional fragmentation. These are: the type of physical networks that imply technical complexity in the operation of markets and requires close coordination and cooperation for network operators in order to trade energy; the fact that electricity is not yet economically storable and transportation is

economically feasible only over limited distances. In some cases there are geographical barriers (insular situations, e.g.) limiting the interconnection among countries. Different market designs and uncoordinated Transmission System Operators (TSOs) are other factors hampering an integrated European market. To cope with these challenges, it is particularly relevant the role of the European Network of Transmission System Operators for Electricity (ENTSO-E) (www.entsoe.eu.), operational as of 1 July 2009, representing 42 TSOs from 34 countries. The network took on functions of six TSO predecessors and its aims have been defined as "promote the reliable operation, optimal management and sound technical evolution of the European electricity transmission system in order to ensure security of supply and to meet the needs of the Internal Energy Market". The EU 3rd Energy Package legislation (see section "Milestones of energy and climate regulation in EU in recent years" in this chapter), approved by the European Parliament and the Council, in April and June 2009 respectively, actually establishes important Europe-wide planning and operations roles for ENTSO-E, as regard the optimal management of the electricity transmission network and the trading and supplying of electricity across borders in the Community.

- The prominent role of incumbents. Market entry is low and incumbents' market shares at domestic level are still very high. Unbundled companies are supposed to establish fair network access and set non-discriminatory conditions between their intra-group's supply business and competitors and this clearly represents a challenge for fair treatment of new competitors.
- There are also political and economic factors that prevent the integration of European energy markets, the most important of which is the different degree of implementation of the liberalisation directives. The protection of cheap domestic sources of energy, the promotion of national champions and of bilateral agreements in order to guarantee domestic supply and the national scope of some climate change policies may contribute to the fragmentation of the European energy markets.

Customers benefits from cross border competition are of various kinds, including, in principle: more choice and more variation between offers, fair and competitive prices, information transparency and awareness about efficient use. Moreover, a larger common market is likely to be a step towards more efficient and secure use of resources as security of energy supply depends on the availability of energy sources, sufficient investments and reliable transmission and distribution systems. Also, such a supply structure would facilitate crisis support between countries and would facilitate EU's common actions for climate change

There can be no truly competitive and single European market without additional physical capacity: this is particularly vital for countries such as Ireland or for the Baltic States, which remain an "energy island," largely cut off from the rest of the community. Equally, additional electricity interconnection capacity is necessary between many areas, and in particular between France and Spain, and through it Portugal, to permit real competition to develop between these countries. The achievement of competitive electric systems should include legislation actions[18] and changes in the organisation of technical and trading infrastructures.

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[18] General rules for the use of transmission capacities for cross-border trade and the related tariff questions should be agreed upon by all interested stakeholders and the EU legislative and

Status of network unbundling in the EU

The gas and electricity markets in the EU have been changing through the requirements of the **electricity and gas Directives** adopted in 2003. The aim was to have gas and electricity markets open for all customers by July 2007, as well as further unbundling the sector's supply as well as distribution and transmission enterprises. The implementation of network unbundling when markets were open is illustrated in Exhibit 2-15.

Exhibit 2-15: Independence of network transmission operators in EU-27, 2007

	Electricity Transmission	Gas Transportation
Austria	Legal	Legal
Belgium	Legal	Legal
Bulgaria	Legal	Legal
Cyprus	n.a.	n.a.
Czech Rep.	Ownership	Legal
Denmark	Ownership	Ownership
Estonia	Legal	Unbundling not yet implemented
Finland	Ownership	n.a.
France	Legal	Legal
Germany	Legal	Legal
Greece	Legal	n.a.
Hungary	Ownership	Legal
Ireland	Legal	Unbundling not yet implemented
Italy	Ownership	Legal
Latvia	Legal	n.a.
Lithuania	Ownership	n.a.
Luxembourg	Legal	Unbundling not yet implemented
Malta	n.a.	n.a.
Netherlands	Ownership	Ownership
Poland	Legal	Legal
Portugal	Legal	n.a.
Romania	Ownership	Ownership
Slovakia	Ownership	Legal
Slovenia	Ownership	Legal
Spain	Ownership	Ownership
Sweden	Ownership	Ownership
UK	Ownership	Ownership
Note: Legal unbundling implies separation of the TSO and DSO from other activities not related to transmission and distribution. Ownership unbundling implies separate ownership of the TSO / the DSO from other activities not related to transmission or distribution.		

Source: IDC Energy Insights update of EU SEC(2005) 1448, 2007

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regulatory institutions. This was the reason for the creation in 1998 of the Electricity Regulatory Forum (known as the "Florence Forum"), which has since then met regularly to address cross-border related issues. The Forum is currently addressing cross-border trade of electricity, in particular the tariffs for cross-border electricity exchanges and the management of scarce interconnection capacity.

Legal unbundling implies separation of the Transmission System Operator (TSO) and Distribution System Operator (DSO) from other activities not related to transmission and distribution. Transmission and distribution have to be done by a separate "network" company. Ownership unbundling implies separate ownership of the TSO / the DSO from other activities not related to transmission or distribution. Transmission and distribution networks are operated under different ownership than generation/production and supply.

The regulation of unbundling in the EU has been recently modified by the adoption of the third energy package (see next section). The package, adopted after two years of discussions between the Commission, the EU Parliament and the Council contains three equivalent options for Member States for separating gas as well as electricity supply and production from transmission network operations:

- Ownership unbundling (OU). This option requires that networks are no longer controlled or majority-owned by energy production or supply companies.
- Independent System Operator (ISO). This option leaves ownership of the transmission networks with the supply companies, but requires that vertically integrated companies hand over the operation of their transmission network to a designated independent system operator.
- Independent Transmission Operator (ITO). This option leaves ownership of the transmission networks with the supply companies, but requires that they abide by certain rules to ensure that the production/supply and transmission network operations are conducted independently.

As an alternative to full ownership unbundling the proposals by the Commission originally contained the option of an Independent System Operator (ISO) as derogation. Following heavy pressure from some Member States, notably Germany and France, a 'Third Way' of unbundling was also introduced. Within this ITO option the TSO remains within the integrated company and the transmission assets remain on its balance sheet. Additional regulatory conditions are imposed to guarantee the independence of the ITO from the vertically integrated undertaking.

Milestones of energy and climate regulation in EU in recent years

A milestone in the European debate about energy policy was the **Green Paper** on a European Strategy for Sustainable, Competitive and Secure Energy, issued in **March 2006**. Suggestions from the Green Paper included completing the opening of European gas and electricity markets and stepping up relations with major suppliers such as Russia and OPEC. Other key suggestions were: boosting renewable energies, energy efficiency, and research on low-carbon technologies.

As a follow up to the Green Paper, in **January 2007** the European Commission adopted the communication "An energy policy for Europe", this Communication included a strategic review of the European energy situation and introduced a complete set of European Energy Policy measures: the "energy package". The package tackled challenges concerning sustainability and greenhouse gas emissions, as well as security of supply, import dependence and the competitiveness and effective implementation of the internal energy market.

In **March 2007** the European Council endorsed the Commission's proposal, agreeing on a **two-year action plan** (2007-2009), to launch a common energy policy. In respect of the action plan, two major legislative packages have been put forward:

- In September 2007 the Commission tabled the **Third Internal Energy Market legislative package** to complete the liberalisation of EU electricity and gas markets. The package aimed at ensuring more effective competition and creating the conditions to foster investments, diversity and security of supply.
- In **January 2008**, the 'climate and energy package' was issued, which featured legislative proposals on CO2 'burden sharing' and on the post 2013 period of carbon trading under the EU-ETS, revised EU state aid rules, a communication on carbon capture and storage (CCS), and a proposed directive on renewable energies, including biofuels.

In **November 2008**, the European Commission issued the **"Second Strategic Energy Review- Securing our Energy Future**". This renewed energy package aims at: putting forward a new strategy to build energy solidarity among Member States and a new policy on energy networks to stimulate investments in more efficient low-carbon energy networks; proposing a Energy security and Solidarity Action Plan to secure sustainable energy supplies in the EU; adopting a package of energy efficiency proposals to make energy savings, such as reinforcing energy efficiency legislation on buildings and energy-using products.

In **December 2008,** the European Parliament voted to approve the EU's **climate package**, focussing on three areas: emissions cuts, renewables and energy efficiency. Changes have been made to the original package unveiled by the European Commission in January 2008, to address European industrialists' concerns about green measures potentially making them uncompetitive at a time of weak global demand. But the overall 20-20-20 targets have been kept. And finally, in **April 2009**, the European Council adopted the climate-energy legislative package. This package includes the following acts:

- **New EU rules promoting the use of energy from renewable sources**. The Council adopted a directive setting a common EU framework for the promotion of energy from renewable sources. The aim of this legislative act is to achieve by 2020 a 20% share of energy from renewable sources in the EU's final consumption of energy and a 10% share of energy from renewable sources in each member state's transport energy consumption.
- **Revised EU Emissions Trading System**. The Council adopted a revised Emissions Trading System (ETS) for greenhouse gases in order to achieve greater emissions reductions in energy-intensive sectors. From 2013 onwards heavy industry will contribute significantly to the EU's overall target of cutting greenhouse gas (GHG) emissions by one-fifth compared to 1990 levels by 2020. To stimulate the adoption of clean technologies, the new ETS provides that GHG emissions permits will no longer be given to industry for free, but be auctioned by Member States from 2013 onwards. The directive also provides for a solidarity mechanism in order to help less affluent EU states with the transition to a low-carbon economy.
- **EU Member States share the effort to make carbon emissions reductions**. The Council adopted a decision to reduce greenhouse gas emissions across a wide range of activities including transport, agriculture and housing (3738/08). The so-called "effort-sharing" decision sets binding emissions targets for EU member states in sectors not subject to the EU's Emissions Trading System.
- **New rules for cleaner cars in Europe**. The Council adopted a regulation setting the first legally-binding standards for CO2 emissions from new passenger cars, to apply as of 2012 The main objective of this new law is to reduce the contribution of

road transport to global warming, thus helping the EU to meet its objective of a 20% reduction in greenhouse gas emissions by 2020.

- **New environmental quality standards for fuels and biofuels**. The Council approved the revision of a directive that will improve air quality and reduce greenhouse gas emissions through environmental standards for fuel. It will also facilitate the more widespread blending of biofuels into petrol and diesel and, to avoid negative consequences, set ambitious sustainability criteria for biofuels. The revised directive introduces for the first time a reduction target for greenhouse gas emissions from fuels.
- **A regulatory framework for carbon capture and storage.** The Council adopted a Directive setting up a regulatory framework for the geological storage of carbon dioxide. The new act is intended to make the deployment of this technology in the EU possible, which could help to mitigate climate change. Whether to use carbon capture and storage or not, is still a matter for independent decision by each EU member state. Carbon capture and storage systems have been recognised by the European Commission[19] as a key-enabling technology that is relevant for future competitiveness. The EC has offered cooperation to international partners in this field and common European research, demonstration, or prototyping initiatives and infrastructures are foreseen.

In **June 2009**, after a long debate and negotiation, which significantly modified the original text, the Council of the European Union adopted the **Third Internal Energy Market legislative package**. The package includes five legislative acts:

- Electricity Directive. The electricity directive establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EU. It lays down the rules governing the organisation and functioning of the electricity sector, open access to the market, the criteria and procedures applicable to calls for tenders and the granting of authorisations and the operation of systems. It specifies several models for achieving the separation of transmission from supply and generation activities (full ownership unbundling, independent system operator and independent transmission operator). The directive also lays down universal service obligations and the rights of electricity consumers and clarifies competition requirements. It strengthens regional cooperation among regulatory authorities and among transmission system operators and sets out the objectives, duties and powers of regulatory authorities so as to improve consistency. This directive repeals directive 2003/54/EC.
- Gas directive. The gas directive, which repeals directive 2003/55/EC, establishes common rules for the transmission, distribution, supply and storage of natural gas. It lays down the rules governing the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisations for transmission, distribution, supply and storage of natural gas and the operation of systems. The gas directive specifies the same three models as the electricity directive for ensuring the separation of transmission activities from production and supply activities. It also provides for public service obligations and

[19] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels, 30.09.2009 COM (2009) 512 final.

the rights of gas consumers and clarifies competition requirements. The directive reinforces regional cooperation among regulatory authorities and among transmission system operators and lays down in great detail the objectives, duties and powers of regulatory authorities so as to ensure a more consistent internal gas market.

- Electricity regulation. The purpose of this regulation, which repeals regulation (EC) No 1228/2003, is to set fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal electricity market. It also aims to facilitate the emergence of a well-functioning and transparent wholesale market with a high level of security of supply in electricity. It provides for mechanisms to harmonise the rules for cross-border exchanges in electricity. In addition, the regulation establishes a **European Network of Transmission System Operators for Electricity**, a new framework in which all transmission system operators will cooperate at EU level. This network is designed to promote the completion and proper functioning of the internal electricity market and to encourage cross-border trade.

- Gas regulation. The objective of this regulation is to set non-discriminatory rules for access conditions to natural gas transmission systems with a view to ensuring the proper functioning of the internal market in gas, as well as to lay down non-discriminatory rules for access conditions to LNG facilities and storage facilities. The new regulation is also designed to facilitate the emergence of a well-functioning and transparent wholesale market with a high level of security of supply in gas and to provide mechanisms for harmonising the network access rules for cross-border exchanges in gas. The regulation also establishes a **European Network of Transmission System Operators for Gas** in order to ensure optimum management of the gas transmission network in the EU. The regulation repeals regulation (EC) No 1775/2005.

- **Agency for the Cooperation of Energy Regulators**. The new Agency will assist national regulatory authorities in exercising, at Community level, the regulatory tasks performed in the member states and, where necessary, will coordinate their action. It will be a Community body with legal personality, comprising an administrative board, a board of regulators, a director and a board of appeal. The Agency's remit will in particular include the following: tasks relating to the cooperation of transmission system operators, tasks as regards the national regulatory authorities and tasks connected with the cross-border infrastructure.

The main objective of this legislative package is to put in place the regulatory framework needed to make market opening fully effective, but it also contains a very relevant element to stimulate the adoption of new metering devices: it mandates implementing intelligent metering systems with a target of 80% of the population to be covered by 2020.

Overall, it appears that long after the first efforts toward liberalisation and implementation of an integrated and common market, large differences between European countries still exist, both of market structure, competitive level, public service and customer protection. The current major challenges for ESI include the following:

- Increase of efficiency in all parts of the ESI supply chain: energy generation, delivery and more importantly in energy usage;

- Shifting of energy mix towards renewable energy and distributed generation, development of clean coal and carbon capture and storage (CCS) technologies.

Renewable sources are key for reducing dependence on fuel from non-members countries for reducing emissions and for decoupling energy costs from oil prices.

- Investment into smart grids, including the pilot and roll-out of smart metering, driven by aging T&D assets, the need to integrate renewable and distributed generation, and the possibility to allow customers active participation in energy markets;
- Integrating infrastructures and migrating systems to more cost-effective platforms, both for electricity and gas.

3 Deployment of ICT and e-business applications in the European ESI

3.1 Overview of issues addressed

This chapter provides insights into current trends of ICT and e-business activity in the ESI. It explores to which extent companies in the ESI sector use ICT for managing their processes and the relevance they attribute to e-business. But most importantly it provides a detailed analysis of the most innovative and promising areas that will affect ESI evolution in the upcoming years, depicting the role and the impact on ICT. The following issues have been selected in coordination and agreement with DG Enterprise and Industry as particularly relevant and topical:

- ICT in joint energy generation, better known as virtual power plant (VPP) (Section 3.3.1);
- ICT in energy transmission and distribution with a particular focus on smart grids (Section 3.4),
- ICT and smart metering (Section 3.5.1),
- ICT in energy demand management, with a particular focus on energy efficiency improvement (Section 3.5.2).

This chapter also analyses the adoption and implications of ICT for reducing environmental impacts of energy supply and supporting the transition to renewable energies (Section 3.6.2). Although delivery of gas through pipelines is not part of this study, a brief description of the relevance of ICT for pipelines is also provided (Section 3.7). Insights on the relation between ICT and innovation (Section 3.6.3), as well as the issue of e-business skills in this sector (Section 3.2.4), are also discussed.

Most of the exhibits presented in this chapter are based on the SeBW Energy Supply Survey 2009, which consisted of 351 telephone interviews with ICT decision-makers in the six largest EU countries (Germany, France, Italy, Poland, Spain, UK). Full information about the sample and the methodology adopted are provided in Annex 1.

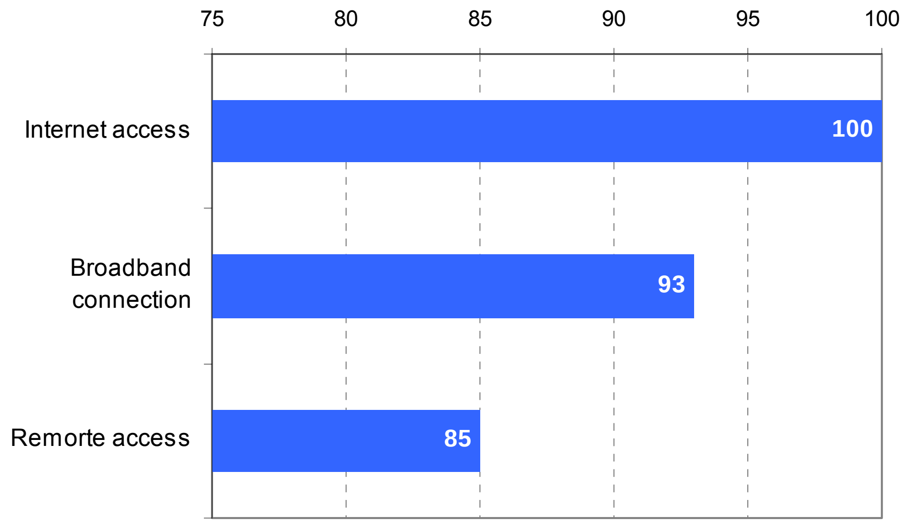
3.2 Basic issues: ICT infrastructure, business process systems, data exchange and skills

3.2.1 ICT infrastructure

Doing business in the ESI without having Internet access is not even conceivable. All companies from the sector are connected to the Internet (Exhibit 3-1). Companies' Internet access is very good across all sub-sectors and size bands, notably among SMEs (data not shown in the exhibit).

The average share of employees with Internet access at their workplace is about 85%. This can be seen as an indicator for the degree of automation of work, applied also to field workforce, as depicted in Enel case study (Section 5.4).

Exhibit 3-1: Level of adoption of Internet access, broadband connection and remote access



Base (100%), All; N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

3.2.2 Business process systems

ESI processes and ICT: an overview

As illustrated in Section 2.3, the European ESI needs to cope with a vast array of policies, unbundling, market competitiveness, the need for major investments, and initiatives ranging from energy efficiency to renewable energy resources to the intelligent grid. Efficiency and productivity of operations, as well as return on assets, are key challenges. Players need to dedicate resources to customers' retention through quality of service, value added services, demand response management. To increase competitiveness it will be increasingly important to develop tailored tariffs, flexible contracts and new-targeted products.

Presently, a broad range of ICT solutions is available for supporting ESI companies in meeting their challenges. These range from general corporate ICT systems to more specific ICT solutions addressing the various activities, from generation to retail. A synopsis of the main ICT systems adopted by ESI companies is provided in Exhibit 3-2.

ICT for energy generation, as well as ICT systems for monitoring distributed energy units (DER), forecast production from DER, ICT for dispatch energy from DER, and ICT that link DE, are analysed in Section 3.3.

ICT systems for Transmission & Distribution are analysed in Section 3.4. Systems for metering and for managing demand are analysed in Section 3.5.

Among general enterprise ICT systems, Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Document Management System (DMS), Computer-Aided Design (CAD), Product Lifecycle Management (PLM)) are analysed in this section of the report.

Exhibit 3-2: Synopsis of main ICT solutions in energy supply companies

<table>
<tr><th></th><th>Generation</th><th>Transmission & Distribution</th><th>Metering</th><th>Retail</th></tr>
<tr><td rowspan="2">Specific systems for energy supply</td><td>• Plant asset management
• Work management
• Load forecasting
• Generation plan & scheduling
• Carbon management system
• Energy Trading & Risk management</td><td>• Grid Asset Management
• Work management
• GIS
• Energy Management System
• Distribution Management System
• SCADA
• Outage Management System</td><td>• Meter Asset Management
• Meter Data Management</td><td>• Billing
• Customer Relationship Management (CRM)
• Call Centre Management</td></tr>
<tr><td colspan="4">ICT for monitoring distributed energy units (DER), forecast production from DER, ICT for dispatch energy from DER, ICT for linking DE,</td></tr>
<tr><td>General enterprise ICT systems</td><td colspan="4">Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Document Management System (DMS), Computer-Aided Design (CAD), Product Lifecycle Management (PLM), Environment, Health & Safety (EH&S),</td></tr>
</table>

Source: IDC 2009

ESI level of adoption of enterprise solutions

The SeBW 2009 survey analysed to which extent the interviewed ESI companies adopt ICT systems to support their corporate business processes. The Exhibit 3-3 provides data about diffusion and usage of Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), Document Management System (DMS), Computer-Aided Design (CAD), Product Lifecycle Management (PLM), and RFID.

Among solutions supporting enterprise business processes, Enterprise Resource Planning (ERP) has currently the widest adoption within this industry as they can 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 form 79% in the energy sector to 45% in the heating/cooling sector. The diffusion per size band (provided as % of firms) not surprisingly indicates that only one out of four small companies adopted ERP, while three out of four large companies rely on it. Standardising corporate processes through ERP technology, when implemented well, can bring various benefits and support companies in facing challenges towards customers, regulation and competitive pressure.

SCM, which implies a high degree of integration along the supply chain, possibly with utility operations, has limited diffusion in the ESI as a whole, not even among large companies; it is hardly present in heating and cooling.

Companies using CRM, representing 56% of employment, again companies active in the electricity sector are more advanced in the usage of such systems with remarkable difference per size class. The possibility for customers to compare suppliers and offers and the emergence of independent web-sites encouraging users to compare prices and service options has made utilities companies to start realising value from their CRM initiatives. It appears, however, that the diffusion of CRM is comparatively higher than the degree of on-line data exchanges with customers (see Exhibit 3-5). This may suggest that there is a lack of integration in the management of the various customer-related activities or that outbound practices towards customers are more diffused than the collection of inputs and feedback.

Exhibit 3-3: Level of adoption of ICT systems in ESI

Energy supply (NACE Rev. 2 35.1-3, EU-6)	Companies using an ERP system		Companies using a SCM system		Companies using a CRM system		Companies using a DMS	
Weighting:	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms
Total	**67**	**39**	**15**	**12**	**56**	**39**	**61**	**43**
By sector								
NACE 35.1 (Electricity)	79	47	21	13	63	43	69	47
NACE 35.2 (Gas)	53	37	10	15	46	45	71	50
NACE 35.3 (Heating/cooling)	45	20	2	7	46	24	32	26
By company size								
Small (10-49)		25		12		29		34
Medium (50-249)		50		10		47		47
Large (250+)		71		14		61		67
Base (100%)	All		All		All		All	
N (Base, total)	351		351		351		351	
Questionnaire reference	A4a		A4b		A4c		A4d	

Continued: Adoption of ICT systems in ESI

Energy supply (NACE Rev. 2 35.1-3, EU-6)	Companies using a CAD system		Companies using a PLS system		Companies using or piloting RFID technology	
Weighting:	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms
Total	**63**	**50**	**9**	**4**	**11**	**6**
By sector						
NACE 35.1 (Electricity)	62	52	10	5	16	7
NACE 35.2 (Gas)	54	50	0	3	0	3
NACE 35.3 (Heating/cooling)	71	44	14	3	8	4
By company size						
Small (10-49)		41		3		4
Medium (50-249)		61		3		5
Large (250+)		63		8		11
Base (100%)	All		All		All	
N (Base, total)	351		351		351	
Questionnaire reference	A4e		A4f		A5	

Source: SeBW Energy Supply Survey 2009

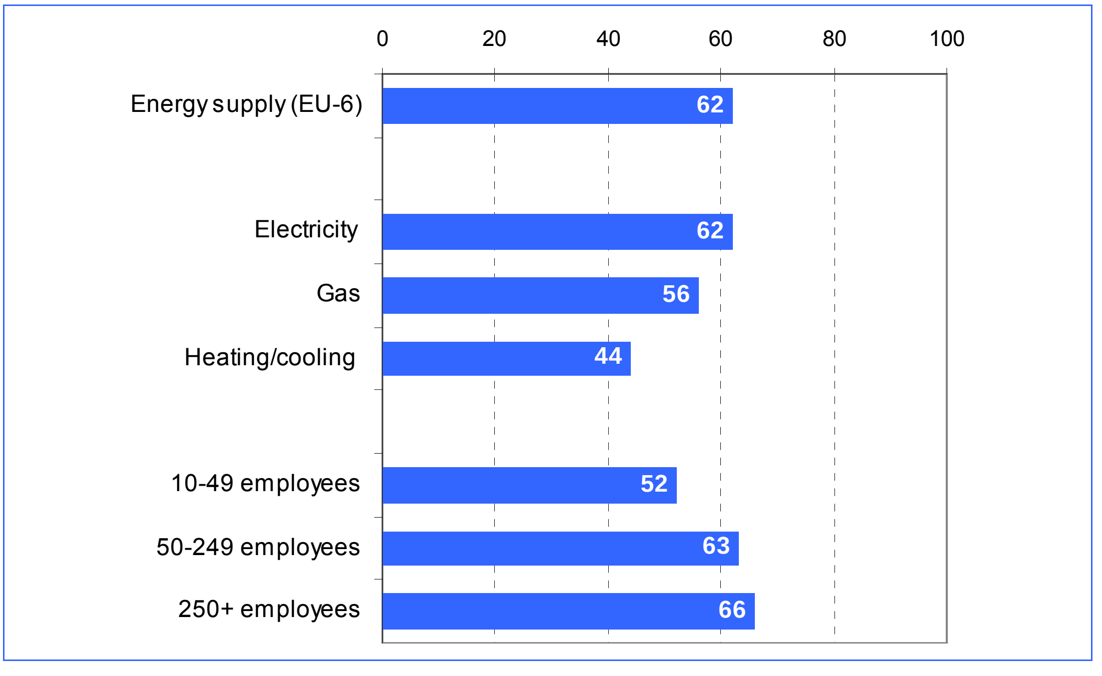
DMS are fairly diffused in companies from the electricity and the gas sector and so are CAD systems. PLS and RFID are definitely limited in all the sectors and class bands as they appear not to represent a priority in this industry.

In summary, the diffusion of general corporate ICT systems varies across sub-sectors and size classes. ERP, CAD and CRM have a significant degree of diffusion, while SCM, which can be considered an indicator for integration along the value chain has limited diffusion. It appears that ESI companies reach a fairly good degree of automation in single processes while they have still a way ahead before reaching cross process integration.

3.2.3 Automated data exchange with suppliers and customers

Supply chain integration via connecting ERP systems (or similar standard software packages) is the most advanced approach to manage operations, provided that business partners have the required systems in place. Electronic exchanges with business partners, however, may take simpler forms such as the electronic exchanges of orders for good and services. The following exhibit illustrates the percentage of firms ordering goods or services from their suppliers on the Internet or via other computer-mediated networks. Firms representing 62% of employment adopt this practice. Online exchange of data is more common in the electricity sector (62% of firms). The percentage is higher among large firms but differences across size bands are not large. Considering the data about diffusion of ERP (67% of forms, employment weighted see ***Exhibit 3-3***) one could have expected a higher automation of ordering. Moreover, the average percentage of orders carried on via network is below 10% for most of the companies (data not shown in the exhibit) thus confirming that this practice is not very diffused.

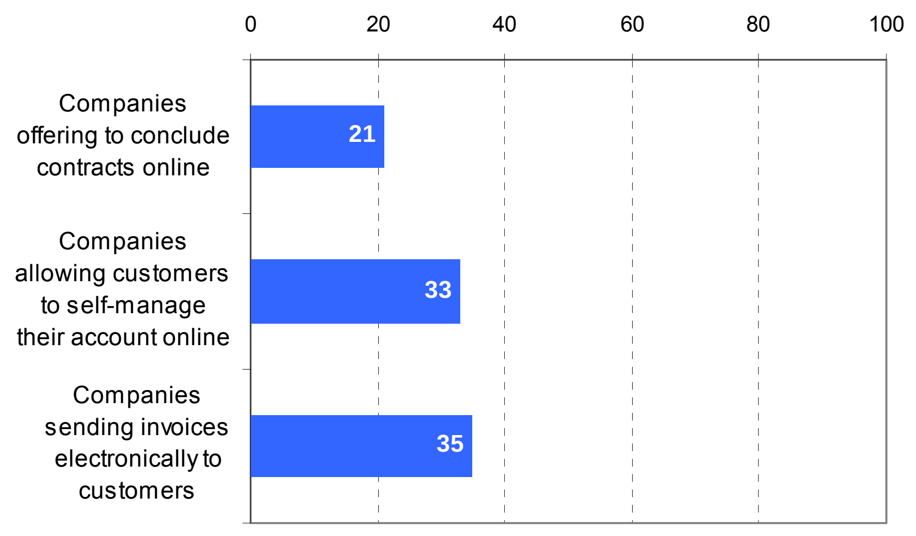
Exhibit 3-4: e-Business data exchanged with suppliers



Source: SeBW Energy Supply Survey 2009

Firms representing 21% of employment in the ESI said that they offer customers to conclude contracts on-line. There is practically no difference between companies from the various size-bands in this respect (data not shown in the exhibit). This is not a very high figure, if compared with the diffusion of CRM (56%, employment weighted, see ***Exhibit 3-5***). Furthermore, the relative share of customer orders received online (as percent of the total order volume, data not shown in the exhibit) indicate that more than 71% of those companies that enable customers to order online say that these orders account up to 15% of their total orders received. About one company out of three (employment weighted) allow customers to self-manage their account on-line and send electronic invoices. e-Commerce, even in this rather simple form is not a common practice in this sector.

Exhibit 3-5: e-Business data exchanges with customers



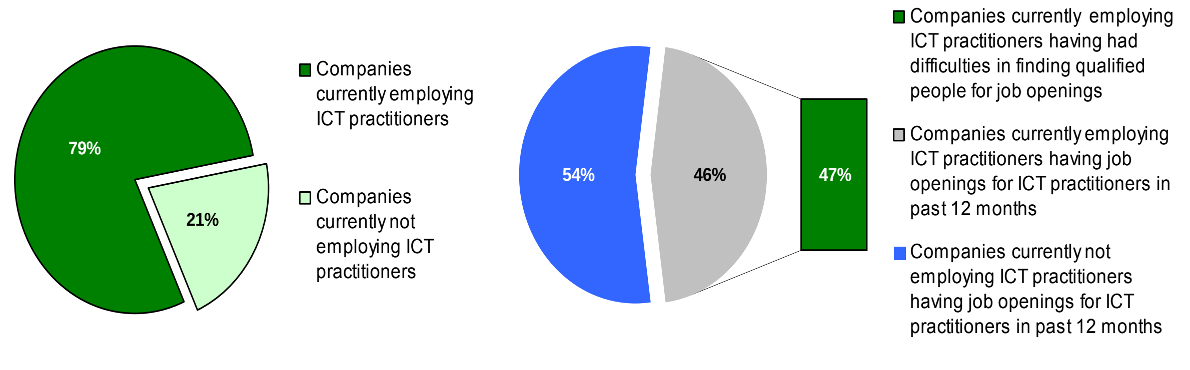
Base (100%), All; N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

3.2.4 ICT skills requirements

Improving ICT and e-business skills, especially among SMEs, has been identified as a relevant concern for policy in various studies by e-Business Watch. Typically, larger companies can afford employing ICT practitioners, i.e. staff with the specialised skills and tasks of planning, implementing and maintaining ICT infrastructure, while smaller ones do so in fewer cases. The SeBW Energy Supply Survey 2009 asked firms if they currently employ ICT practitioners (Exhibit 3-6).

Exhibit 3-6: Demand for ICT practitioners



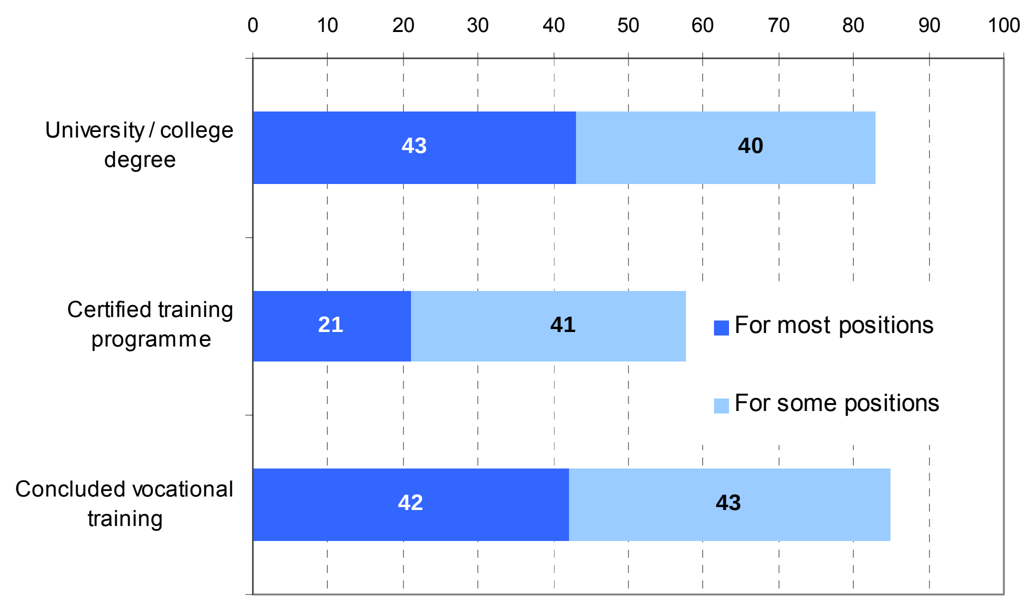
Base (100%), All N (Base, total) 351
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

In total, companies, representing 79% of employment, said that they employed ICT practitioners. Out of the companies currently employing ICT practitioners, 46% had job openings for ICT practitioners in past twelve months and about half of them experienced difficulties in finding qualified people for open positions.

The SeBW 2009 survey investigated which type of qualification companies expect from their ICT practitioners. University and vocational training are the preferred options, as companies representing respectively 43% and 42% of employment expect this type of qualification from their ICT practitioners for most positions. Only 21% expect certified training programme as a qualification for most ICT practitioners' positions (Exhibit 3-7).

Exhibit 3-7: Qualifications expected from ICT practitioners



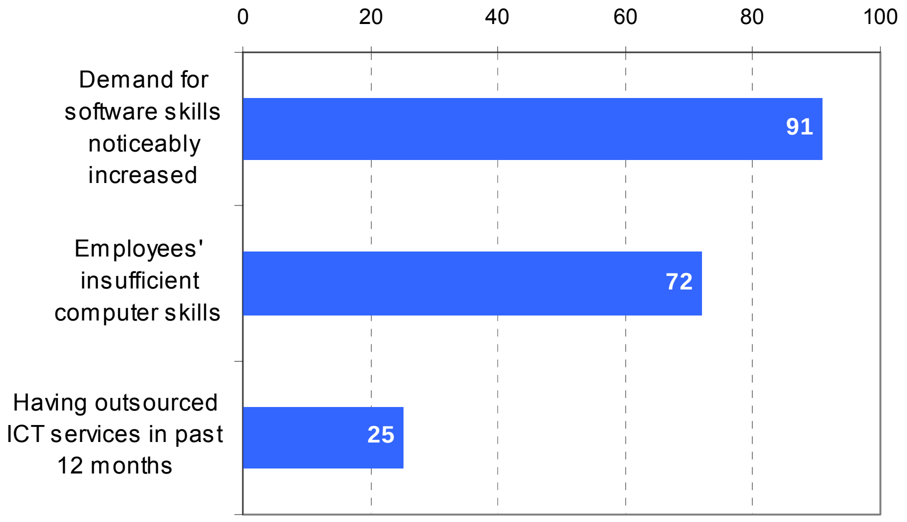
Base (100%), Companies currently employing ICT practitioners N (Base, total) 178
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

Finally, ESI firms were asked to evaluate the users' skills (Exhibit 3-8). Companies representing the nearly totality of employment state that demands on employees regarding their computer and software skills have noticeably increased. This is obviously related to the overall increased importance of ICT in this sector. Many of them also experience insufficient computer skills, this however for most companies affect only a minor part of their employees (data not shown in the exhibit).

About one company out of four has relied on outsourcing in the past twelve months. This data seems to indicate that ESI companies tend to keep ICT under internal control. The strict standards of reliability and security of ICT required in this industry could be a reason for such a choice.

Exhibit 3-8: ICT users' skills



Base (100%), All N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

The picture about ICT skills in this sector highlights some issues. The figures indicate that 47% (employment weighted) of companies that had ICT job openings in the previous 12 months are experiencing difficulties at recruiting skills. Moreover 72% of firms (employment weighted) indicate that the computers' skills of their employees' are insufficient. This should be carefully considered at policy level: ICT skills shortage may have negative impact not only at company level but also at a broader level, as ICT proves to support general energy efficiency and favour the reduction of emissions.

3.3 ICT in energy generation

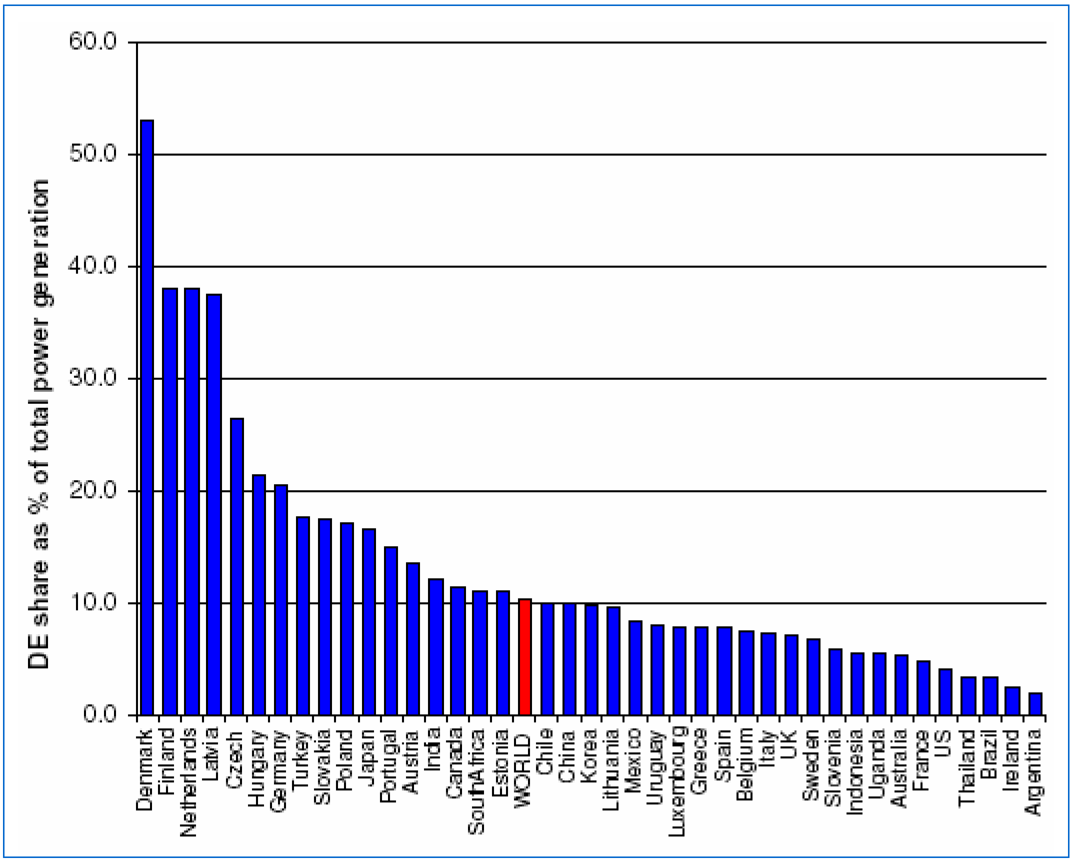
3.3.1 ICT in joint energy generation – virtual power plant

VPP background and features

Joint energy generation is the distributed and co-ordinated operation of several small generation units, acting virtually as a single power plant. This is currently referred to as **Virtual Power Plant** (VPP). In recent years, distributed energy generation (DER) has increased through the spread of a variety of facilities, such as wind energy systems, combined heat and power plants (CHP), photovoltaic systems, small hydro-electric power stations and biogas plants. The advantages of DER are that power is generated close to where it is consumed. This can lower the transmission and distribution losses, as well as the transmission and distribution costs. It can also help to bypass congestion in existing transmission grids and enable the use of waste heat, thus improving overall system efficiency.

As illustrated in Exhibit 3-9, the production of DER is relatively low in most European countries – with the exception of a few Nordic countries –, its share has nevertheless been increasing remarkably in the past years and is expected to grow further. Denmark generates more than half of its electricity through decentralised units, with combined heat and power accounting for 80% of local-area heating, and wind power about 20% of all electricity. As a result, its carbon dioxide emissions have tumbled from 937 grams per kilowatt-hour in 1990 to 517 grams per kilowatt-hour in 2005.

Exhibit 3-9: Share of decentralised energy production out of total power generation, 2006



Source: WADE, World survey on decentralised energy, 2006

The benefits of DER can be fully exploited when the distributed units act together in a decentralised energy management system, a VPP. In a VPP, the operation of distributed installations is scheduled and optimised, either for the purpose of energy trading in the wholesale market or to services, such as real time information on operations to the power system operator, as well as to the individual distributed units.

The VPP is not a new technology but a scheme to combine decentralised generation and storage and exploit the technical and economic synergies between the various system's components. This aggregation is not pursued by physically connecting the plants but by interlinking them via ICT.

A VPP may then be a multi-fuel, multi-location and multi-owned power station. A virtual power station balances required and available power in identified areas, based on off-line schedules for distributed energy sources, storage, demand side management capabilities and contractual power exchanges. For a grid operator or energy trader, buying energy or ancillary services from a VPP is equivalent to purchasing from a conventional station. In this perspective, a VPP may alter the 'traditional' production, transmission and distribution hierarchy.

Potential impact of VPP

There are a number of benefits that, in principle, a VPP can bring. The implementation of a VPP allows that the distributed plants can be operated efficiently, therefore more economically. A VPP can optimise the whole network, as it provides coherent control of minor and geographically distributed units, thus achieving the optimal use of available production capacity. It may improve reliability of the electricity production both overall and in the single units, reduce peak loads by shifting local units operations whenever it is needed and, most importantly, quickly detect changes in the demand of the system by exploiting its distributed architecture.

There is a wide range of environmentally interesting options that a VPP can allow:

- Such a system is flexible and independent from the technologies adopted for generation, therefore it can easily accommodate changes as well as the introduction and integration of small-scale renewable energy technologies (PV, wind) in the energy supply chain;
- It improves the overall efficiency, as a reduced distance between electricity transmission and distribution reduces losses, resulting in additional energy savings and overall reduction of emissions;
- It improves reliability, security of supply and flexibility of supply, thanks to the multiple grid connections

From a market point of view, a VPP makes it possible to use sales channels that otherwise would not be available to the operators of the individual plants, as it is represents a portfolio of DER that can be used to make contracts in the wholesale market and to offer services to the system operators. It also allows more choice to customers and facilitates the delivery of more tailored services to customers. What follows is a brief description of the Fenix project, (http://www.fenix-project.org/) an EC funded initiative in the field of Distributed Energy Resources, which aims at reaching relevant goals in the field of large scale VPPs.

Fenix, Flexible Electricity Network to Integrate the eXpected energy evolution

Fenix is a research project launched in late 2005 on behalf of the European Commission. The objective of FENIX is to boost Distributed Energy Resources (DER) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralised management. The project is organised in activities aimed to conceptualise, design and demonstrate a technical architecture and commercial and regulatory framework for Virtual Power Plant based large-scale aggregation of DER.

The consortium includes all main sector stakeholders: universities, research centres, Transmission and Distribution operators, ICT and service vendors, DER owners and regulators from various European countries.

The rationale for the project is as follows: "In the last decade, the EU has been deploying significant amounts of DER of various technologies in response to the climate change challenge and the need to enhance fuel diversity. However conventional large-scale power plants remain the primary source of control of the electricity system assuring integrity and security of its operation. Levels of DER penetration in some parts of the EU are such that DER is beginning to cause operational problems (Denmark, Germany, Spain). This is because thus far the emphasis has been on connecting DER to the network rather than integrating it into overall system operation".

The expected benefits stated by the project can be summarised as follows. For Distributed Energy Resource owners: to capture the value of flexibility, increasing value of assets through the markets, reduce financial risk through aggregation, improve the ability to negotiate. For Distribution and Transmission System Operators: to increase the observability of DER for operation through aggregation, to take advantage of flexibility of DER for network management, improve optimisation of the grid investments, improve the coordination between DSO and TSO, mitigate the complexity of operation caused by the growth in inflexible generation. Benefits for society at large and policy makers are: cost effective large scale integration of renewable energies while maintaining system security, open the energy markets to small scale participants, increasing the global efficiency of the electrical power system by capturing flexibility of DER, facilitate the renewable targets and reduce CO2 emissions, improve consumer choice, new employment opportunities.

Source: http://www.fenix-project.org/, July 2009

Another initiative founded by the EU (6^{th} Framework Programme) is the EU-DEEP initiative which aims at integrating DER into today's electrical system and particularly at integrating residential scale flexible Micro-CHP into electricity markets.

EU-DEEP (European- Distributed EnErgy Partnership)

EU-DEEP is a project funded by the European Commission The goal of EU-DEEP is to design, develop and validate an innovative methodology, based on future energy market requirements, and able to produce innovative business solutions for enhanced DER deployment in Europe by 2010.

The project has identified the current "hosting capacity" of the electrical power system and the conditions that will enable this to be increased at an acceptable cost. The economic analysis of DER has demonstrated that they can provide significant added value for the electrical system when they comply with network design constraints and contribute, in a reliable way, to better management of peak consumption. Using three aggregation business models extensively tested in the field, the project highlights the most promising directions that will ensure efficient and sustainable integration of DER in the current electrical power system. The results of the EU-DEEP project pave the way for the achievement of the main European environmental target as for emission cut and renewables and contribute to enhancing different stakeholders' practices, whilst pinpointing the new areas of knowledge required in order to keep expanding on DER integration.

Source: http://www.eu-deep.com/, July 2009

ICT for VPPs

The actual implementation of VPPs poses nevertheless significant technological challenges and requires adequate ICT solutions.

The main challenge is inherent to the characteristics of distributed energy generation units, which mostly deal with renewable sources and are, therefore, dispersed and variable that is to say are not constant over time as they depend on weather conditions, and have different technological profiles. To make them work as unique large central units requires a management system that should include:

- Monitoring, planning and management of the decentralised units, including a front end for communication with the other system components. Best performances are achieved when it is the system to automatically determine which plants are the most suitable to be connected up to the power supply system, having elaborated all relevant data about energy forecast, prices and demand curve.
- Forecasting of generation and load capacity of renewable energy power plants.
- Data management. The amount and variety of data to be managed, analysed and combined together by the systems is remarkable, including, to quote only a few: plant control, loads, contractual data, energy forecasts, weather forecasting, electricity prices and the energy requirements of customers.
- Demand management, including analysis and assessment of customers' purchase behaviour and contract management (see also Section 3.6).

Cost-optimal planning, management and control of the units, conformity with and integration into the grid, including adherence to planned schedules, are the main features that such decentralised energy systems must fulfil. They require the installation of measurement facilities, communication channels and remote control for all the units involved. This calls for efficient ICT solutions that should be able, at the same time, to integrate and exploit the infrastructure already in place, such as local area networks

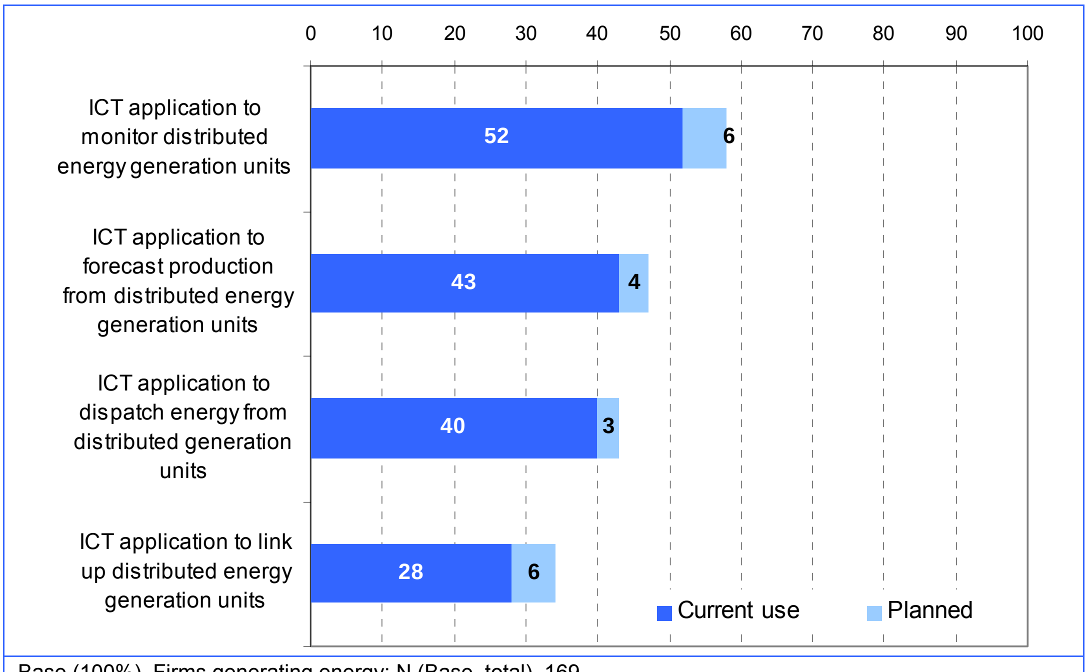
(LAN), wide area networks (WAN) and telecommunication buses. Standardisation defining suitable interfaces may be necessary.

To better understand key achievements and lessons learned by running VPP pilot projects a case study was developed. It refers to RWE Energy experience and is analysed in Section 5.1. This project seeks 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. From a technical perspective, the most important lesson learned from this case is the importance of having a reliable communication system in place. Customers' knowledge, acceptance and participation proved to be critical aspects for the running of VPP.

The analysis of the diffusion of ICT solutions for distributed generation management is supported by the SeBW Energy Supply Survey 2009, with specific questions asked to the six surveyed countries. The ESI companies that operate in energy generation were asked to indicate which solutions they use for managing distributed energy generation units.

Data from the survey indicate that specific ICT solutions for monitoring, forecasting and dispatching energy are currently in place in a percentage of companies representing from 40 to 52% of total employment. These applications run at unit level and are necessary for managing distribution networks. When it comes to linking up distributed units in order to really manage them as a virtual power plant, the share of companies is definitely lower (28%). The plans for implementing ICT solutions to support virtual power plant are quite disappointing, as only a minor share of companies plan to introduce ICT (6%). From the survey data it appears that most companies plan to run these units in a scarcely integrated way and as "islands" of activity rather than in an integrated way, thus demonstrating that the actual concept of VPPs is far from a diffused implementation.

Exhibit 3-10: Joint energy generation



Base (100%), Firms generating energy; N (Base, total) 169
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

The concept of VPP - basically a scheme to combine decentralised generation and storage through ICT interlinking - has been theoretically developed. It is nevertheless far from being common practice in the ESI. The survey results indicate that ICT solutions for managing distributed energy generations units (monitoring, forecasting and dispatching energy) are in place in a percentage of companies representing form 40 to 52% of total employment. Still many companies generating energy through distributed units run these units as "islands" of activity rather than in an integrated way. Another interesting result (not shown in exhibit) that seems to confirm the low degree of maturity of VPP is that only a limited share of companies (a share representing 19% of employment) trade energy generated by VPP. Leading edge initiatives – such as Fenix and EU-DEEP – and projects such as the one by RWE Energy presented in Section 5.2 have been implemented in the EU. However, it is not yet possible to illustrate a standard architecture, nor there is consensus about costs and benefits of such implementation. It would be advisable to address this issue at policy level, by developing and disseminating learning and best practice guides.

3.3.2 ICT for renewable energy management

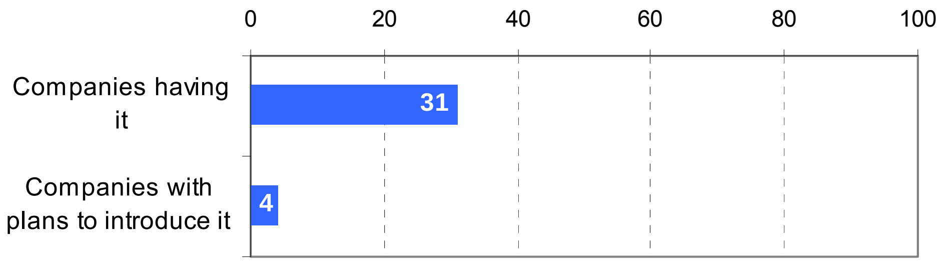
As illustrated in Chapter 2, renewable sources are important for reducing dependence on fuel from non-members countries, for reducing emissions and for decoupling energy costs from oil prices. It has also been highlighted that the development of renewable electricity generation implies relevant technological and organisation challenges and calls for changes along the entire ESI supply chain. Renewable sources are, by definition, intermittent. In order to deal with that, stationary storage technologies have been tested but they are still far from being largely commercially applied due to technical and cost reasons.

ESI companies need to have reliable forecast information about the quantity and availability of the power output. Thus, forecasting systems are one of the primary requirements to achieving increased penetration of wind and solar energy. Secondly ESI companies need to combine forecast information with the real-time operational data in their control centres for decision-making – both in the front and back offices. In other terms there is the need for a fully integrated renewable energy information system that uses the information from smart sensors and other intelligent applications to optimise the utilisation of the renewable generation resources.

The need for an integrated renewable energy information system is based on the fact that ESI operators have to assemble an avalanche of data from disparate sources in order to make informed decisions. Operators need tools to enhance their local and global situation awareness. The executives and managers need decision dashboards to better manage their portfolio of RES and mitigate operational risks and uncertainty. Integrated renewable energy information system will also allow them to maximise their asset performance based on the opportunities in emissions markets.

The SeBW Energy Supply Survey 2009 asked companies generating energy whether they have or plan to introduce renewable energy information systems to manage wind farms and large-scale solar plants. About 31% have it and 4% declared to have planned to introduce it. Considering that this question was asked to all the companies generating energy (not only to those engaged in renewables), this should be considered quite a high percentage.

Exhibit 3-11: Renewable energy information system

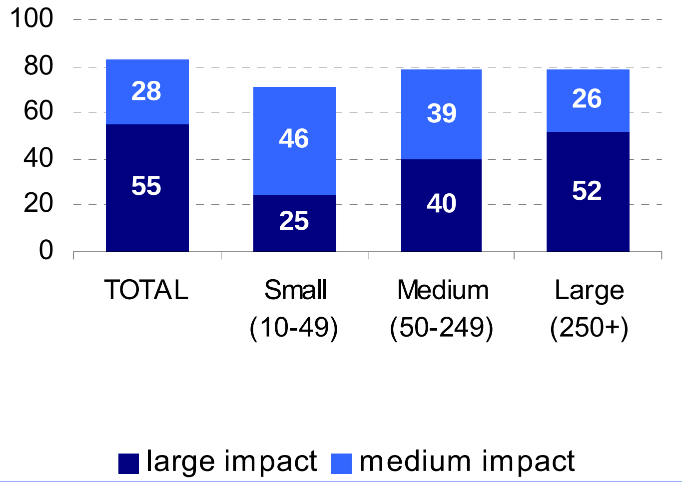


Base (100%), Firms generating energy; N (Base, total) 169
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector)

Source: SeBW-Energy Supply Survey 2009

In addition, the survey analysed the envisaged impact of ICT on future renewable energy generation management. This is illustrated in the following exhibit, which indicates that the large majority of ESI companies, and especially large ones, foresee a large to medium impact for ICT on future energy generation management.

Exhibit 3-12: % of companies stating that ICT will have large and medium impact on future renewable energy generation management



Base (100%), Firms generating energy; N (Base, total) 169
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

About one out of three companies in the ESI sector have a renewable energy information system. The data confirm, not surprisingly, the increasing attention to this kind of energy source.

3.4 ICT in energy transmission and distribution

3.4.1 Introduction to energy transmission and distribution

As illustrated in Section 2.1, electricity networks can be 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** usually distribute power from the transmission network to customers. With the exception of wind and other renewable power plants, small-scale generation (defined as distributed generation) is normally inherent to distribution networks.

Over the past years, various issues such as the EU energy and environmental policy targets, the security of supply, the integration of renewable resources, and the aging infrastructures have been influencing the way power is generated, transported and used, and are making the management of transmission and distribution (T&D) grids more and more complex. Networks, therefore, have been starting to evolve as they are increasingly integrating decentralised generation services and are more actively interacting with the various players involved in value chain operations. This implies profound architectural and technical changes and relies on investments in innovative technologies needed to bring enhanced management, reliability and sustainability of the networks.

A new vision on how networks will have to meet current challenges and fulfil policy mandates has been developed in recent years; this is commonly referred to as "**smart grids**". A smart grid is commonly understood as an upgrade of distribution and transmission grids with the aim to optimise current operation, include and efficiently exploit alternative energy production, integrate generators, distributors and consumers, in order to efficiently deliver sustainable, economic and secure electricity supplies. The concept of smart grid, therefore, encompasses issues and challenges that are common both to transmission and distribution networks and it is made possible by ICT, advanced metering (see also Section 3.5.1) and data management techniques.

Energy transmission: increasing automation and control

As it has been described in Section 2.3, flows across European electricity markets are presently hampered by a lack of integration and insufficient physical capacity. Investment programmes are also addressing the interconnection problem through various bilateral projects. Investments in transmission grids encompass a broad range of technologies and applications.

The management of the assets of the transmission systems relies on network automation and control systems, including tele-measures and tele-control systems. These systems may include operation aid decision tools, aimed at supporting sector-specific functionalities related to real-time measurement, analysis, forecast and monitoring of operations. Systems are also used for the data collection and analysis (often off-line) for the condition monitoring of main equipment and for the planning and control of condition assessment and maintenance operations.

As the systems for network and asset management are becoming increasingly complex, it will be more and more necessary to develop architectures for integrating the data communication networks and the intelligent equipment in place, in order to support the power delivery systems. There is a need for methods and tools that can assure interoperability, flexibility, effective security and expandability of the systems. ICT can have a role also on the consumers' side, as it can allow large consumers to supply system services by adjusting their load curves.

The combined investment programmes of the largest transmission service operators (TSOs) in Europe recorded 5 billion euros in 2007.[20] Investments will have to continue in the next years, both to replace aging assets and to solve network congestion problems. (According to the International Energy Agency, by 2030 about 90 billion euro will be invested in transmission and 300 billion euro in distribution networks. A conservative estimation of 20 billion euro (based on 100 euro per connection) will be spent on data and information for markets and regulations by 2030[21].

Energy distribution

Distribution networks today

Distribution networks have been traditionally designed and operated to distribute power passively from the upstream generation and transmission system to the final customers. In a traditional grid, power flows go mono-directionally to the consumers and the DSOs do not have the opportunity or the need to take active control of the power flows, unlike the TSOs for the transmission grids. For this reason, most distribution systems are designed as passive.

However – as briefly illustrated also in the previous sections of this report – new issues have arisen that impact on the current activity of distribution networks.

A challenge that electricity distribution networks in Europe are increasingly facing is the integration of numerous small-scale units generating renewable energies, such as photovoltaic power. Uncoordinated supply from small generation units can destabilise low- and medium-voltage distributions systems, e.g. by increasing voltage levels beyond their maximum thresholds. Integration of distributed generation into Europe's electricity networks may be feasible, but the design of distribution grids in particular needs to evolve towards new models, in order to avoid problems. Moreover, as illustrated in Chapter 2, network unbundling has been taking place in EU, and operators have increasingly developed value added services that requires a new approach to the market.

To face these challenges, distribution grids need to evolve in order to accommodate bi-directional power flows and to fulfil a broad new range of requirements, as illustrated in Exhibit 3-13.

In summary, a distribution network can no longer be passively attached to the transmission network, instead the entire system has to be designed and operated as an integrated unit.

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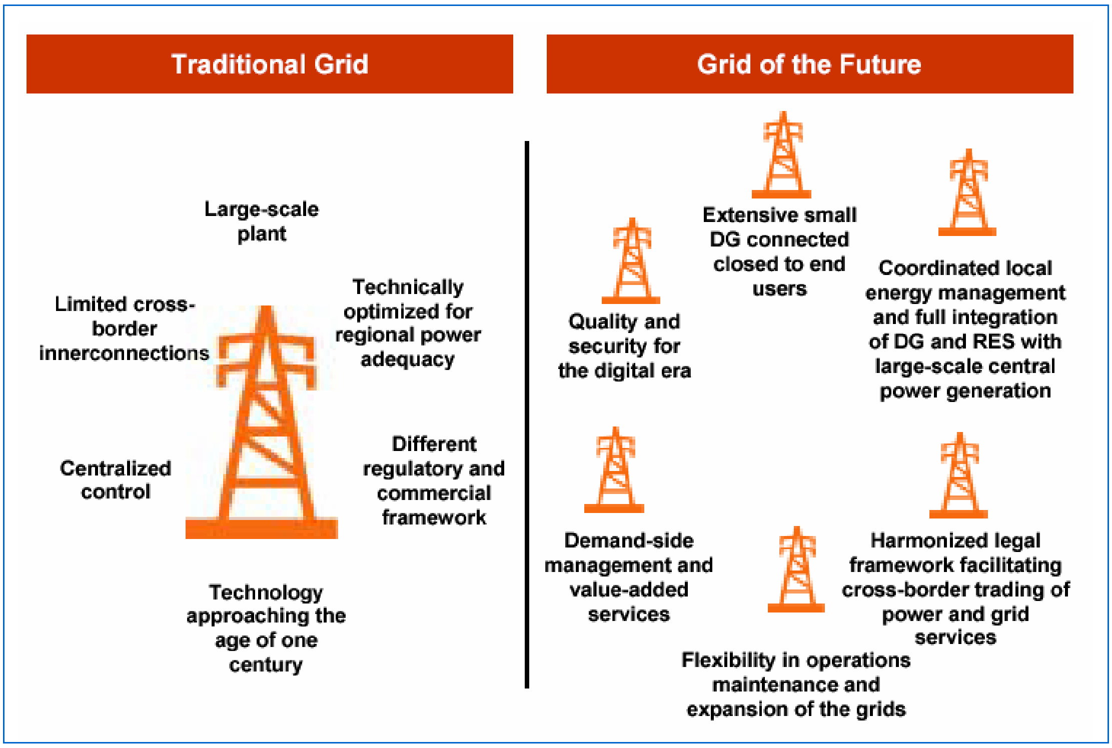
20 European Energy Markets Observatory by Capgemini

21 ICT for Smart Distribution Network, May 2009.

Exhibit 3-13: Evolution of energy delivery



Source: Elaboration from European Technology Platform Smart Grids 2007.

The evolution of distribution networks

Currently, the most common model for the evolution of distribution systems is the so-called "**active network**" where distribution systems are designed and managed similarly to transmission systems, that is to say they are able to manage bi-directional flows of power (deliver power to the users and transfer power to the transmission system).

MICROGRIDS and MORE MICROGRIDS

Research within the FP5 Project MicroGrids (2003-2005) focused on the operation of a single microgrid. The project aimed at investigating, developing and demonstrating the operation, control, protection, safety and telecommunication infrastructure of microgrids. It demonstrated the feasibility of microgrids operation through laboratory experiments and determined the economic benefits.

More Microgrids (2006-2009) aims at the increase of penetration of microgeneration in electrical networks through the exploitation and extension of the microgrids concept, involving the investigation of alternative microgenerator control strategies and alternative network designs, development of new tools for multi-microgrids management operation and standardisation of technical and commercial protocols. The consortium comprises major European manufacturers, power utilities, potential microgrid operators and research teams.

http://www.microgrids.eu/default.php

An evolution towards active grids is **microgrids.** According to the European Technology Platform SmartGrids, microgrids are low voltage networks with distributed generation resources, together with local storage devices and controllable loads (e.g. water heaters and air conditioning). The unique feature of microgrids is that, although they operate mostly connected to the distribution network, they can be automatically transferred to islanded mode in case of faults in the upstream network.

Research around microgrids have been supported by the European Commission's 5th and 6th Framework Programmes since 2003, respectively through the MICROGRIDS and MORE MICROGRIDS initiatives, as described in the following box text. These projects could be the basis for further ICT developments for efficient distribution networks. Technological developments of ICT for Smart Grids are illustrated in Section 3.4.3.

3.4.2 Plug in Electric Vehicles

The evolution of distribution systems raised interest towards **Plug in Electric Vehicles,** both pure electric and Hybrid (PHEV)[22], as illustrated by the case study about EDISON (Section 5.3). This could be an attractive source of revenue for utilities, particularly if the batteries are recharged during off-peak periods. Through these systems, power can be sold 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). The most interesting feature is that, thanks to that onboard battery capacity, EVs conceivably could also provide energy storage.

Key drivers are pushing the viability and penetration of EV, such as developments in scale, safety and capacity of batteries. Availability of offer from car manufacturers is also increasing and there is a strong socio-economic rationale that includes efficiency, reduced emissions and exploitation of off-peak periods (EV are typically recharged in off-peak periods, such as evening and night and, at the same time, could function as support or energy storage service). Should they develop on a large scale, this would bring a dramatic impact on the distribution system.

On the other hand, EVs pose significant challenges, as many technical, energy and environmental considerations must be examined before they become widely available. The foremost obstacle to their successful commercialisation is the cost and performance of the large battery storage systems needed for sufficient vehicle range. Cost, battery size and performance, durability and safety still need to be improved and tested. There may be an issue of interconnection and feeding power back onto the distribution grid from dispersed locations.

According to estimation by IDC Energy Insights[23], their significant market penetration likely remains ten years away. Nevertheless, utilities and carmakers should speed-up pilots and begin to rethink the grid and the requirements for handling distributed sources and two-way power flows.

Should EVs be deployed on a broad scale for V2G applications, the impact on the electric power system (particularly the distribution system) would be tremendous. The industry

[22] PHEVs are similar to the hybrid electric vehicles (HEVs) on the market today, but have a larger battery that can be recharged from the electrical grid.

[23] · IDC Energy Insights, *What Path are PHEVs Taking in Europe?* (May 2008)

would have to learn how to manage large numbers of distributed energy storage devices and two-way power flows, thus confirming the importance of the evolution towards smart grids.

3.4.3 Smart grids

As illustrated in the previous section, transmission and distribution networks are converging toward innovative and comprehensive systems, currently labelled as smart grids. As stated before, a smart power grid is essentially an intelligent electricity delivery system where power providers (TSOs and DSOs) and consumers are all connected and can interact in real time, thus allowing to predict and adjust network changes, using ICT.

The term "SmartGrids" is also used by a European initiative[24], the "European Technology Platform for Electricity Networks of the Future" that started in 2005. It aims to formulate and promote a vision for the development of European electricity networks looking towards 2020 and beyond. The main goal of the Platform is to increase efficiency, safety and reliability of European electricity transmission and distribution systems and remove obstacles to the large-scale integration of distributed and renewable energy sources.

A further Sectoral e-Business Watch study was issued in 2009 about "Metering and measurement facilities as enabling technologies for smart electricity grids in Europe." The study focuses on the measurement and metering infrastructure for the electrical grid, in order to better understand the current situation in the deployment of the measurement and metering infrastructure.

Drivers of smart grids

Driving factors for the development of smart grids can be summarised as follows:

- Market evolution, including increasing concern of customers about energy consumptions and interest towards renewables.
- Security and quality of supply. As illustrated in previous sections, ageing infrastructure, grid congestions and peaks in demand pose relevant challenges as for technology and innovation.
- Environmental policies, both at the EU and at national level, require new approaches to energy generation, consumption and delivery and drive interest towards renewable and distributed energy technologies.
- The need for more cross-border integration that should lead, ultimately, to an interoperable pan-European network.
- Finally, the progress and the availability of proper technology, which allows improvements in operation and new services at reasonable costs this facilitating the implementation of smart grids.

[24] Information at http://www.smartgrids.eu.

Benefits and impacts of smart grids

The adoption of smart grids is expected to bring relevant benefits to both operators and consumers, these are:

- Energy efficiency and better and more reliable usage of existing grids through increased asset optimisation.
- Avoid or delay construction of new transmission and distribution infrastructures. Optimisation of plants may allow utilities to postpone – or avoid – new generation investments.
- Reduce growth of demand. On the consumer side, smart grids may enable consumption monitoring, therefore allowing more energy-efficiency. Moreover they provide timely information on energy pricing, in such a way that consumers can optimise their consumption patterns.
- Facilitate increasing penetration of renewables. Smart grids can manage various sources of power more easily than traditional infrastructures, therefore allowing more distributed generation to be integrated. Moreover, smart grids encourage home and building owners to invest in micro-generation technologies.
- Increased understanding and predictability of the power system state, in such a way that operators can easily optimise their operations, manage peak demands and provide value added services.

Technological developments in smart grids

The transition to smart grids requires technological transformations. This involves enhancing and upgrading of existing infrastructure, implementing new systems and improving integration throughout the ICT operating environment.

According to IDC Energy Insights[25] the main ICT components that drive the development and the implementation of smart grids are:

- Sensors for remote asset monitoring and measurement to support both traditional and innovative applications such as time of use pricing and demand side management
- Communication networks for real time data transmission, allowing integration of all the players involved.
- Advanced analytics for real time decision-making that may support the control and the execution of innovative applications.

Other more specific technology developments that will shape smart grids include energy storage, domestic micro combined heat and power (MicroCHP), increased residential application of photovoltaic systems, and smart metering or advanced metering infrastructure (AMI).

Operators will continue to rely on the technical software already in place like SCADA, as well as on the management software (like EAM and ERP) thus calling for more interoperability and integration.

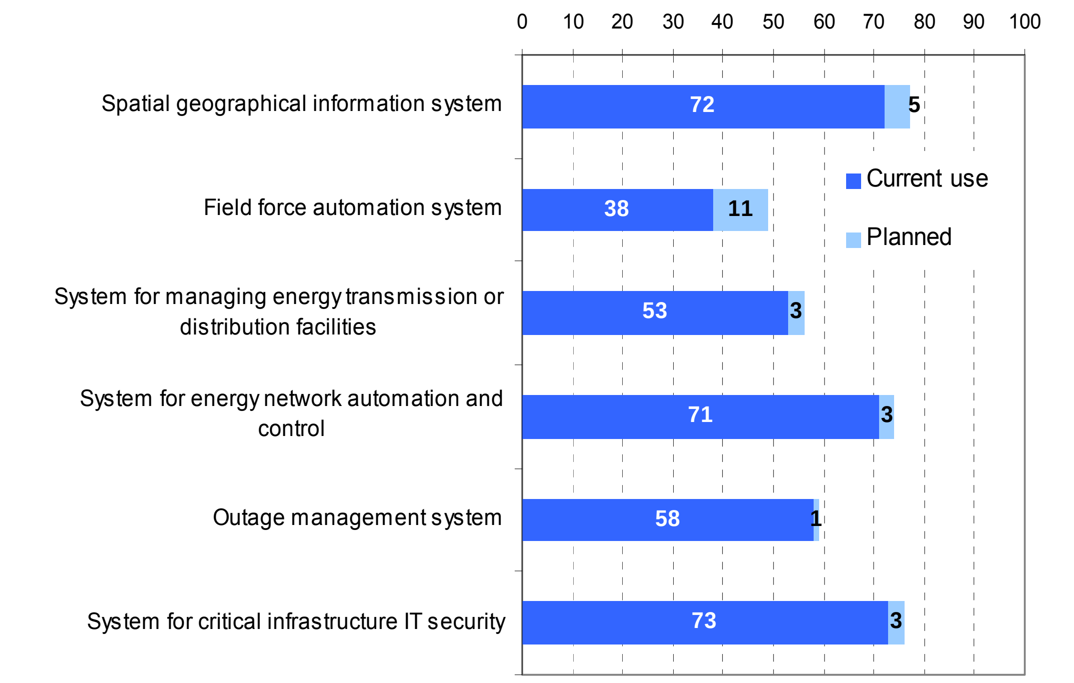
[25] IDC Energy Insights, *Intelligent Utilities: The Future of Electric Grids* (November 2007).

3.4.4 Usage of ICT systems for energy transmission and distribution

Both the current T&D networks and their evolutionary models would need the widespread adoption of ICT for asset and work management, monitoring, control and integration of different tools and devices in place, management and control of distributed energy resources, security, maintenance operations, as well as for field workforce management. These systems are becoming increasingly important as they allow to optimise operations and increasing flexibility, response and robustness and regulatory compliance. Finally, ICT-based technologies can be used to improve the communication between a DSO and a TSO. This calls for technical standardisation and harmonisation of the operational framework.

Exhibit 3-14 provides information about the pace at which European ESI companies are adopting IT systems for energy transmission and distribution. It indicates that ESI companies are fairly well equipped with systems supporting energy network automation and control: companies representing 71% of employment have these systems in place. Technologies for control may include soft controllers based on ICT and hard controllers based on power electronic devices like Flexible AC Transmission System) (FACTS), which are able to increases the number of control parameters. At distribution level the equivalent devices are known as D-FACTS, they improve control of power flows, voltage level, power quality issues in distribution grids. At distribution system level, currently adopted technologies may include also interfaces for connection to local supervisory control and data acquisitions (SCADA) and distributed control systems (DCS) and possibly Internet systems.

Exhibit 3-14: IT systems for energy transmission and distribution



Base (100%), Firms active in transmission of electricity, distribution of energy; N (Base, total) 264
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector)

Source: SeBW-Energy Supply Survey 2009

The issue of managing distributed assets is reflected by the widespread adoption of GIS, 72%, (Exhibit 3-14). As security is more than an issue in the sector, systems supporting critical infrastructure IT security are also largely adopted (73%). Quite surprisingly, a relevant share of companies says they are not relying on outage management systems (adopted by companies representing 58% of employment).

This sector may largely benefit from the adoption of applications for field force automation. These allow to schedule, route and dispatch field workforce for activities such as service restoration and routine maintenance. These applications can stream the flow of information, enable timely response and increase the level of service, ultimately improving customer satisfaction. Field force automation, however, has not been exploited yet, as only companies representing 38% of employment have such systems in place. This is nevertheless the kind of systems that more (11%) companies plan to adopt in the near future. An example of key achievements and impacts from a mobile workforce management solution is provided in the ENEL case study, (analysed in Section 5.4). The redesigned operations of the approximately 8,500 field engineers contributed significantly in the Enel's overall reduction of operating costs.

Overall, ESI companies are fairly well equipped with systems supporting management and control of their activities in energy transmission and distribution. This holds true across the sub-sectors and class sizes (data not shown in the exhibit), although smaller companies slightly lag behind. It appears that this kind of solutions is increasingly becoming necessary to stay on the market efficiently. An issue that should be addressed is why such a low percentage of companies that presently do not have these solutions, plans to adopt them. It would be interesting to know to which extent this attitude is driven by long-term strategies or short-term, may be crisis-related concerns. There is evidence that further enablement of smart grids, a pillar of the EU energy policy, needs to be supported by adequate ICT. Moreover, according to the European Commission Consultation Group "there is a need for a better coordination of the transmission and distribution systems, which have to efficiently and safely work together. Both systems need to be further developed, not necessarily only in terms of carrying capacity but also and mostly in terms of ICT infrastructure and communication platforms. In particular, the transmission system strongly needs clear interfaces with the downstream distributed system."

(Source: ICT for Energy Efficiency: Consultation Groups Sectors Reports, Smart grids, October 2008).

3.5 ICT and energy demand

3.5.1 Smart metering

Definition and features

The evolution towards smart girds (as illustrated in Section 3.4.3) 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 slightly differ, although the main feature is that it should allow for two-way communication between the utility (supplier or DSO) and the meter. For the purpose of this report, Smart Metering will be defined according to the position paper "Smart Metering for Europe":[26]

> Smart Metering systems consist of several different technical components and vary in design dependent on the specific market conditions in different Member States, but the majority include the following functions:
>
> - Accurate measurement of electricity, gas, water or heat usage
> - A data transmission infrastructure
> - An IT environment suited to the ensuing data volumes
> - A consumer-oriented invoice system
> - Local display of energy usage data

Smart meters may be part of a smart grid, but alone do not make a smart grid.

Typically, in a residential or small business context, smart meters measure electricity consumption and supply characteristics. Data are stored and access to these data is made possible 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 connection without requiring access to the premises.

As stated before, smart metering is a two-way communication channel through which consumers receive accurate information about their consumptions and billing. The rationale for raising consumers' awareness about consumption patterns is that electricity consumption usually peaks at certain predictable times of the day and the season. Prices can rise significantly during these times, as more expensive sources of power may need to be used. If consumers receive more accurate information about their consumption (and if tariffs are varied accordingly) they can modify their behaviour in response to market prices. In summary, smart metering may improve energy efficiency and encourage a more rational use of energy. This would be in line with the targets set by the EU as for energy savings. It is actually worth reminding that, according to the Action Plan for Energy efficiency, more than 40% of the energy consumption in Europe is building-related and that the largest cost-effective energy savings potential lies in the residential and commercial buildings where smart metering could be implemented.

For suppliers, smart metering firstly allows to save on the costs of meter reading. The communication channel towards customers may include information about consumption, tariffs, alerts and complementary services. Both consumers and suppliers would also benefit from increased customer services.

The data provided by these systems can improve the utilisation of grid and generation assets, as it allows to accurately pinpointing outages, reduce non-technical losses and thus optimise the grid functioning. At a more general level, decrease of residential consumptions and peak shaving would avoid further unnecessary investments in infrastructures and, ultimately, contribute to reduction of CO_2 emissions.

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[26] Smart Metering for Europe, A key technology to achieve the 20-20-20 targets, ESMIG, 21 January 2009.

ICT for smart metering

Enabling automated delivery, processing, management and usage of metering data has significant ICT implications.

As described above, smart metering may embed advanced functionalities, such as real time information to customers about pricing, remote change of tariffs, control of the usage of electrical devices inside the customer's premises. 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, as well as a data storage and processing system(s) capable of dealing with the large amounts of data. Data needs then to be integrated in other utilities systems: not only billing systems but geographic information systems (GIS), outage management systems (OMS), load forecasting/balancing, load research, distribution/facility design, 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 in case where micro-generation, such as PV, is installed).

Basically, the information flow between the meter and the energy company, can be carried out:

- either in a real-time modality, via a gateway to the customer. In this case there may be a Energy Management System for optimising energy consumption on the premises, or
- via communication network to the energy company. This kind of exchange is generally on a daily basis.

All this relies on the available ICT infrastructure, potentially including all the technologies that may support connectivity, for instance the Internet, the various wireless technologies, optical fibres. In such a scenario, there are both regulatory and technical challenges that are to be addressed.

Interoperability of smart metering solutions is a key to fully exploit the opportunity for expanded deployment and new added value services. Presently, adoption of smart metering is still hampered by the lack of open standards that may support interoperability between different systems and devices, as highlighted also in Exhibit 3-17.

OPEN METER

A European initiative has been launched to cope with the challenge of standardisation: the Open Meter project. The main objective of this initiative is the development of an open and common technology for remote meter management. Operationally speaking, it will work to achieve open telecommunication standards capable of guaranteeing interconnectivity between the equipment and systems of different manufacturers. The concept has been developed to address the EU's requirements for the large-scale implementation of remote electricity and gas meters. The project started on the 1st of January 2009 and it is scheduled to finish in 30 months. It is coordinated by Iberdrola (ES) and includes nineteen partners from seven European countries (Spain, France, Italy, Germany, Netherlands, Belgium and Switzerland), comprising electricity companies, meter manufacturers, TLC companies, research centres and universities.

Source: http://www.openmeter.com/ July 2009

Related to this is the issue of integration of all the various available communication networks and the smart metering solutions: there is not a single technology or mechanism that can support the deployment of smart metering, it will be instead the combination of various technologies, according to the different needs and situations, that will be able to support its diffusion.

Implementation of smart metering

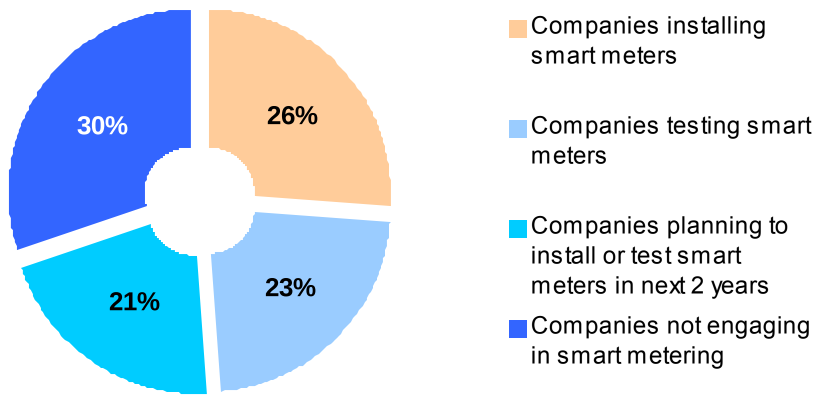
The Exhibit 3-15 provides data about the status of smart metering implementation of ESI, as it appears from SeBW Energy Supply Survey 2009. Companies representing about half the employment in the sector are either installing or testing smart meters and other 21% plan to do so in the next two years. These plans for investment represent the unique exception in the scenario for investments from the SeBW Energy Supply Survey 2009: no other application or technology is regarded with the same attention.

Through a telephone survey, it is not possible to capture the complexity of the technologies and functionalities of smart metering, as they have been described in the previous section. The SeBW Energy Supply Survey 2009, therefore, focused only on the main issues related data reading and management.

As illustrated in Exhibit 3-16 about half of the ESI companies that do *not* currently implement smart metering allow nevertheless customers to provide meter readings online, including Internet or other computed-mediated networks (excluding e-mails). Most of the companies that are engaged in distribution of energy, wholesale energy trading, retail sale of energy, heating and cooling supply have computerised meter data management solutions or plan to introduce them.

Overall, the survey depicts a scenario where ESI companies are heavily engaged in implementing or testing solutions that enhance the flow of information and allow more exchanges with their customers. The factors still hindering a wider spread of these solutions are presented in the following section of this report.

Exhibit 3-15: Smart metering implementation status



Base (100%), Companies engaged in 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).

Source: SeBW-Energy Supply Survey 2009

Exhibit 3-16: Meter data reading and management

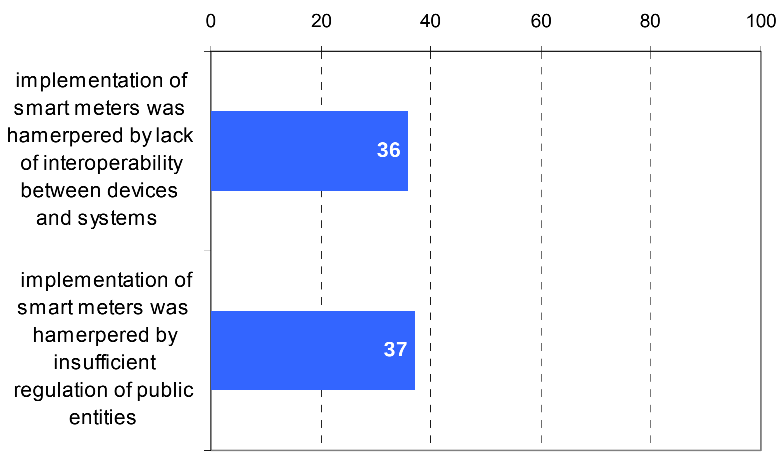
Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	Companies allowing customers to provide meter readings online to company		Companies having computerised meter data management solutions		Companies having plans for computerised meter data management solutions	
Weighting:	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms
Total	**48**	**36**	**78**	**59**	**5**	**12**
By sector						
NACE 35.1 (Electricity)	61	47	81	61	5	12
NACE 35.2 (Gas)	(28)*	(42)*	63	40	10	6
NACE 35.3 (Heating/cooling)	(19)*	(10)*	80	67	2	15
By company size						
Small (10-49)		31		48		15
Medium (50-249)		41		68		8
Large (250+)		(51)*		(77)*		(5)*
Base (100%)	Companies currently not implementing smart meters		Companies engaged in distribution of energy, wholesale energy trading retail sale of energy heating and cooling supply		Companies engaged in distribution of energy, wholesale energy trading retail sale of energy heating and cooling supply	
N (Base, total)	190		279		279	
Questionnaire reference	C10		C11a		C11b	

Source: SeBW-Energy Supply Survey 2009

Barriers to the implementation of smart metering in the EU

The following Exhibit 3-17 confirms that a relevant share of ESI companies implementing or testing smart metering still face barriers. For companies representing 36% of employment, these 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, as illustrated also in the following Section "The regime for Smart Metering in Europe".

Exhibit 3-17: Barriers for companies implementing, testing or planning smart meters

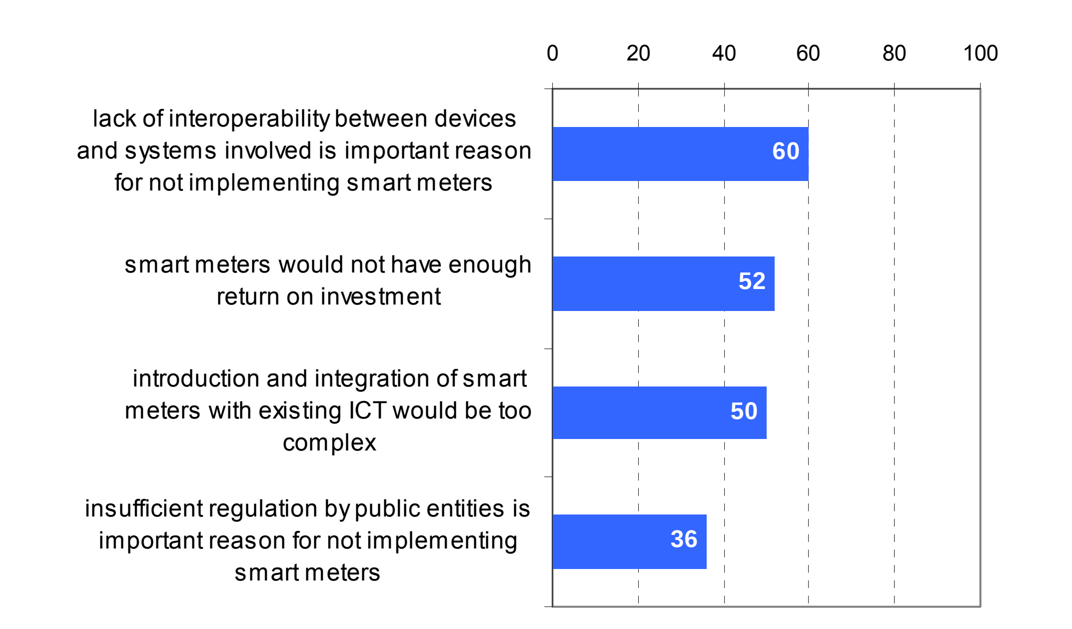


Base (100%), Companies implementing, testing or planning smart meters N (Base, total) 167
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment).

Source: SeBW-Energy Supply Survey 2009

Companies that have not and are not entering this business (Exhibit 3-18) also indicate various reasons for making such decision. Interoperability of devices and integration with existing ICT rose as the main motivations. Concerns about return on investment are also important, as they are expressed by firms representing 52% of employment. A very important issue as regards the roll out of smart metering is actually how to build a business case. Migrating to smart metering requires significant overhaul of existing systems, as well as investment in hardware, networking and software. The distribution of cost and benefits among the various players along the value chain is a central theme: if investors may not be able to retain the full benefits of the roll out, (for instance if suppliers invest in smart meters and the customer changes supplier afterwards) this limits the deployment of smart metering projects

Exhibit 3-18: Barriers for companies neither implementing nor testing nor planning to install 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

The barriers presently hampering the development of smart metering are to be met in order to fully exploit the potential for energy savings, process efficiency and new value added services.

A successful implementation: Telegestore by Enel

At a European level, Enel SpA, in Italy, undertook the largest and most successful smart meter rollout with its Telegestore project.

Telegestore project: smart meter by Enel, Italy

From 2000 to 2005 Enel, the largest Italian energy company, deployed smart meters to its entire customer base. The project was mainly completed in 2006, with few meters still to be installed. By March 2008, Enel had installed 31 million meters and 350,000 concentrators, i.e. the systems that manage the communication towards the central system and towards the electronic meters To each concentrator, a set of electricity meters is connected, such that bi-directional communication between each meter and its associated concentrator is possible.

The architecture of the project is based on integrated (i.e. equipped with breakers or disconnectors) electronic meters providing metering, contract management and Power Line Communication functions. The Automatic Meter Management communicates via public telecommunication networks (GSM, GPRS, PSTN, i.e. the Public Switched Telephone Network and satellite, with Low Voltage concentrators installed in every medium-voltage substation (one concentrator per transformer). LV Concentrators are able to manage the communication in both directions: to/from the Remote Metering Central System (via public telecommunication network) and to/from Electronic Meters (private Distribution Line Carrier communication, half–duplex mode, net speed rate of 2400 bit/s). TCP/IP support is used in communication between concentrators (C-BT) and Automatic Meter Management System (AMM). Meters are owned by distributors and customers are not allowed to buy their own meter.

The system provides a wide range of advanced features, including the ability to remotely turn power on or off to a customer, read usage information from a meter, detect a service outage, detect the unauthorised use of electricity, change the maximum amount of electricity that a customer can demand at any time; and remotely change the meters billing plan from credit to prepay as well as from flat-rate to multi-tariff.

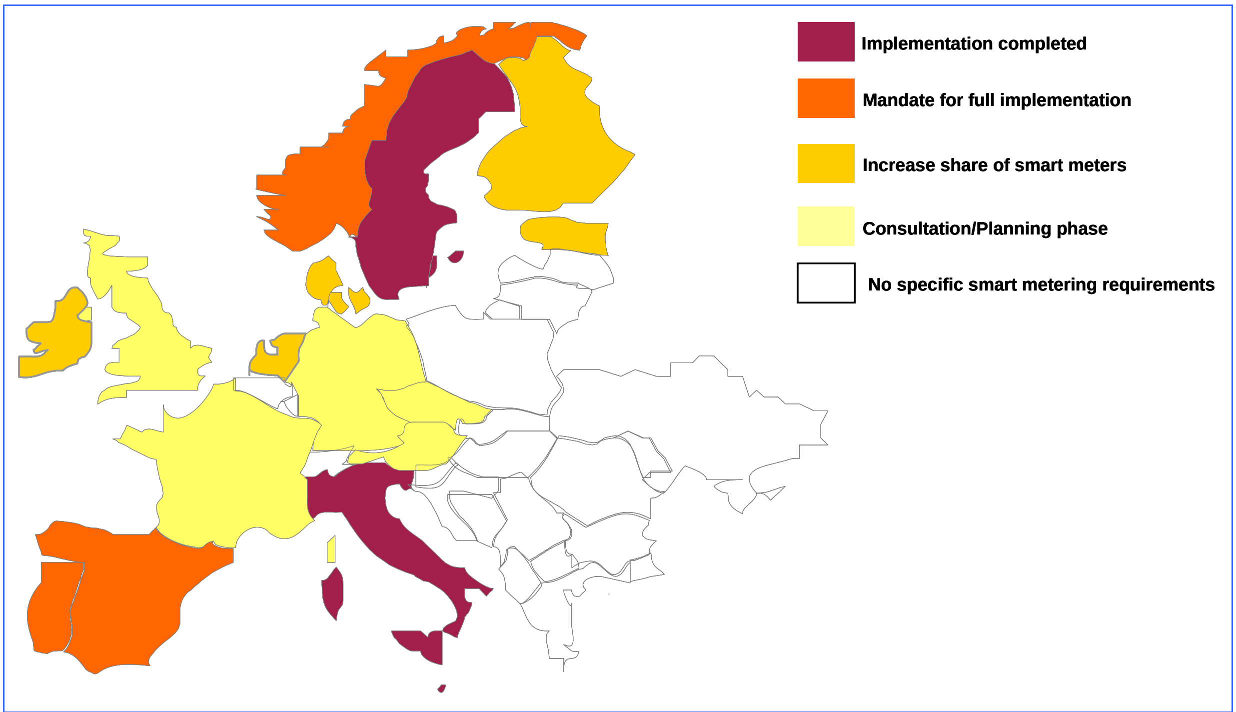
In various publications Enel has estimated the cost of the project at approximately 2.1 billion Euros. This includes R&D costs, production and installation of electronic meters, IT system development, production and installation of concentrators. Benefits can be summarised as follows: invoices on real consumption (no more estimated bills), remote contract management, tailored tariffs; peak shaving, energy efficiency and CO2 reduction, reduction of commercial and technical losses. The project payback period is estimated in 4.5 years and the savings they are receiving in operation are estimated in 500 million Euros per year.

Source: ENEL 2009

Smart metering regulation in the EU

As previously indicated, the deployment of smart metering in the EU is heavily conditioned by regulation. As a result of different national approaches, currently, the penetration of smart metering is significant only in a few countries; developments are however taking place, as illustrated in the following map (Exhibit 3-19).

Exhibit 3-19: Smart meter rollout in Europe



Source: IDC Energy Insights, 2009

There are liberalised markets, where metering is open to competition (by now only Germany, the Netherlands and the UK). In these countries, however, the deployment of the infrastructure has been inhibited by various market factors.

In the regulated markets, metering is a monopoly carried out by grid operators and paid by the final customer as part of tariffs. Incentives can be given for installation of smart meters (e.g. by allowing for higher meter tariffs) or there could be an obligatory rollout; in open markets, metering is carried out by third party companies.

In most countries, customer meters are owned by distributors; there are however differences. In UK, for instance, it could be owned by the distributors, the supplier, the metering company or the final consumer.

As illustrated in Chapter 2, the third energy package agreed in 2009 introduce the mandate for implementing intelligent metering systems with a target of 80% of the population to be covered by 2020. It is therefore difficult to envisage which the actual pace of change will be.

Exhibit 3-20: Regulatory regime of electricity meters in the EU, 2008

	Liberalised	Regulated unbundled from DSO	Regulated bundled in DSO	Mixed
Austria				
Belgium		x	X	
Bulgaria			X	
Cyprus			X	
Czech Rep.		x		
Denmark			X	
Estonia			X	
Finland			X	
France				x
Germany			X	
Greece			X	
Hungary			X	
Ireland			X	
Italy			X	
Latvia			X	
Lithuania			X	
Luxembourg				x
Malta			X	
Netherlands	X			
Poland			X	
Portugal		x		
Romania				
Slovakia			X	
Slovenia			X	
Spain		x		
Sweden			X	
UK	X			

Source: Survey of Regulatory and Technological Developments concerning Smart Metering in the European Union Electricity Market, 2008

Smart metering is a very important issue in the ESI sector, as it may improve energy efficiency and encourage a more rational use of energy. Companies representing about half of the employment in the sector are either installing or testing smart meters and other 21% plan to do so in the next two years. It is the technology in which ESI companies intend to invest more, according to the results of the SeBW-Energy Supply Survey 2009. However, companies implementing or testing smart metering still face barriers related to the interoperability of the devices and systems and need to cope with regulation deficiencies. These challenges are to be met in order to fully exploit the potential for energy savings, process efficiency and new value added services. Regulatory issues have been recently addressed by the third energy Package. As regard the technical issues, the results of the analysis especially lead to recommendations for actions addressing technical standards that may support interoperability between different systems and devices.

3.5.2 ICT for energy demand management

Demand-side management is the process of managing the consumption of energy, generally to optimise available and planned generation resources, possibly with the support of financial incentives, education or other programmes. The goal is to reduce energy consumption, for instance, by continuous monitoring and active management of appliances. Related to demand side-management is **demand response**. Typically, demand response encourages the user to reduce the load at peak times or move the time that the load is used to off-peak times, such as nighttime or weekends, or shift their consumption (demand) of energy. The active participation of the customers is a response to factors such as incentive pricing and new tariffs schemes.

SINTEF's "Market Based Demand Response" project, Norway

The "Market Based Demand Response[27]" project was started in 2005 by SINTEF Energy Research, with the Norwegian Transmission System Operator (Statnett) as responsible partner towards the Research Council of Norway. The main project goal was to improve power market efficiency by increasing the demand side price elasticity, through the usage of ICT in the interplay between the main stakeholders-customers, power suppliers, distribution companies, the TSO and the authorities. More precisely, this project encouraged demand response to the marginal price in the electricity markets. Spot price energy products and Time of Day (ToD) tariffs have been used both for households and for larger customers. Pilot tests involved households and medium sized customers have been carried out, as regard to: a) "Fixed Price with Return options" energy contract, b) Remotely controlled load shifting, c) "Smart house" control in housing cooperative, d) Low prioritised loads controlled by building energy management system (institution and shop) and e) Automatic Demand Response to the electricity spot price. During the pilot, the customers with the new product (a) reduced their consumption by 24.5 percent in quarter of 2006, while customers with spot price power products and standard power products increased their consumption by percent and 7.7 percent respectively in the same period. The power balance in the Nordic power market was very tight and spot prices increased significantly. The pilot customers got strong incentives to reduce consumption, and the registered response shows the potential for this type of contract. The Norwegian authorities have now decided that "smart meters" should be installed to all customers in Norway by 2014.

Source: Market-Based Demand response, by Hanne Sæle and Ove S. Grande , SINTEF Energy Research, 2008

Once consumers have information on such price differentials and if their energy consumption is time-specifically metered, they can adjust their consumption pattern. 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 customers. Demand side management and demand response, therefore, can bring

27 See http://www.energy.sintef.no/prosjekt/mabfot/UK/uk_index.asp.

relevant benefits in achieving the goals of energy efficiency and, in turn, reduction of emissions. There are various projects running worldwide that rely on ICT-based solutions and tools aiming at implementing demand response solutions. Some of these involve smart metering or are part of more general smart-grids programmes, with clear overlapping at technological and strategic level.

At a European level, the ADDRESS initiative is also actively dealing with demand response and, more broadly, with active consumers participation in power market.

ADDRESS

ADDRESS stands for Active Distribution network with full integration of Demand and distributed energy RESourceS. Its target is to enable the Active Demand in the context of the smart grids of the future, or in other words, the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants. ADDRESS is framed in the Smart Grids European Technology Platform. ADDRESS aims at developing a comprehensive commercial and technical framework for the development of active demand. This will concern mainly equipment installed at the consumers (prosumers) premises: electrical appliances ("pure" loads), distributed generation (such as Photovoltaic or micro-turbines) and thermal or electrical energy storage systems.

To deal with active demand a new approach is being adopted by ADDRESS: the "Demand Approach" in contrast to the "Generation Approach" that is generally used to deal with generation and in particular Distributed Generation (DG). Contrary to DG and large industrial customers, domestic customers are not motivated by purely economic considerations. Moreover, they are not able (e.g. due to the lack of appropriate equipment) or not prone to characterise precisely in advance the services and flexibilities that they can provide. Domestic consumers are not likely to "offer" services. Therefore, the services they can provide will be "requested" through the developed price and/or volume signal mechanisms and will be provided on a voluntary and contractual basis.

To support this approach on the consumer side, both appropriate technologies have to be developed in the houses or at the interface with the aggregator, and relevant accompanying measures have to be studied to deal with societal, cultural and behavioural factors. To enable active demand ADDRESS intends to develop technical solutions both at the consumers' premises and the power system level; to identify the possible barriers against active demand development and develop recommendations and solutions to remove these barriers considering economic, regulatory, societal and cultural aspects.

To exploit the benefits of active demand ADDRESS: identifies the potential benefits for the different power system participants; develops appropriate markets and contractual mechanisms to manage the new scenarios; studies and proposes accompanying measures to deal with societal, cultural and behavioural aspects. The proposed solutions will be validated in 3 complementary test sites with different geographical and demographic characteristics and different infrastructure mixes. Sites will be selected in Spain, Italy and France to meet these diversity requirements and to provide a representative realisation of the ADDRESS architecture.

Source: http://www.addressfp7.org)

As a result of smart processes for managing demand and consumptions, it is increasingly possible, for suppliers, to develop targeted contracts, tariffs and offers for customers, as illustrated in the example about the GridWise Olympic Peninsula Project.

Real Time Price Control in the GridWise project, US

The GridWise Olympic Peninsula Project *(2004-06) in the Northwest of the US, dealt with real-time price controls of distributed energy resources. It consisted of a field demonstration and test of advanced price signal-based control of distributed energy resources (DERs) in 120 households. It was sponsored by the US Department of Energy (DOE) and led by the Pacific Northwest National Laboratory. The rationale for the project was that inserting intelligence into electric grid components at every point in the supply chain would significantly improve both the electrical and economic efficiency of the power system. ICT were used to create a real-time energy market system controlling demand response automation and distributed generation dispatch. The project investigated the impact of 5 minutes energy price signals combined with smart in-home appliances. Some of the project results were: 15% peak demand reduction over 12 months; 50% peak reduction over significant periods and successful internet-based control, even in situations of intermittent communication, effective usage of distributed generation units.*

Source: www.gridwise.pnl.gov.

Usage of ICT for energy demand management

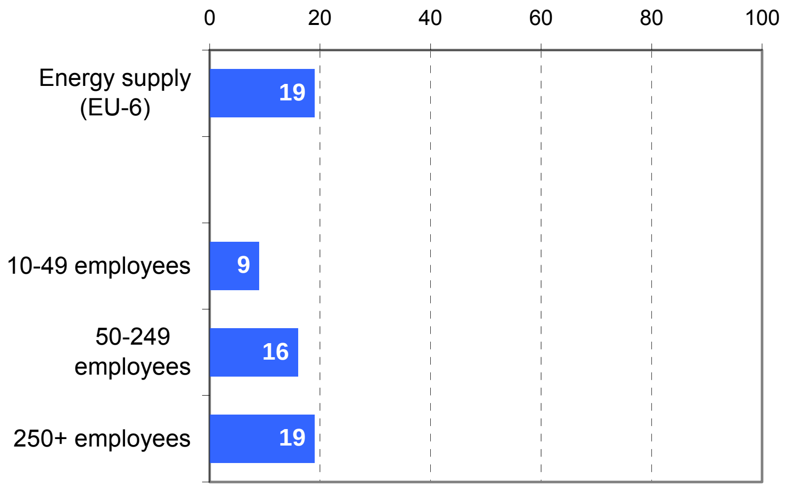
To fully exploit the potential inherent to Demand Side management, as well as real time pricing, it is necessary to rely on adequate ICT systems.

ICT can facilitate the efficient use of energy by helping energy suppliers to analyse consumption data and to stimulate consumers to respond to energy prices at specific times. On the supply side, companies installing, controlling, managing and monitoring energy distribution grids can use ICT for purposes such as complex billing, remote meter reading and advanced metering infrastructure solutions. These facilitate the collection and analysis of consumption data. Based on such analyses, energy suppliers can set prices for specific points in time, which reflect the true value of bottlenecks in the system. Time-specific prices will be higher than standard tariffs during peak hours and lower during off-peak hours.

The SeBW Energy Supply Survey 2009 investigated whether ESI companies adopt any programmes for communicating with end users about price changes and encouraging them to reduce or shift their consumption. Firms were asked if they have ICT solutions to support such demand response programmes.

Demand response programmes as such have not yet spread in the ESI, and this is not surprising due to the relevant organisation and technical implications involved in their implementation, as illustrated in the previous examples. Only companies representing 19% of total employment state having ICT solutions in this field (Exhibit 3-21).

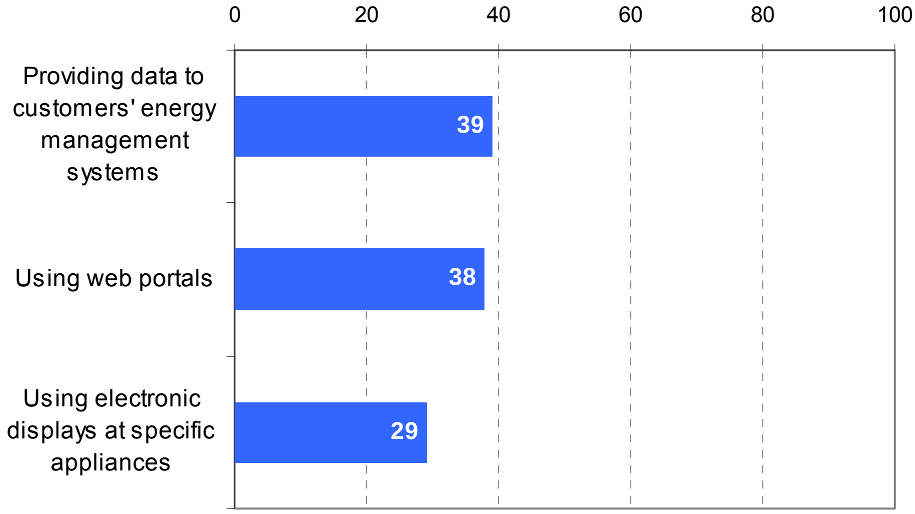
Exhibit 3-21: % of companies having ICT solutions to support demand response programmes



Base (100%), Companies engaging distribution of energy, retail sale of energy, heating and cooling supply N (Base, total) 265
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

Exhibit 3-22: % of companies informing customers about their energy consumption real time



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

Source: SeBW-Energy Supply Survey 2009

The set up of real time communication channels with end users (see Exhibit 3-22) is, instead, becoming a more common practice. It may be embedded in specific service programmes or accessible via the company's web site. Generally speaking, these tools do not provide bi-directional communication, though. Few companies offer their customers the possibility to simulate, analyse and optimise energy consumption on their own: only companies representing 17% of employment offer such service and 18% plan to introduce it in the next 2 years. Interactive features via web site are not a common practice in this sector (Exhibit 3-23).

Demand side management can also include the opportunity for new business models. Companies can outsource energy services such as heating and lighting to specialist service providers that commit themselves to provide a certain energy service (e.g. room temperature) at a given price. Energy service outsourcing as it may be part of a more comprehensive range of services. Currently, ESI firms representing 41%of employment offer to manage services on behalf of their customers (Exhibit 3-24).

Exhibit 3-23: % of companies having or planning to offer web portals for customers to simulate, analyse and optimise energy consumption

Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	**Web portals for customers to simulate, analyse and optimise energy consumption**			
	companies having it		**companies planning to offer it in next 2 years**	
Weighting:	% of empl.	% of firms	% of empl.	% of firms
Total	**17**	**12**	**18**	**20**
By sector				
NACE 35.1 (Electricity)	20	15	17	24
NACE 35.2 (Gas)	1	6	31	15
NACE 35.3 (Heating/cooling)	24	10	10	13
By company size				
Small (10-49)		8		20
Medium (50-249)		17		18
Large (250+)		(15)*		(21)*
Base (100%)	IF C1(c) OR C1(e) OR C1(f) = (1)		IF C1(c) OR C1(e) OR C1(f) = (1)	
N (Base, total)	265		265	
Questionnaire reference	C16a		C16b	

Source: SeBW-Energy Supply Survey 2009

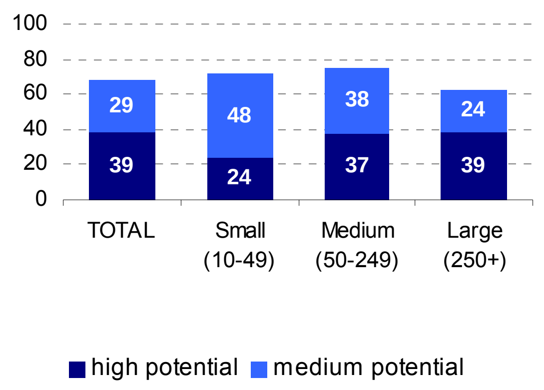
Exhibit 3-24: % of companies offering or planning to offer to manage customers' energy supply, heating or cooling on their behalf

Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	**Companies offering to manage customers' energy supply, heating or cooling on their behalf**		**Companies having plans to offer to manage customers' energy supply, heating or cooling on their behalf in next 2 years**	
Weighting:	% of empl.	% of firms	% of empl.	% of firms
Total	**41**	**31**	**5**	**9**
By sector				
NACE 35.1 (Electricity)	39	29	5	9
NACE 35.2 (Gas)	53	34	2	10
NACE 35.3 (Heating/cooling)	36	35	10	9
By company size				
Small (10-49)		23		9
Medium (50-249)		39		12
Large (250+)		(43)*		(4)*
Base (100%)	IF C1(c) OR C1(e) OR C1(f) = (1)		IF C1(c) OR C1(e) OR C1(f) = (1)	
N (Base, total)	265		265	
Questionnaire reference	C17_a		C17_b	

Source: SeBW-Energy Supply Survey 2009

The potential of ICT in increasing efficiency of business customers is perceived as high or medium by about three out of four of the surveyed companies (Exhibit 3-25).

Exhibit 3-25: Assumed ICT potential to increase energy efficiency of other companies

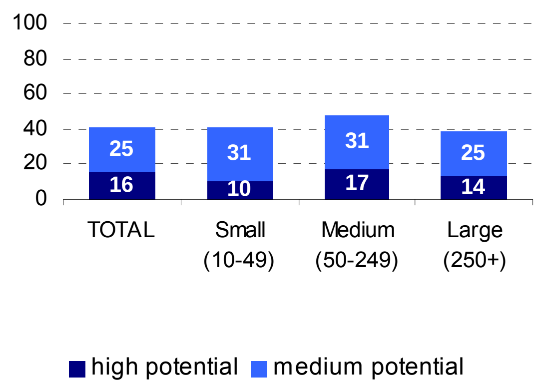


Base (100%), Companies engaging in distribution or retail sale of energy or heating/cooling supply) N (Base, total) 249 Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

When it comes to private households, the potential of ICT is perceived as definitely lower. This is not surprising due to the necessary infrastructure to be put in place if relevant efficiency gains are to be achieved (Exhibit 3-26).

Exhibit 3-26: Assumed ICT potential to increase energy efficiency of private households



Base (100%), Companies engaging in distribution or retail sale of energy or heating/cooling supply) N (Base, total) 241 Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

The potential benefits of demand side management and demand response management have been demonstrated in various pilot projects and are clear to ESI companies. The full deployment of such programmes, however, is quite complex as it involves not only the supply side but requires active participation from the customer's side, with relevant organisation and technical implications. This explains the limited adoption among ESI. The set up of real time communication channels with end users (via web portal, displays, link with customers' programme) is, instead becoming a more common practice. ESI firms have also started broadening their range of outsourcing services. There is clearly a large untapped potential for energy efficiency in this field that should be addressed at policy level.

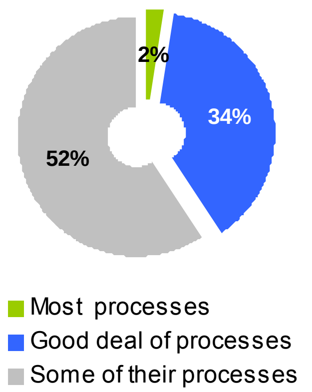
3.6 Overarching issues

3.6.1 e-Business impact, drivers and inhibitors

Perceived importance of ICT and e-business in ESI: a mixed picture

In the SeBW Energy Supply Survey 2009, ESI companies were asked about the relevance of e-business for the company, by indicating whether they conduct most of their business processes, a good deal of their business processes or some of their business processes as e-business, i.e. through computer-mediated networks.

Exhibit 3-27: Companies saying that most processes, a good deal of, some processes are conducted as e-business



Base (100%), All N (Base, total) 351
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

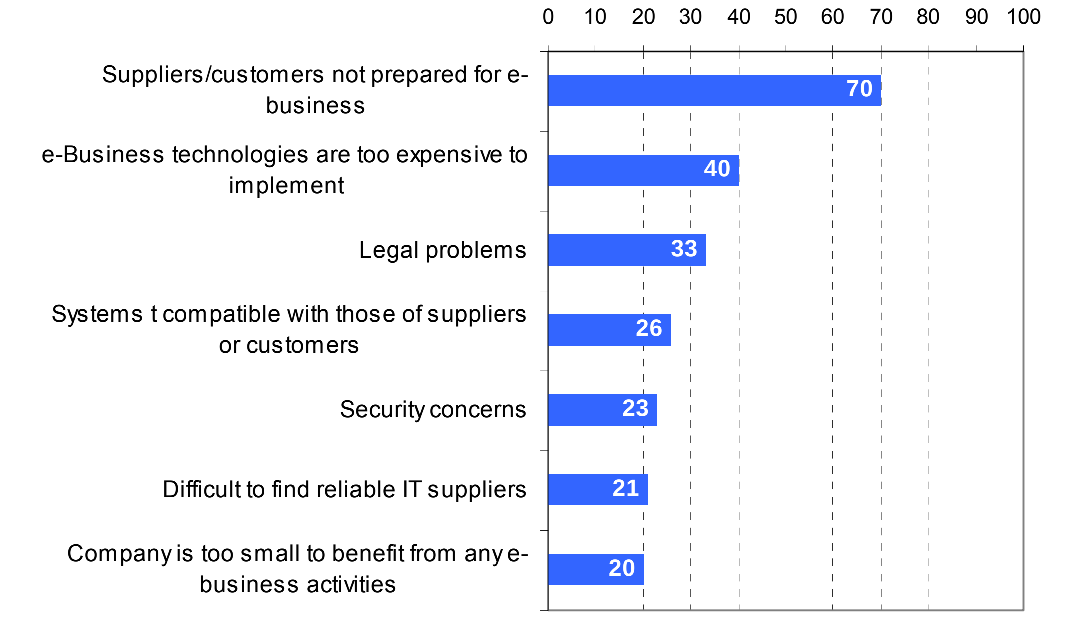
Firm representing 34% of employment say that they conduct a good deal of processes as e-business and companies representing 2% of employment state that they conduct most of their processes as e-business.

As ESI firms are well aware of the potential benefits inherent to the effective implementation of ICT and largely rely on it for innovating their products and processes, it is particularly interesting to highlight the motivations for the low or non usage of e-business. This is illustrated in Exhibit 3-28.

The main constraints are found in the business partners along the value chain who are not prepared for e-business, followed by costs. This seems to confirm the adoption model of ICT that emerged from the analysis in the previous sections: automation of critical processes but little system integration in the company or with business partners.

So far, it appears (see Exhibit 3-29) that only a few players along the ESI value chain are in a position to exert a driving force that may spread the adoption of relevant ICT, as only 26% of firms have experienced pressure towards adoption.

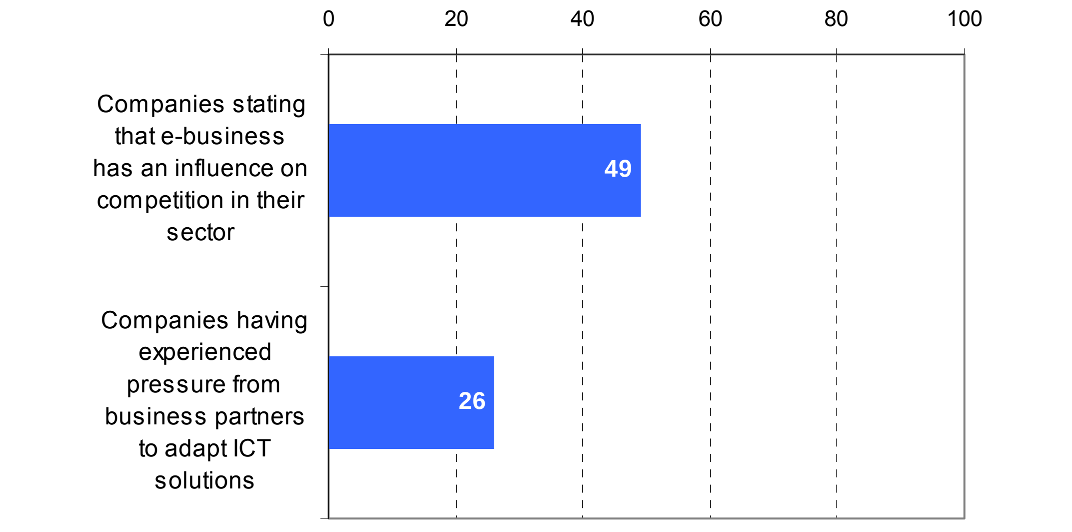
Exhibit 3-28: Companies with low or no e-business use indicating reasons for not using e-business



Base (100%), All N (Base, total) 239, companies with low or no e-business use
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

Exhibit 3-29: e-Business and competition



Base (100%), All N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

A very interesting result from the survey, also relevant in a policy perspective, is the picture that ESI companies have about 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 impacts on future energy management will increase. The same companies, however, also indicate that presently most of their processes are only partly managed as e-business. According to the opinion of the interviewees, the main constraints to a wider adoption of e-business are the business partners along the value chain, who are not prepared for e-business, (costs, the second motivation lags far behind). Not even larger players act as a driving force able to support and broaden the adoption of ICT technologies that are nevertheless recognised as beneficial for this industry.

3.6.2 ICT and environmental impact

Towards a more climate-friendly energy sector

As illustrated in Chapter 2, the EU is heavily engaged in facilitating the transition towards a more climate-friendly energy sector: emissions cuts and the related ETS, energy efficiency and rules promoting the use of energy from renewable sources are the pillars of the European policy. This transition is supported by a range of ICT solutions that respond to changing regulatory, safety, and security requirements, while enhancing value chain visibility and ensuring continuity of operations. Figures about the adoption of a few of such solutions are provided hereby. Chapter 4 provides an econometric analysis to gain evidence on the impact of ICT in reducing greenhouse gas emissions at sector level. This section is focused on highlighting the SeBW 2009 survey findings.

Health, safety & environment and carbon management solutions

The SeBW 2009 survey analysed the adoption of ICT systems addressing the issue of environmental impact. These include systems for managing electronically health, safety and environment aspects (HS&E) and, more specifically, IT solution for carbon management.

HS&E systems that maximise compliance for electric utility industry facilities have been adopted by companies representing 50% of employment, this corresponding to only 32% of firms. It should be noted that only one out of two large companies have HS&E systems in place. While electricity and heating/cooling companies are fairly aligned with the sector average, gas companies lag behind.

Carbon management systems are more popular among heating/cooling companies, although the overall diffusion at a sector level is really limited.

Overall, the diffusion of this kind of ICT solutions appears to be low, if compared with the general market trends in the ESI and the regulation in place. Clearly, the prevalence of small companies, in the population and in the survey sample, accounts for the limited diffusion of advanced ICT solution. However, large companies have also not yet widely adopted these solutions.

Exhibit 3-30: Use of ICT solutions for health, safety and environment and carbon management

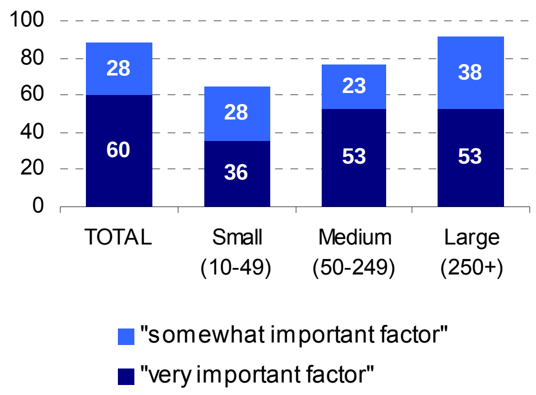
Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	Companies having the following general ICT solutions for energy supply:			
	Health, safety and environment system		Carbon management system	
Weighting:	% of empl.	% of firms	% of empl.	% of firms
Total	**50**	**32**	**25**	**16**
By sector				
NACE 35.1 (Electricity)	58	35	21	14
NACE 35.2 (Gas)	28	27	8	5
NACE 35.3 (Heating/cooling)	48	29	50	34
By company size				
Small (10-49)		28		11
Medium (50-249)		31		24
Large (250+)		50		22
Base (100%)	All		All	
N (Base, total)	351		351	
Questionnaire reference	C2a		C2b	

Source: SeBW-Energy Supply Survey 2009

ICT for reducing greenhouse gas emissions

The EU Emissions Trading System, to achieve emissions reductions, is a business concern and international efforts to reduce industrial emissions have significantly gained support and momentum. Europe is committed to take a lead in this field (see Chapter 2 of this report). The results from the SeBW Energy Supply Survey 2009 indicate that the intensive debate about the impacts of the EU ETS raised concern about this issue in many companies. 60% of ESI companies engaged in generation activities consider ETS very important, medium and large companies are more aware than small ones (Exhibit 3-31).

Exhibit 3-31: Emission Trading Scheme, % of companies saying that the EU ETS is very / somewhat important for their company



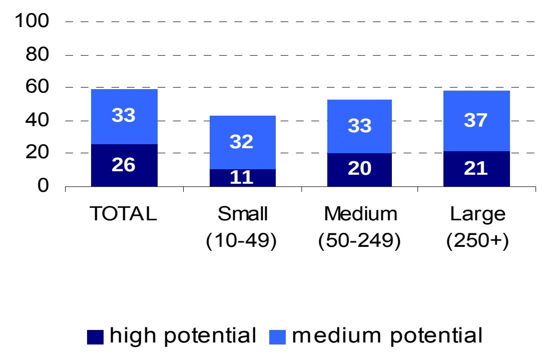
Base (100%), Firms generating energy; N (Base, total) 169
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

One company out of four thinks that ICT has a high potential for reducing greenhouse gas emissions in the ESI (Exhibit 3-32). For the rest of sample, ICT have medium potential (for companies representing 33% of employment) or even little (30%). For most of the sector's firm, therefore, ICT alone are not enough and need to be accompanied by other tools and/or actions.

Coherently with their perception about the role of ICT (Exhibit 3-33), only ESI companies representing 24% of employment have an ICT-enabled system to monitor greenhouse gas emissions, with hardly any difference per size class (data not presented in the exhibit). Companies representing 12% of employment have nevertheless introduced a dedicated process for systematically monitoring greenhouse emissions. Out of these, the majority (58%) have introduced a system covering emissions of the total plant, while in 26% of them, these monitoring systems work at level of single units.

Exhibit 3-32: Emission Trading Scheme, % of companies saying that ICT has medium and high potential or reducing greenhouse gas emissions in the ESI



Base (100%), Firms generating energy; N (Base, total) 169
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector). Figures for size-bands in % of enterprises.

Source: SeBW-Energy Supply Survey 2009

Exhibit 3-33: % of companies having an ICT-enabled system to monitor greenhouse gas emissions

Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	Companies having an ICT-enabled system to monitor greenhouse gas emissions		Companies having no ICT-enabled system, but a dedicated process for monitoring greenhouse gas emissions		Companies whose system / process monitors greenhouse gas emissions of total plant		Companies whose system / process monitors greenhouse gas emissions of specific units	
Weighting:	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms
Total	**24**	**13**	**12**	**7**	**58**	**66**	**26**	**25**
Base (100%)	C1a = yes (Firms generating energy)		C1a = yes (Firms generating energy)		C2.2 = yes OR C2.3 = yes (Companies with system or process to monitor greenhouse gas emissions)		C2.2 = yes OR C2.3 = yes (Companies with system or process to monitor greenhouse gas emissions)	
N (Base, total)	169		169		61		61	
Questionnaire reference	C2_2		C2_3		C2_4a		C2_4b	

Source: SeBW-Energy Supply Survey 2009

The results from the SeBW 2009 survey indicate that the debate about the impacts of the EU ETS raised concern about this issue in many companies. 60% of ESI companies consider ETS very important, medium and large companies being more aware than small ones. Firms also believe that ICT can provide a relevant contribution to the efficient management of processes related to this issue. The same results, however, point out that presently these processes are supported by ICT in a still limited number of cases and the potential impact of ICT is not fully exploited by ESI companies. Whether it is a matter of awareness or of efficiency of the currently available systems, is not clear form the results.

Besides monitoring and trading solutions, specifically related to emissions, ESI companies recognised ICT as having a high potential for reducing greenhouse gases in relation with the energy efficiency improvements it could facilitate. This element has been mentioned in previous sections dedicated to smart grids, smart metering and energy management. The Enel case study (Section 5.4) is a further example of ICT's indirect positive effect on emission reductions: optimising field crew navigation to destination it is possible to reduce vehicles' environmental impact.

Overall, the diffusion of ICT solutions for monitoring and reducing environmental impact is low, if compared with the general market trends in the ESI and the regulation in place. It appears that a relevant share of firms still do not fully understand the potential of ICT in contributing to the reduction of environmental impacts. There is a clear awareness gap that needs to be filled if the environmental goals of the EU policy are to be met.

3.6.3 ICT and innovation in ESI

ICT is crucial for innovation of new products and services and, even more so, of new processes. Companies representing 53% of this industry's employment said they introduced new products or services in the past twelve months, and 76% introduced new processes.

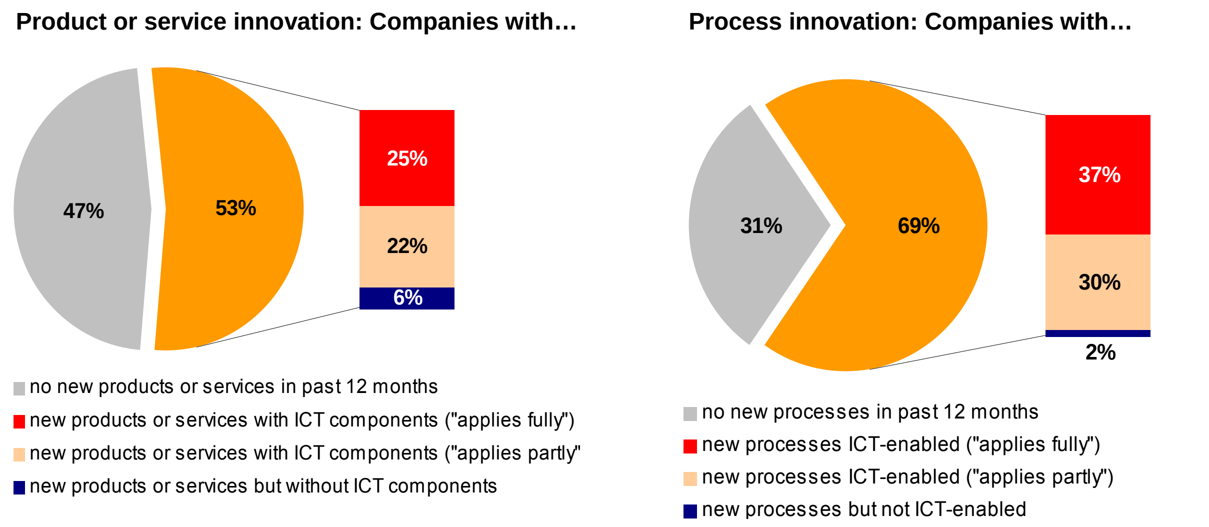
The vast majority of innovators stated that ICT played a crucial role for innovating. In energy supply 89% said that the new products or services have ICT components (48% "applies fully", 41% "applies partly") and even 97% that the new processes are supported by ICT (54% fully, 43% partly). These are the highest values for ICT-enabled innovation that the e-Business Watch has ever found in an industry.

71% of the companies (employment-weighted) stated that ICT was important for R&D leading to the product and service innovation and also for market launch. For process innovation, the related values were larger than 90%.

Innovation is strongly relying on expertise from outside the company, involving, e.g., external experts or business partners in product, service or process innovation.

As illustrated in Chapters 2 and 3 of this report, the entire ESI sector is undergoing profound changes leading closer to the vision of "intelligent utility" to which users can actively participate. Innovation in smart grids, smart metering, demand response require enhancing and upgrading of existing infrastructures and implementing new ICT. It is therefore not surprising that ICT is perceived as major innovation enabler in this industry.

Exhibit 3-34: Role of ICT for innovation in the ESI companies



Base (100%), All N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW Energy Supply Survey 2009

3.7 ICT for gas pipelines

Delivery of gas through pipelines is not part of this study. Therefore, this topic is not extensively analysed. However, due to its relevance in the current scenario for EU energy supply, a brief description of the key drivers in this industry and of the relevance of ICT for pipelines is provided.

Natural gas meets 23% of the world's primary energy demand, the same holds true for Europe, where natural gas sustains 25% of energy demand. Variations in energy prices and cutbacks in supplies of natural gas in recent years have heightened EU concerns about the security, diversification, reliability and affordability of natural gas supply. EU gas demand is covered by imports from a small number of countries, the single largest supplier being Russia. From a practical point of view, the diversification of gas imports is constrained by the fact that 94% of natural gas is transported through pipelines; about 6% is transported through Liquefied Natural gas (LNG) tankers. Among the top policy priorities for EU energy development is avoidance of strategic dependence[28]; diversification of supply countries is being supported by the allocation of funds for gas pipelines, more specifically $325 million for the Nabucco pipeline (Caspian Sea to Austria), $130 million for ITGI-Poseidon (Turkey to Italy), $195 million for Skanled (Sweden to Poland), $195 million for the France-North Africa pipeline, $175.5 million for the pipelines between the Northern Sea and the Mainland, and another $208 million for pipelines between Europe and the Middle East.

This infrastructure for transporting gas clearly poses huge challenges to the widespread structure, the inherent hazard and the inflammability, not to mention the risks related to the political relevance of the supply.

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[28] European Commission, (2006), Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy, SEC (2006) 317.

The natural gas value chain is very complex and it is affected by a vast array of business drivers and market factors, as summarised in Exhibit 3-35. In order to cope with such challenges, pipeline management can greatly benefit from the adoption of complex ICT solutions, covering and integrating the main business processes. Main applications include: SCADA (for recording, analysing and controlling), asset management (including, among the others maintenance management), workforce management, ERP as well as specific pipeline applications such as leak detection, gas management, pipeline simulation, GIS, satellite imagery (for pipeline monitoring), disaster management and recovery. An integrated approach to gas pipeline management allows to gain relevant advantages related to business processes' automation, visibility and integrated governance of the assets.

Exhibit 3-35: Key factors and challenges in the gas pipeline industry

Global scenario	Government policies Competing forms of energy New gas finds
Regulation, Environment, Health and Security related issues	Health and safety for employees and surroundings Disaster management Regulatory compliance Emissions
Market trends and competition	Demand trends Consumer analytics Quality of service Adherence to gas agreements
Efficiency of operations (management of physical and financial assets)	Asset performance Reliability Efficiency in pipeline operations Spread across remote locations Monitoring and management of scattered assets Workforce management Price analysis Gas trading Gas balancing

Source: IDC Energy Insights 2009

4 ICT impact on greenhouse gas emissions: an econometric analysis

4.1 Introduction to the econometric analysis

There are high expectations for the potential impact that ICT can have on reducing GHG emission levels. For instance, the Smart2020 report, which was conducted by McKinsey and Company and quantifies the potential of ICT to reduce greenhouse gas emissions, states that "*while the* [ICT] *sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.*" Areas where ICT is expected to have the biggest impact are transportation, logistics, buildings and energy supply and grids. The use of ICT in production processes in particular has been lauded as a promising solution to reduce emission levels through technological progress.[29]

Despite such high expectations, empirical evidence on the impact of ICT on GHG emissions is very scarce. The impact of ICT on energy efficiency – closely related since energy consumption is a major driver of GHG emissions – has been investigated by multiple studies, which find only modest evidence that ICT has so far enabled large energy savings. However, the results and conclusions of these studies suffer from significant data limitations and – in part – the lack of a well-defined theoretical background. Clearly, there is considerable need for a comprehensive empirical assessment of the past and present role of ICT in reducing GHG emissions. To our knowledge, there exists so far no comprehensive assessment on this topic, neither for the energy supply sector nor for European industry in general.

To identify and assess the relationship between the ICT capital intensity of production and GHG emissions per output in the European energy supply sector, we utilise econometric techniques applied to emissions and capital stock data from eleven EU member states over the period from 1995 to 2005. Overall, we find that greater ICT capital stock is significantly related to lower greenhouse gas emission intensity in the energy supply industry. When the analysis is restricted to old EU member states (due to substantial structural differences in new Eastern European members revealed by the data), we find that ICT capital has been associated with much greater emissions reductions in old EU 15 states. Furthermore, while the estimated cost in ICT investment per ton reduction in GHG emissions is higher than alternative abatement technologies, it is much lower for the energy supply sector than for other European energy-intensive sectors. This collection of insights suggests the particularly promising role of ICT in the energy sector to reduce GHG emissions through a general modernisation of existing capital stock, with emissions-reducing ICT innovations most strongly developed and implemented among older EU member states so far.

[29] Morgenstern (2005).

4.2 Empirical background

4.2.1 Data sources

In the analysis in this chapter we make use of the following data sources:

- EU KLEMS is an extensive database provided by the Groning Growth Development Centre (GGDC). 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 is the statistical office of the European Communities and collects data from national statistical institutes and other competent bodies to harmonise them according to a single methodology. Information is available on regional and country level for the enlarged Union, the Candidate Countries and the EFTA countries (EUROSTAT, 2008).
- The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED). The treaty was created with the aim of stabilising greenhouse gases that contribute to climate change. To supplement the treaty and further the work done by the convention, the UNFCCC secretariat compiles an international database of the GHG emissions for participating countries as well as releases numerous publications on the topic of climate change (UNFCCC, 2008).
- The OECD is an international organisation of 30 countries dedicated to the ideals of democracy and the market economy. A significant part of their focus is to provide a forum for policy comparisons as well as coordinating international and domestic policy. To supplement this goal and enable a meaningful comparison of different social and economic indicators, the OECD collects harmonised data from member countries in addition to select non-member countries on a variety of relevant topics (OECD, 2008).

Based on data from these sources, a panel data set is constructed. The data set includes all required information for all five sectors over a period from 1995 to 2005 for the following eleven EU member states: Czech Republic (CZE), Denmark (DNK), Germany (DEU), Italy (ITA), Netherlands (NDL), Austria (AUT), Portugal (PRT), Slovenia (SVN), Finland (FIN), Sweden (SWE) and the United Kingdom (GBR).

GHG Emissions Data

In this chapter, data on annual GHG emissions (GHG) and nominal producer energy prices (NRG_P) are primarily taken from EUROSTAT. Where necessary, data on emissions levels as provided by the UNFCCC is used to complement the available information. Altogether, data is available for the years 1990 to 2006 and 1991 to 2007 respectively, with respect to limited availability depending on industry level and country concerned.

Methodologically, the GHG emissions data as provided by EUROSTAT and the UNFCCC are compiled according to the standards defined by the IPCC (IPCC 2006). This GHG inventory methodology accounts for the amount of emissions emitted to or removed from the atmosphere. It also provides information on the activities that cause emissions and removals. These activities are divided into the following main groups: Energy consumption, Industrial processes and product use, Agriculture, Forestry and other land use, Waste and Other. The energy supply sector, as analysed in this chapter, is categorised as emitting emissions from Energy consumption.

Input and Output data

The EU KLEMS database uses a 63-industry breakdown based on the NACE classification revision 1.1 for the major of the EU-25 member states as well as for the U.S., Japan and Australia (EU KLEMS, 2008). The input-output data used in this study are comprised of annual gross output (GO), total fixed ICT capital stock (K_ICT), and total fixed non-ICT capital stock (K_NICT). Depending on the sectoral level and the country concerned, the length of the available time series varies.

Complementary Information

To ensure comparability of data reported in nominal terms, price and/or quantity indices are used to adjust nominal values. For example, the producer price index provided by OECD is used to convert nominal producer energy prices (NRG_P) provided by EUROSTAT into real values.

4.2.2 Data trends in the energy sector

At the heart of the parametric regression results lie the individual trends of greenhouse gas emissions and capital stock in the energy supply sector. Exhibit 4-1 contains an overview of changes in key variables related to capital stock, output, and emissions over the sample period. For the eleven European countries selected for analysis, emissions from the energy supply sector have been responsible for, on average, over a quarter of the annual GHG emissions in the aggregate economy from 1995 to 2005. This share has even slightly increased from 1995 to 2005, by about 2 percentage points. The energy sector also has particularly large energy expenditures, which have increased 14% from 1995 to 2005. This growth indicates a growth in energy consumption for production, which is a central driver of aggregate emissions growth. The aggregate energy sector's emissions intensity – emissions per output – has actually decreased by 17% over the same period, however. This can be explained by the change in gross output, which increased 18%.

ICT capital stock in the sector has more than doubled from 1995 to 2005, in conjunction with a 13% increase in non-ICT capital stock. The ratio of ICT capital to gross output (ICT capital intensity) has grown 62% for the aggregate sector over the period. These measures indicate an ICT capital growth rate that is greater than the growth rate of output, and that the energy sector has been developing its ICT more than non-ICT capital.

Exhibit 4-1: Overview on structural changes in the energy supply sector in the eleven sample countries

	1995	2005	Change
Gross output (mil. Euros, 1995 prices)	211,587	271,248	28%
Energy expenditure (mil. Euros, 1995 prices)	85,789	98,074	14.3%
GHG emissions			
- Aggregate (million tons CO2 equivalent)	776	825	6.3%
- Share in total economy emissions in the eleven countries	25.0%	27.5%	
- Per gross output (tons of CO2 equivalent per thousand Euro, 1995 prices)	3.7	3.0	-17%
Real fixed capital stock			
- ICT capital stock (mil. Euro, 1995 prices)	10,953	22,812	108%
- ICT capital intensity, defined as ICT capital stock per gross output (%)	5.2%	8.4%	62%
- Non- ICT capital (mil. Euro, 1995 prices)	581,590	655,673	13%

Source: EU KLEMS, EUROSTAT, DIW econ, 2009.

4.3 Approach and methodology

The goal of determining the impact of ICT capital on firms' emissions is a delicate one, especially in the context of economic analysis. Greenhouse gas (GHG) emissions can be thought of as a result of the normal production process or as a substance that is subject to a specific abatement process, and the form of the relationship between ICT and GHG has not been conclusively determined by previous empirical studies. Nevertheless, certain bodies of empirical literature provide both conceptual inspiration and technical guidance for the econometric methods utilised in this chapter to model and estimate the impact of ICT capital on GHG emissions.

Conceptual and technical foundations

The most substantial and relevant empirical studies used as sources for the economic analysis in this chapter come from the body of literature on economic activity and emissions that assesses the *environmental Kuznets curve* (EKC) hypothesis. The EKC 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. Graphically, this leads to an inverted parabolic or U-shaped relationship between the two variables.[30]

This relationship is postulated to derive from a variety of effects that occur as economic activity increases, as follows:[31]

- **Scale effect**: emissions increase with a larger scale of economic activity;

[30] Originally, the Kuznets curve describes the relationship between inequality and economic development of a country. It is based on the hypothesis that inequality initially increases with per-capita income but decreases after per-capita income has reached a certain threshold. The analogy to pollution has been established by Grossman and Krueger (1995) and Panayotou (1993).

[31] See Aslanidis (2009) and Stern (2004).

- **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 increase energy efficiency or allow for changes in production processes.

According to the EKC hypothesis, the scale effect tends to prevail in the initial stages of economic development, while the other effects prevail in later stages. The inverted U-shape is produced as the output, input, and technology effects overwhelm the scale effect. The hypothesis has also been expanded to analyse the relationship of other variables, offering guidance on how the relationship between GHG emissions and economic variables such as capital stock can be empirically analysed for different sectors and countries.[32] Furthermore, the discussion on technical issues in the estimation of panel data that accompanies the EKC literature is valuable for this study's econometric estimation process.

Despite the plethora of literature on the EKC hypothesis, there have been a variety of criticisms directed toward the conceptual assumptions and technical estimation procedures of the EKC hypothesis.[33] Considering these critiques, the econometric analysis implemented in this chapter utilises a parametric regression approach with flexible model specifications. These specifications, which allow the effect of ICT capital on GHG emissions to take different forms, are explained in the next section of this chapter.

As a final note, we compare this methodology with that developed by the authors in a parallel study for the Sectoral e-Business Watch (2009) with a focus on ICT capital and GHG emissions in energy-intensive industries. In the parallel study, the authors also utilise a semi-parametric efficiency analysis to estimate the effect of ICT on sector efficiency and sustainability. For the energy supply sector, however, the results of such an efficiency analysis would not be meaningful for interpretation. The European energy supply sector is notorious for its low level of competition, which distorts efficiency scores and obscures the relationship between ICT inputs and efficiency levels. The econometric approach employed in this chapter of the present study, therefore, is restricted to a meaningful set of parametric regressions.[34]

Parametric regression models

All in all, we design three plausible model specifications that isolate the effect of ICT capital on GHG emissions in the energy sector. Each model uses GHG emission

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32 For example, Judson et al. (1999) estimate an EKC curve between income and energy consumption for a variety of energy-intensive sectors. The authors find a U-shaped relationship in the industry and construction sectors for a large panel of data across countries and years. See for example Stern (2004) for reviews on this literature.

33 See Arrow et al. (1995) and Stern (2002).

34 For a further detailed explanation of the methodology utilised in this chapter of the present study, along with more information about other appropriate approaches for analysing the effect of ICT on GHG emissions in European energy-intensive industry, see e-Business W@tch (2009).

intensity[35] as the dependent variable and ICT capital intensity[36] as the central independent variable, treating the relationship between the two in slightly different ways:

- The **linear model** assumes a linear relationship between ICT capital intensity and emissions intensity and hence, a direct one-for-one effect of ICT capital on emissions.
- The **log-linear** model implies that the relation of capital and GHG emissions is based on a standard type of production function, which resembles the so-called *Cobb-Douglas technology*, which is commonly used in empirical analyses. It has the same form as the linear model, but with logged variable values.
- The **non-linear** model treats the relationship between ICT capital as quadratic, drawing on the EKC hypothesis that ICT capital and emissions follow a U-shaped curve as the energy sector develops.[37]

In all three models, non-ICT capital intensity[38] is also included as an explanatory variable, isolating the particular effect of the rest of the energy sector's capital stock on the sector's emission intensity. A variable representing energy prices, a time trend, and structural effects are further included in all models. These additions control for other possible contributing factors to GHG emission intensity levels in the energy sector and further isolate the true impact of ICT capital intensity on emission intensity. The models are estimated through two different procedures[39] in order to consider the possibility that structural differences in each country cause significantly different base levels of emissions per output in the sector.

Expected results

This analysis quantifies the contribution of changes in ICT capital intensity to changes in emissions intensity of production. The analysis will also provide insight into if and how this marginal effect has changed in magnitude over the sample period, concurrently predicting the potential for ICT to affect GHG emissions in the future. The most robust finding will be the direction of the marginal effect of a greater ratio of ICT capital stock to gross output (either emissions-increasing or emissions-reducing) on GHG emissions per output. With three different models, we expect to estimate the magnitude of this effect within a range. Additionally, the parametric regression estimation results will quantify the influence of non-ICT capital and energy prices on industry emissions per output. Lastly, we expect to discover the significance of structural differences among countries and time-induced sectoral changes on total emissions per output. All results will be specific for the energy supply sector in Europe.

35 Defined as million tonnes CO2 equivalent divided by gross output in million Euro.

36 Defined as ICT capital stock in million Euro divided by gross output in million Euro.

37 The underlying reasoning, which is based on the assumption of an "environmental Kuznets curve", is further explained in the parallel 2009 e-business watch study on the impact of ICT on GHG emissions in energy-intensive industries.

38 Defined as non-ICT capital stock in million Euro divided by gross output in million Euro.

39 The estimators used are the fixed-effects and random-effects estimators.

4.4 Empirical results

As discussed in the previous section of this chapter, we estimate three different parametric models in order to determine the direction, magnitude, and robustness of the effect of ICT capital intensity on emissions per output in the energy supply sector. Exhibit 4-2 shows the estimation results for the entire group of eleven sample EU member states.[40]

Exhibit 4-2 Results of the parametric analysis for the energy supply sector

	Linear Model	Log-Linear Model	Non-Linear Model
Dependent variable: GHG emissions per output			
Independent variables:			
- Energy prices	-0.01107	+0.0440	-0.00958
- ICT capital intensity	-0.00192	-0.0768**	-0.00880
- ICT capital intensity, squared			+0.00998
- Non-ICT capital intensity	+0.00068***	+ 0.4054***	+0.00071***
- Time	-0.00003	-0.0042	-4.13e-06
Model statistics:			
Significance of Whole Model	***	***	***
Hausman Test: Are there significant structural effects?	Yes *** (Random Effects)	Yes *** (Random Effects)	Yes *** (Random Effects)
R squared (within)	0.0881	0.2663	0.1287
Significance levels: * = 90%, ** = 95%, *** = 99%			

Glossary:

- A **dependent variable** is the one observed to change in response to the **independent variables**, which are deliberately manipulated to invoke a change in the dependent variables;
- The **coefficient** is a constant multiplicative factor that is estimated for each independent variable;
- **Significance levels** indicate the statistic probability with which the estimated coefficient describes the impact of an independent variable on the dependent one;
- The **Significance of Whole Model** indicates the probability that the model's variables explain the changes in the dependent variable better than a simple constant does, as computed by various statistical tests. A higher level of significance indicates a better model;
- The **Hausman Test** assesses how structural effects (differences) between countries should be considered, once these effects are determined to be significant: under *Fixed Effects*, the explanatory variables are correlated with structural effects, under *Random Effects* they are not;
- The **R squared** reports the proportion of variation in the dependent variable that can be explained by the specific model (if structural effects are significant, the R squared refers to the proportion of variation in the dependent variable within each country that is explained by the model).

Source: DIW econ, 2009.

The first estimation, the linear model (column 2 of Exhibit 4-2), produces a negative coefficient for ICT capital. This suggests that relative to overall output, a higher ICT capital stock is associated with lower emission levels. However, this result is statistically not significant. The log-linear model (column 3) improves this finding: the coefficient is

[40] Note that only the relevant effect estimations are shown here (e.g. using the random effects estimator). Both models were also estimated with the fixed effects estimator in order to compute the Hausman test. Reported significance levels of the coefficients were computed using cluster-robust standard errors, as is common with panel data.

significant and confirms the negative relationship between ICT capital and GHG emissions. In fact, the log-linear relationship implies that at given level of output, a 1% increase in ICT capital is linked with a reduction of emissions by almost 0.08%. The non-linear model adds no new information in this case, keeping the negative sign (emissions-reducing) of ICT but without statistical significance.

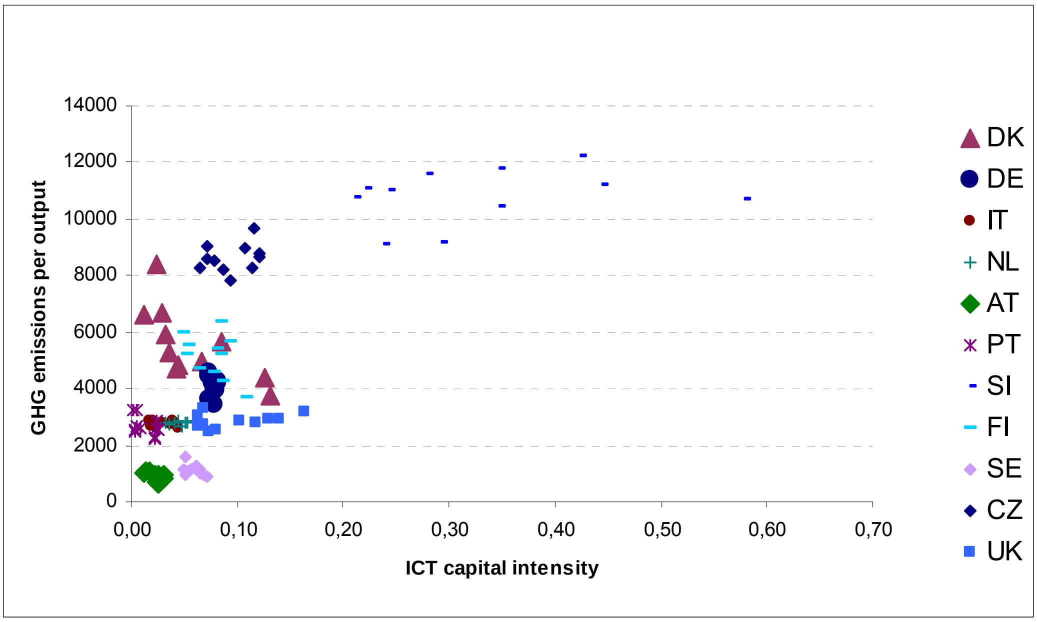
The effect of non-ICT capital intensity on emissions per output is also highly significant and positive in all models. The robustness of the effect across models suggests that greater non-ICT capital stock per output also increases emissions per output in the energy supply sector. In the case of the log-linear model, a 1% increase in non-ICT capital intensity is estimated to bring a 0.4% increase in emissions per output. This is a considerably greater change in emissions per output than the change effected by greater ICT capital, suggesting that the climate impact of non-ICT capital growth in the energy supply sector will overwhelm any benefits engendered by increased ICT capital. A possible explanation might be that investments in the past ten years have caused a larger increase in thermal electricity generation capacity relative to emission-neutral technologies such as nuclear or renewable energy.

For the eleven selected countries, the log-linear model is the most meaningful, and is highlighted in blue in Exhibit 4-2. It finds significant effects of ICT capital and non-ICT capital and has a good R-squared value of 0.27, which measures how well the model fits the data. We also find structural effects to be highly significant, confirming that the energy supply sector has different base levels of emissions per output in different countries. The effect of time on emissions per output is insignificant, suggesting that time-driven processes of firm learning and process changes do not reduce emission intensity in the energy sector to a notable extent when changes in investment are controlled for. The effect of energy price changes is also insignificant, reflecting the fact that energy prices both reduce energy use (reducing emission levels) and increase gross output (with emission levels increasing, ambiguously affecting emission intensity) in the energy sector.

With significant structural differences among countries, we also need to check whether the relationship between ICT capital and GHG emissions within countries is similar in order to ensure that the parametric regression results are meaningful. Exhibit 4-3 displays trends in GHG emissions per output and ICT capital intensity for the eleven selected countries. Each point represents the combination of GHG emissions intensity and ICT capital intensity of a country in a specific year.[41] The data from the new Eastern European member states included in the data set stand out for their levels and variance. Slovenia (SI) and the Czech Republic (CZ) are the two countries out of the eleven sample countries that have the highest levels of GHG emissions per output for all years, and Slovenia has the highest ICT capital intensity levels and the highest variance in levels across the sample period.

41 Hence, for each country there are 11 different points for 11 years from 1005 to 2005, which are all marked by the same symbol.

Exhibit 4-3 Trends in ICT capital intensity and GHG emissions per output in the energy supply sector[42]



Source: EUROSTAT and EU KLEMS.

It is not surprising that the apparent data outliers are the two new Eastern European member states in our sample, given the economic transition period undergone by these countries during the beginning of our sample period. In order to control for the suspicion that the particular structural changes undergone by these countries would produce a different relationship between ICT capital intensity and emissions per output in comparison to older EU member states, we estimate the three regression models again, with the Czech Republic and Slovenia excluded. The results of this second estimation are included in Exhibit 4-4.

In this reduced data set estimation, we discover a different relationship between ICT capital and emissions that is specific to just older EU member states. The main effect of increased ICT capital is still to reduce emissions per output, which confirms the robustness of the effect of ICT capital discovered in Exhibit 4-2. However, the quadratic term attached to ICT in the non-linear model is now significant, suggesting that increased ICT capital stock is emissions-reducing but with diminishing returns. Furthermore, the model suggests that after a certain turning point, greater ICT capital stock contributes to increased emissions per output. This turning point is estimated to be an ICT capital intensity level of 11.7%, which is near the high end of the range of the data as observed in Exhibit 4-3.

42 GHG emissions per output is reported in million tons CO2 equivalent per Euro, and ICT capital intensity as a ratio.

Exhibit 4-4: Results of the parametric analysis for the energy supply sector (excluding the Czech Republic and Slovenia)

	Linear Model	Log-Linear Model	Non-Linear Model
Dependent variable: GHG emissions per output			
Independent variables:			
- Energy prices	+0.00198	+0.1199	+0.00571
- ICT capital intensity	-0.00605	-0.0489	-0.03183***
- ICT capital intensity, squared			+0.13664**
- Non-ICT capital intensity	-0.00035	+0.2326	-0.00033
- Time	-0.00005**	-0.0110*	-0.00002
Model statistics:			
Significance of Whole Model	***	***	***
Hausman Test: Are there significant structural effects?	Yes *** (Random Effects)	Yes *** (Random Effects)	Yes *** (Random Effects)
R squared (within)	0.2419	0.2954	0.3092
Significance levels: * = 90%, ** = 95%, *** = 99%			

Source: DIW econ, 2009.

Notably, the R squared of the non-linear model improves considerably when analysis is reduced to older EU member states (from 0.13 to 0.31) suggesting that this model (the collection of variables and the particular non-linear form of ICT impact) explains the variations in emissions per output in the energy supply sector particularly well in older EU states. This model is highlighted in blue in Exhibit 4-4 as the most appropriate model for the relationship between ICT and emissions in older EU member states' energy supply sector.

In all models, the effect of non-ICT capital on emissions per output is no longer significant as it was when all eleven countries were analysed. This suggests that non-ICT capital in new Eastern European member states makes a particularly strong contribution to increased emissions in the energy supply sector, while older EU member states' emissions per output are not significantly tied to their level of non-ICT capital. In this second estimation, structural effects are still highly significant, and time and energy prices remain unimportant for an economic explanation of emissions per output in the energy supply sector.

Key findings

Greater ICT capital stock is found to significantly reduce GHG emissions in the energy sector, but we find significant differences in the magnitude and form of this impact depending on whether new EU member states are considered in the analysis. Exhibit 4-5 summarises the estimated effects of ICT from the two estimations – with and without new Eastern European member states, Slovenia (SI) and the Czech Republic (CZ) – and provides additional informative measures regarding absolute emissions impact.

Exhibit 4-5: Summary table of effects of ICT for the energy supply sector

Summary Table of Estimated Effects of ICT		
	Full data set	**SI and CZ excluded**
(a) % Change in emissions per output due to 1% increase in ICT capital intensity		
Log-linear model	-0.077%	
Non-linear model		-0.297%
(b) Equivalent absolute reduction in GHG emissions from (a)		
Log-linear model	72,700 tonnes	
Non-linear model		240,200 tonnes
(c) Cost in ICT fixed capital stock of a 1 tonne reduction in GHG emissions		
Log-linear model	€250	
Non-linear model		€58

Calculation details:

(a) For the log-linear model, this value is simple the marginal effect attached to ICT capital intensity in the model. For the non-linear model, this value is the percentage change off the mean emission intensity level that corresponds to a 1% increase off the mean ICT capital intensity. The mean emission intensity was calculated to be 4305.43 million tonnes CO2 equivalent per Euro (1995 prices) for the full data set and 3102 million tonnes CO2 equivalent per Euro (1995 prices) for the reduced data set.

(b) The absolute change was evaluated using the percentage change from (a) off the mean emission intensity, which was calculated as the mean value across all years and countries. The absolute change in emissions was evaluated assuming ceteris paribus, in which gross output was held at the mean of 21,975 million Euro (1995 prices) for the full data set and 26,085 million Euro (1995 prices) for the reduced data set.

(c) These measures were calculated as the absolute change in GHG emissions from (b) divided by the absolute change in ICT capital stock that corresponds to a 1% increase in ICT capital intensity off the mean ICT capital intensity level. The mean ICT capital intensity level was calculated to be 0.0824 million Euro ICT fixed capital stock (1995 prices) per million Euro gross output (1995 prices) for the full data set and 0.0535 million Euro ICT fixed capital stock (1995 prices) per million Euro gross output (1995 prices) for the reduced data set.

Source: DIW econ, 2009.

As Exhibit 4-5 demonstrates, greater ICT capital intensity is found to significantly decrease emissions per output in the energy supply sector *across all sample countries.* However, at average levels of gross output and ICT capital, the impact of a 1% increase in ICT capital is much greater when the analysis is restricted to older EU members, corresponding to a 0.3% reduction in emissions. When this reduction in emissions per output is translated into an absolute reduction in GHG emissions (based on average levels of GHG emissions and when gross output is assumed to remain constant), the relative impact of ICT in older EU member states is even more striking, with a 1% increase in ICT capital intensity corresponding to a decrease in GHG emissions by approximately 240,200 tonnes. These effects are some of the greatest in comparison to the other five energy-intensive sectors analysed in the parallel Sectoral e-Business Watch study[43], suggesting that there has been both a strong development of ICT innovations that are emissions-reducing and a sector-wide implementation of these innovations in the energy supply sector among older EU member states.

[43] These five sectors are the basic metal and fabricated metal sector; the chemicals, rubber, plastic and coke sector; the paper, pulp, printing, and paper products sector; the glass, cement, and ceramics sector; and the transport and storage services sector. For the equivalent analyses, elasticities range from a 0.12% to 0.52% decrease in emissions per output or a 26,400 to 74,000 tonne decrease in absolute GHG emissions with a 1% increase in ICT capital intensity.

The “cost” in ICT capital that corresponds to a one tonne decrease in GHG emissions is calculated to be 58 Euros, with the required value of ICT capital jumping to 250 Euros when new Eastern European member states are considered. This implies that the economic potential of ICT to reduce GHG emissions in the energy supply sector is far greater in the old EU member states than in the two new ones in Eastern Europe. For these countries, the strongly significant, positive impact for non-ICT capital intensity suggests that the biggest contributions to emissions abatement can be expected from a general modernisation of the existing capital stock.

The estimated costs per ton reduction in carbon emissions are also clearly higher than the current market price per tonne CO2 equivalent, and also high as compared to other possible abatement technologies. For example, McKinsey & Company (2007) estimates that between 2002 and 2030, GHG emissions in the amount of 9.6 gigatons of CO2-equivalent (which is more than global GHG emissions of the power sector in 2002 of 9.4 gigatons of CO2-e) can be abated at a cost of less than 40 Euros per ton by using established technologies such as demand reduction, carbon capture and storage, renewable energies, nuclear power, fuel shifts and improved plant efficiency. Hence, greater ICT investment is clearly not the most cost-efficient way of reducing GHG emissions. Nevertheless, the estimates in this chapter underscore the statistically-significant potential of ICT to reduce emissions in the energy supply sector and highlight the particularly strong and cost-efficient impact in older EU member states from 1995 to 2005. Moreover, the estimated costs per ton emission reduction are also below the levels that were estimated by the authors in the parallel Sectoral e-Business W@tch study on ICT capital and GHG emissions in European energy-intensive industries (covering the metal, paper, chemical, glass and transport industries), where costs varied from 170 Euro in the metal industry to up to 1,350 Euro in the chemical sector. This comparison illustrates the particularly promising potential of ICT in the energy supply sector to reduce GHG emissions from European industry overall.

Summary of ICT impact on greenhouse gas emissions in the ESI

Econometric methods were used to gain better evidence on the impact of ICT in reducing greenhouse gas emissions. The analysis presented in Chapter 4 focuses on links between ICT capital and GHG emissions. It is a macro-data analysis using the EU-KLEMS Growth and Productivity Accounts as well as Eurostat data. The analysis starts from the consideration that there are high expectations for the potential impact that ICT can have on reducing GHG emission levels. There is also considerable need for a comprehensive empirical assessment of the past and present role of ICT in reducing GHG emissions.

Key findings form the analysis are that greater use of ICT capital is found to significantly decrease emissions per output in the energy supply sector, with significant differences in the magnitude and form of this impact depending on whether new EU member states are included in the analysis or not. This relationship is clearly more pronounced when only old EU member states are considered. This suggests that in these countries there has been both a strong development of ICT innovations that are emissions-reducing and a sector-wide implementation of these innovations in the energy supply sector. On the contrary, for new member states, the analysis finds that the use of non-ICT capital has a clearly stronger impact on GHG emission reductions. Hence, for these countries the biggest contributions to emissions abatement can be expected from a general modernisation of the existing capital stock[44].

This comparison illustrates the **particularly promising potential of ICT in the energy supply** sector to reduce GHG emissions from European industry. Although the quantitative results are more of indicative character and in particular the estimated abatement costs should not be over-interpretated,[45] a comparison with the results from the same analysis for different energy-intensive sectors clearly reveals the particular role that ICT plays for reducing GHG emissions in the ESI.

[44] The evolution of generation asset portfolio towards lower carbon technologies has a fundamental role in the ESI industry.

[45] See the discussion on the methodology utilised in this chapter in e-Business W@tch (2009).

5 Case studies

5.1 Selection criteria and methods

The case studies for this report were selected according to the following criteria, meeting requirements from the European Commission:

- **Largest EU countries**: Most case studies were meant to be from the largest European countries in order to complement the data gathered in the SeBW Energy Supply Survey 2009, which included the UK, Germany, France, Spain, Italy and Poland. One case study is not from these countries (Denmark) because of its distinctive characteristics. One case study is from the US, to evaluate similarity of challenges and approaches with the European scenario.
- **Large companies**: The case studies collect information mainly about large companies, while the impact on and relationships to SMEs are also considered.
- **Innovative approach**: The case studies are supposed to represent innovative practice and to reveal some insight about future developments in the sector.
- **Typical example**: Some case studies represent a typical example of state-of-the-art e-business activity in the ITS industry.
- **Good e-business practice** has been another criterion for selecting case studies. The assessment whether a case represents good practice was based on the citation of the case in media, on the expertise of the correspondents and on actually measured results.
- **Lessons learned**: The activities described are meant to offer valuable insights about lessons learned, to the extent possible measurable and tangible but also intangible. If a company or project is in an early phase, such as EDISON, the case study describes expected results and outcomes.

The case studies are mainly based on original primary research, i.e. interviews, complemented by secondary data. An interview with at least one representative from the respective company or project was carried out. Interviews were normally conducted one-on-one via telephone with more than one call organised if necessary. Secondary data sources such as company presentations, brochures, annual reports, and information on company websites, were used when available. Case studies examined in this report are listed in the following table (Exhibit 5-1).

Exhibit 5-1: Case studies presented in this report

Company / organisation	Country	Study Focus	Reference
RWE	Germany	Virtual power plant management	Chapter 5.2
Edison Consortium	Denmark	Infrastructure for electric vehicle charging, metering and billing	Chapter 5.3
Enel	Italy	Mobile Work Force Management	Chapter 5.4
Austin Energy (Texas)	USA	Smart grid	Chapter 5.5
Gas Natural	Spain	Automatic meter reading (gas)	Chapter 5.6

5.2 Virtual Power Plant at RWE, Germany

Abstract

RWE is collaborating with Siemens for its first Virtual Power Plant implementation. The project was started in 2007 and seeks 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 gather is sold on the EEX Power exchange as well as reserve capacity through internet auctions. The current success of the project has given the partners the possibility to continue it by expanding its capacity from currently 10 MW to 30-40 MW over the next two years.

Case study fact sheet

• *Full name of the company:*	*RWE*
• *Location (HQ / main branches):*	*Germany (HQ), UK, Central and Eastern Europe*
• *Main business activity:*	*Electricity, gas, water and upstream oil&gas*
• *Year of foundation:*	*1898*
• *Number of employees:*	*66,000*
• *Turnover in last financial year:*	*€49 billion (2008)*
• *Primary customers:*	*Residential households, commercial operations, business and industrial customers, municipal and regional utilities*
• *Most significant geographic market:*	*Germany, UK, Central and Eastern Europe*
• *Main e-business applications studied:*	*Virtual Power Plant*
• *Case contact person:*	*Michael Laskowski* *RWE Energy AG*

5.2.1 Background and objectives

RWE is among Europe's five largest utilities. The company is active in generation, trading, transmission and supply of electricity and gas. It is also active in the water business in Continental Europe. RWE is the biggest power producer in Germany, the third largest in the UK. It is present in Hungary, Poland, Slovakia, Czech Republic, Belgium and the Netherlands. Through its affiliate RWE Dea, it operates in the exploration and production of natural gas and crude oil. RWE's other subsidiaries include: RWE Power, RWE Innogy, RWE Supply & Trading, RWE Energy, RWE npower, and RWE IT.

With a total of 66,000 employees, overall RWE supplies over 14 million customers with electricity and 6 million customers with gas. In fiscal year 2008, the company recorded €49 billion in revenue.

In 2007, RWE (more precisely RWE Energy) teamed up with Siemens Power Transmission and Distribution to develop and pilot business models and technical concepts for the creation of a virtual power plants (VPP). Siemens was involved as technology supplier but also to centrally manage the IT system to be implemented during the pilot.

A virtual power plant is a link-up of small, distributed power stations, like CHP (Combined Heat and Power) units, photovoltaic systems, wind farms, small hydropower plants and biogas units, but also of loads that can be switched off, in order to form an integrated network. The plants are controlled from one central energy management system.

Even if centralised power generation goes on being the most important pillar in energy supply, distributed power generation will continue gaining importance in the coming years. These types of plants, typically belonging to final consumers (industrial, commercial and residential) are usually not integrated in the national power supply network. Regardless, their increasing deployment must be coordinated more effectively if such plants are to be economically and environmentally viable and are to play a greater role in providing a reliable power supply.

In a VPP, the operation of distributed installations is scheduled and optimised by an "aggregator", either for the purpose of energy trading in the wholesale market or to provide ancillary services to the grid operator, as well as to the individual distributed units.

The VPP concept is not itself a new technology but a scheme to combine decentralised generation and storage, which exploits the technical and economic synergies between system's components. This aggregation is not pursued by physically connecting the plants but by interlinking them via ICT.

The RWE VPP project sought 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. For the project, RWE Energy's trading department plays the role of the aggregator, while Siemens centrally manages the IT system.

On October 31, 2008, RWE's first virtual power came on line. In a first phase nine hydroelectric facilities operated by Lister- und Lennekraftwerke in Sauerland, North Rhine-Westphalia, were integrated in the plant linkup. The capacity of these distributed generating facilities ranges from 150 kW to 1100 kW. The total capacity of all the plants amounted at that date to approximately 8.6 MW.

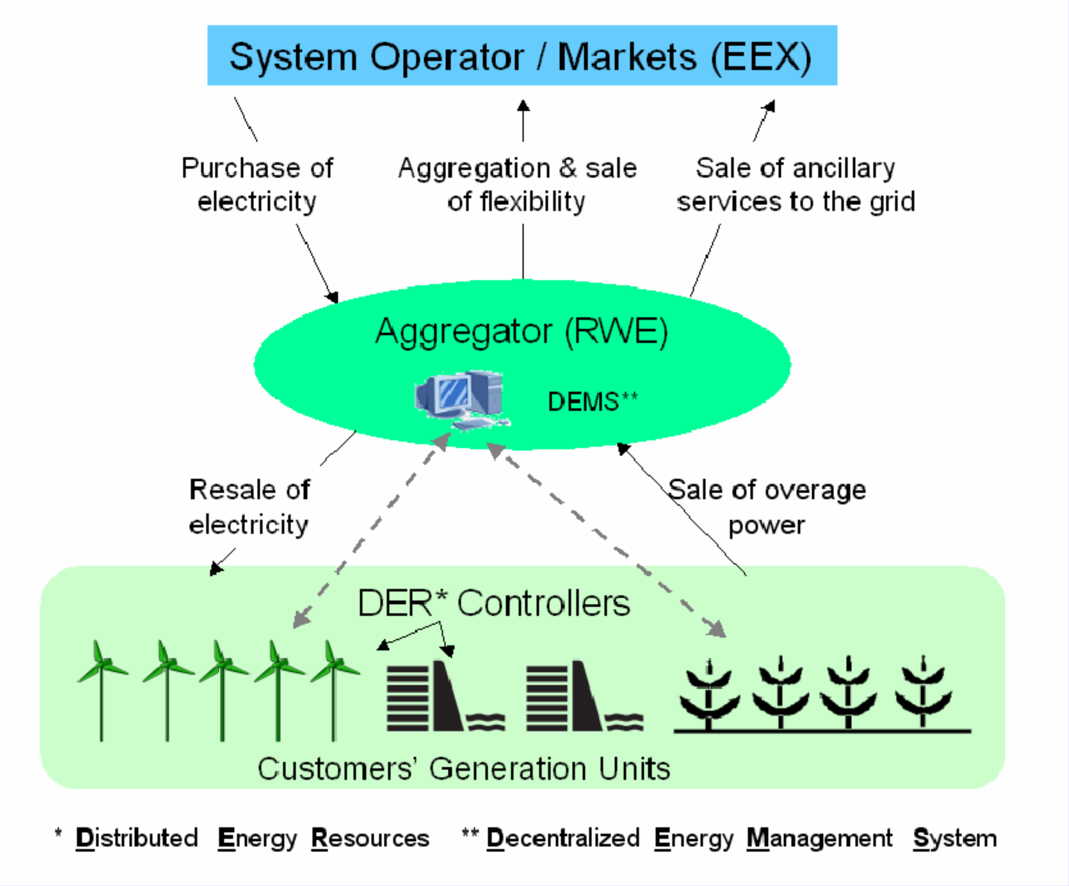
5.2.2 e-Business activities

Siemens' Distributed Energy Management System (DEMS) is the central feature of the virtual power plant, 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 all relevant information, such as the latest electricity prices and the energy requirements of customers. On the basis of this data, the software calculates a scheduling plan for the upcoming day and, thus, determines which plants are to be dispatched.

The other component is the DER Controller, locally installed at the generation unit site, which allows bidirectional communication with DEMS. Its main functionality 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 between themselves, each unit is tracked with GPRS. The GPRS signals feed relevant information into the DEMS. The aggregation and control architecture is depicted in Exhibit 5-2.

Exhibit 5-2: Aggregation and control architecture



Source: IDC Energy Insights, RWE and Siemens

RWE Energy sells the electricity generated by the distributed units using their existing trading IT systems, in two ways: as electricity on the EEX (European Energy Exchange) power exchange, as reserve capacity through Internet auctions. The two markets have different requirements:

- The EEX power exchange obliges suppliers to provide their electricity within a 15-minute period. If the deadline is not respected then the supplier is subjected to penalties or fines. Using DEMS, individual boilers (or whatever DER) can be powered up precisely, thereby reducing standby costs to a minimum. Without DEMS or similar energy management tools, suppliers are only able to predict average values for energy availability and demand, forcing them to calculate safety margins into their figures to avoid facing penalties for incorrect forecasts.
- In order for a supplier to sell its reserve capacity to the German Transmission System Operator (TSO) it needs to have an initial offering of 15 MW. The VPP plays a fundamental role aggregating single unit capacity to fulfil minimum power limit.

5.2.3 Impacts

The VPP aggregation conceptual model started to be developed in order to enhance economics for distributed energy resources integration[46]. DER integration translates into an optimised use of this kind of power facility but also brings value as a “network replacement” and may deliver services to the distribution system (balancing services).

With this pilot RWE Energy is demonstrating the technical and economic viability of the VPP concept and the key enabling role of ICT in innovating the ESI business.

Initial findings showed that it is economical to integrate generation units with a capacity of a minimum of 500 kW. Below this threshold communications cost related to the hardware equipments to be installed (i.e. modem) and operational communication costs (to transmit data) are too high to generate a positive margin when compared to the revenue coming from the limited quantity of energy that can be sold on the market (distributed generation unit first goal is to provide energy to their owner self consumptions).

The VPP impacts of the ESI value chain. RWE (in particular its trading company) proposes itself to the customers as an “aggregator" allowing them to take advantage of portfolio effects, and to reach a size that is sufficient to be able to enter energy power markets or to obtain better selling condition, and eventually provide services to network operators.

VPP enables also a change in the relationships between the customer and the energy supplier, with the first becoming a "supplier of the supplier"[47].

Overall, RWE and Siemens partnership is accumulating results and experience for further project extensions. RWE Energy currently has about 10 MW integrated into its first VPP. The current success of the pilot project has convinced the two partners to continue their research and extend the number of generation units involved. The project is now looking to add additional capacity 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 about what contribution VPP can make to reducing CO_2 and to improving energy efficiency. Results can be expected in one-year time.

5.2.4 Lessons Learned

From a technical perspective, the most important lesson learned from this case is the importance of having a reliable communication system in place. As explained in Section 5.2.3, the availability of 15-minute period data is a pre-requisite to trade on the power exchange (EEX). If information on tradable capacity is not available the VPP cannot operate.

As mentioned above, communication costs (equipment investment and operating cost) are still the most relevant economical barrier to overcome to create condition to include in

[46] 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 DG, this is not possible when DER scale up to thousands of units.

[47] Commonly referred as prosumers.

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 in the future facilitate interoperability and foster DER integration at a lower cost.

From an application perspective the pilot allowed to test on the field Siemens DEMS software, which proved to be a robust application allowing effective energy management of the distributed generation units.

Customers' knowledge, acceptance and participation are critical aspects for the running a VPP. The RWE pilot experienced a very positive customers willingness to join the initiative with their generation units. The key to success was a clear communication and understanding of expectations and the creation of a transparent partnership.

5.2.5 References

Research for this case study was conducted by Roberta Bigliani and Gaia Gallotti (IDC Energy Insights), on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interview with:
  - Prof. Dr. Michael Laskowski, RWE Energy AG, Netzservice
- Websites:
  - www.rwe.com
  - EU-DEEP (http://www.eu-deep.org/)
  - FENIX, Flexible Electricity Network to Integrate the eXpected energy evolution (http://www.fenix-project.org/)
- Other material:
  - RWE company presentation (spring 2009)
  - Siemens and RWE Press releases " First virtual power plant operated by Siemens and RWE Energy on line" (31 October 2008)

5.3 Electric vehicles using sustainable energy and open networks: the EDISON project, Denmark

Abstract

In February 2009, a consortium of energy companies, research institutes and private technology providers launched the project "Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks" (EDISON). EDISON aims to design a full-scale system for implementation of electric vehicles in Denmark. The technology will be tested in a real-life testbed on the Danish Island of Bornholm. The long-term objective of the project is to support over 200,000 vehicles on the road or over 10% of the total number of vehicles in Denmark. The project seeks to increase the share of renewable energy and increase energy efficiency (the EU's "20-20-20" target) and is partly publicly financed. The research consortium is made up of several key actors such as energy companies, research institutes and private technology providers. It will therefore be able to give a complete view of the feasibility of full-scale electric vehicle adoption from the perspective of the electric infrastructure.

Case study fact sheet

• *Full name of the company:*	*Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks (EDISON).* *Consortium partners are Danish Energy Association, IBM, DONG Energy, Siemens, Technical University of Denmark (DTU), Eurisco and Østkraft*
• *Location (HQ / main branches):*	*Denmark*
• *Main business activity:*	*Design a full-scale system for implementation of electric vehicles in Denmark.*
• *Year of foundation:*	*2009, duration of 3 years*
• *Number of employees:*	*Not applicable*
• *Turnover in last financial year:*	*Not applicable*
• *Primary customers:*	*Not applicable*
• *Most significant geographic market:*	*Island of Bornholm, Denmark*
• *Main e-business applications studied:*	*Smart Grids*
• *Case contact person(s):*	*Tim Mondorf (Nordic Business Development Executive, Energy&Environment, IBM Denmark)* *Jørgen Christensen (Danish Energy Association, Leader of the consortium)*

5.3.1 Background and objectives

In February 2009, a consortium of energy companies, research institutes and private technology providers launched the project "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 in Denmark. The main objective is to prepare the electricity distribution network in order to allow 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 along with a marketplace for the energy.

Electric Vehicles have a battery that can be recharged by simply plug-in them, like any other electrical appliance. This is an attractive source of revenue for Danish utilities, particularly if the batteries are recharged during off-peak periods (for example during night time) and using wind energy that would be otherwise wasted. This would shift consumption from fossil fuel to renewable energy sources even for transportation purposes with positive impact to CO_2 emissions. Widespread adoption of electric vehicles is crucial for Denmark's energy goal to have 50% wind power penetration in the electric power system.

The interesting feature of EVs is that, thanks to that onboard battery capacity, EVs 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) [48].

Denmark, with its high penetration of renewable and distributed energy, is a perfect environment to test and deploy EVs fuelled by renewable energy, and namely wind. In fact another project (Better Place) is also targeting this country. Furthermore, Danish companies and research institutions have a very strong knowledge and competence regarding design, development, and operation of power systems with high penetration of distributed generation. Danish industry is involved in technologies,which are critical to a widespread use of EVs such as strategy for optimised battery charging and discharging, as well as power electronics related to battery charging and discharging.

EDISON consortium partners include:

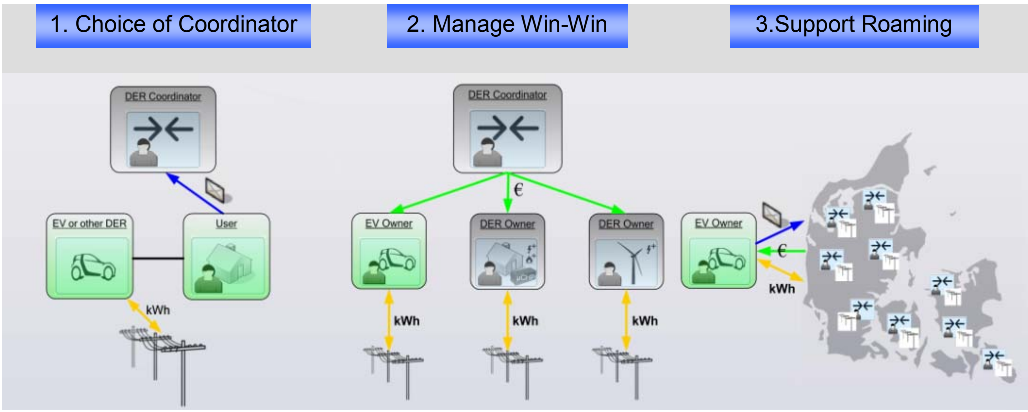
- Danish Energy Association: Danish Energy Association is an industry association and umbrella organisation for associations and groups of energy companies in Denmark. The Association's membership is predominantly made up of Denmark's energy companies.
- DONG Energy: Denmark's leading energy company. The majority (73%) of DONG Energy is owned by the Danish Government. The rest of the shares are owned by former Elsam (16%) and Energi E2 (11%) shareholders.
- Østkraft: Power generation and distribution company for Island of Bornholm.
- IBM (particularly IBM Denmark and IBM's Zurich Research Laboratory).
- Siemens: Siemens Energy will provide key metering and power and control electronics technologies. For example, control systems for optimum utilisation of battery capacities.

[48] For more details see Chapter 3.

- Technical University of Denmark, with its Departments of Electrical Engineering and the Department of Informatics and Mathematical Modelling
- Eurisco: An independent Danish research and development company, belonging to Eurisco Holding.

The EDISON project has a three-year horizon culminating in the prototyping of the solution on the Island of Bornholm. The Danish island of Bornholm in the Baltic Sea has a population of 40,000 and a large proportion of wind energy in the total energy mix. The overall budget of the project is 7 million euro, of which 4.5 million euro are provided by the Danish government through the state-owned, electricity and natural gas transmission system operator, Energinet.dk.

Exhibit 5-3: Initial scenarios of the EDISON project



Source: Energy Insights redrawing of IBM and Technical University of Denmark

The project initial scenario comprises of three parts as shown in Exhibit 5-3:

1. **Choice of coordinator**: When an electric vehicle is connected to the powergrid, related user information is sent to a Distributed Energy Resources (DER) Coordinator which uses the developed IT solution that supports a broad range of different electric vehicles and eventually other source of distributed generation (under the logic of Virtual Power Plant).
2. **Manage win-win** (both for electric grid operator and vehicle owner): The DER Coordinator broadcasts price information to influence the electric vehicles' behaviour. By doing so DER Coordinator can smooth peak demand. The electric vehicles can be given a price to contribute with short voltage bursts to balance the grid or to be kept informed of the real-time prices for charging the battery.
3. **Support roaming**: This system will allow an electric vehicle to connect to the grid at any location on a national level (home, offices, parking, service stations…) and under different DER Coordinators. This active integration benefits the user and reinforces the portion of grid to which the connection is made.

5.3.2 e-Business activities

ICT will be key for the realisation of the vision of EDISON, and particular emphasis will be given to collection, communication and management of data about energy demand and supply.

The main ICT enabler for the EDISON project will be the IBM company. IBM will develop a smart charging system that will collect data from the vehicles, and from the supply side of the energy system. The system will process these data, will balance them and optimise the charging of the vehicles – for instance charge 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. A metering and billing solutions as well a system to provide real time pricing to users will be also part of the smart charging systems. IBM has also provided the servers hosting applications.

The Edison project involves three steps for developing the IT solution: designing the IT solution, test lab validation and island demonstration.

- **Designing the IT solution**: The first task is to analyse and evaluate different software designs and technologies that can be used in the prototype solution. The prototype will be based on well-documented standards and offer a high degree of interoperability.
- **Test lab validation**: The next task will be to implement the software solution on a server. The server will be connected to a number of clients that represents the participants in a distributed scheme.
- **Island demonstration**: The solution will be implemented for a large-scale demonstration on the Island of Bornholm, Denmark. This island is well suited as a test-site for actively integrating electric vehicles into the powergrid because it provides a clearly defined and isolated area. Demonstration will start on 2011.

The target of the EDISON project is full-scale implementation of electric vehicles in the energy system of an entire country, and it is therefore an improvement upon previous and more partial electric vehicles 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, electric vehicles service companies and the transmission system operator.

As concern cars, no single car manufacturer is part of the consortium. Since the project scope is to define open standard any type of cars adopting the standard could plug-in

The EDISON project concept provides that consumers will probably still own their vehicle, but the EVs' use may come closer to a service business model. Independent electric vehicle services companies are planned to sell mileage to car users and be responsible for the charging of the cars. Charging may take place either through decentralised charging points or through battery swapping stations.

5.3.3 Prospective impacts

The main impact of the EDISON consortium is supposed to be proof of concept: EDISON is to demonstrate that Electric Vehicles can actually 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 relate to the national level, grid level and user level:

- National Level: Support an environment-friendly development; optimise power production and consumption; enable energy independence.
- Grid Level: Maintain security of supply; actively integrate distributed energy resources.
- User Level: Realise an economic incentive to contribute to CO_2 reduction.

The adoption of EVs on a broad basis will facilitate the achievement of EU's 20-20-20 target, i.e. 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 CO_2 emissions are targeted.

The EDISON project is also meant to crate a Denmark-based, global research environment to address future energy challenges.

5.3.4 Lessons to be learned

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

- Understanding all the ICT functional requirements needed to support EVs full-scale rollout. For instance as concern applications like meter data management, billing, but also IT architecture to be designed.
- Testing the smart charging system in a real environment.
- Creating a standardisation of communication protocols, and electrical interfaces such as voltage and current ratings.
- Evaluate the business case results.

Additionally the EDISON project will provide the infrastructural framework to test and evaluate the feasibility of alternative business models. As previously mentioned, the EDISON project concept provides that consumers still own their vehicle, but the EVs' use may come closer to a service business model. Independent electric vehicle services companies are planned to sell mileage to car users and be responsible for the charging of the cars. Charging may take place either through decentralised charging points or through battery swapping stations. One service company has already announced its investment plans for the Danish market (Project Better Place). They will depend on IT solutions for instance for billing purposes.

5.3.5 References

Research for this case study was conducted by Roberta Bigliani and Gaia Gallotti IDC Energy Insights, on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interviews with:
  - Tim Mondorf, Nordic Business Development Executive, Energy&Environment, IBM, tmn@dk.ibm.com
- Website:
  - http://www.edison-net.dk/
- Other useful links:
  - Description "The EDISON project" by Dansenergi (http://www.danskenergi.dk/~/media/EDISON/EDISON_hand_out%20pdf.ash)
  - Power Group Online Article by Power Engineering / PennWell: "Siemens to explore connection of electric vehicles to power grids", 26 February 2009. (http://pepei.pennnet.com/display_article/354546/6/ARTCL/none/INDUS/1/Siemens-to-explore-connection-of-electric-vehicles-to-power-grids/?pc=ENL)
  - Press release "IBM Joins EDISON Project to Build Smart Grid for Electric Cars", 25 February 2009, (http://www-03.ibm.com/press/us/en/pressrelease/26783.wss).
  - www.dtu.dk/centre/cet
  - http://www.energymap.dk

5.4 Enel's Work Force Management System, Italy

Abstract

In order to enhance field force operations, Enel, Italy's largest utility, implemented a new Work Force Management system. The project, completed in 2008, aimed at redesigning 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. The project was structured into three phases: two pilots were conducted to define, refine and test the vehicle equipment and to conduct an internal "benchmarking" of the various "rugged notebooks" available in the market. In the second phase a new pilot was set up, with more vehicles equipped with the final configuration. During the third phase the final version of the vehicles with all the required applications were fully deployed over a two-year period (2007-2008). Overall results of the project were very positive and contributed significantly in the Enel's overall reduction of operating costs

Case study fact sheet

• *Full name of the company:*	*Enel S.p.A.*
• *Location (HQ / main branches):*	*Italy (HQ) and 22 countries across the world*
• *Main business activity:*	*Integrated utility producing, distributing and selling electricity and gas.*
• *Year of foundation:*	*1962*
• *Number of employees:*	*83,700*
• *Turnover in last financial year:*	*€61.18 billion (2008)*
• *Primary customers:*	*Industrial, commercial and residential customers*
• *Most significant geographic market:*	*Italy, Spain, North and Latin America, France, Slovakia, Romania, Russia*
• *Main e-business applications studied:*	*Work Force Management*
• *Case contact persons:*	*Paola Petroni, Enel Distribuzione S.p.A.* *Massimo Maffeis, Enel Distribuzione S.p.A.*

5.4.1 Background and objectives

Enel is Italy's largest power company, and Europe's second listed utility by installed capacity. It is an integrated player, which produces, distributes and sells electricity and gas. Enel is present in 23 countries going from Europe, Russia, North and Latin America. Enel's acquisition of Spanish utility Endesa, started in in 2007, not only strengthened its presence in Spain, but also enhanced its presence in Argentina, Colombia, Morocco, Peru and Portugal. Enel has approximately 95,000 MW of electricity generation capacity and the company serves over 61 million of customers, including the 2.7 million gas clients the company has in Italy.

The company has some 83,700 employees and posted revenues of 61.2 billion euros (an increase of 40% compared with 2007).

Enel was the first utility in the world to replace the totality of its Italian customers' traditional electromechanical meters with smart meters.

As concern electricity distribution, Enel is overall responsible for more than 330,000 km of medium voltage (MV) lines, and 750,000 km of low voltage (LV) lines. More than 8,000 technical “field” engineers, working in about 6,200 teams, are employed daily across the entire Italian territory to provide services to Enel’s customer base and to maintain the MV and the LV network. These field engineers undertake a variety of tasks, ranging from inspections and repairs to construction works. This skilled workforce is also bestowed with the task of prioritising and responding to customer emergencies.

In 2008, Enel undertook to completely redesign its Work Force Management (WFM) process. Enel's project was launched in 2005 with pilots running over 2006 and full deployment taking place over 2007 and 2008. The project was aimed at delivering improvements to three main areas:

- Defining and providing adequate crew vehicle equipment;
- developing a range of “mobile applications” to support the daily work of field engineers;
- designing a centralised “field force solution”, fully integrated with Enel’s IT systems.

The goals identified by Enel to be accomplished included:

- Providing logistic support to Enel's crew;
- providing Enel cartographic information to Enel's crew;
- supporting all processes through mobile applications;
- connecting the Field, to the Centre, to all of Enel's crew.

5.4.2 e-Business activities

Overview of components

The key components of Enel's WFM project are:

- rugged notebooks[49];
- equipment installed on the vehicles (in-dash monitor, mobile communication facilities, docking station and hardware cabling);
- mobile ICT applications developed to support field engineers' activity;
- field force management solution.

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

[49] A rugged (or ruggedized, but also ruggedised) computer is a computer specifically designed to reliably operate in harsh usage environments and conditions, such as strong vibrations, extreme temperatures and wet or dusty conditions.

Rugged notebooks

Enel decided that the most suitable mobile devices to adopt for its field force were rugged notebooks. 5,300 rugged notebooks[50] were deployed over 2007 and 2008. Enel had a previous large-scale experience in the use of palmtops, as their field engineers have been using them since 2001. Over a five-year period, Enel tested more than 5,000 palmtops of different brands and specifications for the replacement of over 30 million meters. However, for the new Work Force Management project, Enel decided to move to a different solution, "rugged" notebooks. The choice was driven by:

- the need to store large amount of data (maps, various technical documentations needed for different types of activity, databases and software applications);
- the rich range of applications available in a “standard” Windows environment, and the potential for an easy development of new applications in this standard environment;
- the availability of a larger screen to facilitate use for technicians.

Vehicles equipments

The main objective of the project was to transform the vehicle in "mobile offices" in order to significantly ease the day-by-day work to the field engineers (see the standard activities daily performed by field engineers with the new solution depicted in Exhibit 5-4), as well as deliver efficiencies by shortening the time of intervention and speeding-up operations. In total, between 2007 and 2008, 5,300 vehicles were suited up.

All vehicles used by field engineers are equipped with a satellite navigator, integrating both commercially available navigation tools and maps and Enel's proprietary technical GIS information. Enel's technical cartography provides a detailed mapping of the whole MV and LV electrical networks, encompassing 30 million customer supply points (meters). The availability of this technical navigation information helps field engineers to easily localise the installation they have to act on - which is not always referred to a specific address, or easy to be seen, especially in case of bad weather conditions.

Each vehicle is equipped with a rugged notebook. The notebook is installed in a docking station placed in the rear of the car, with the display of the notebook then “replicated” in an “in-dash” monitor in the front of the car. For security reasons field engineers are not allowed to directly use the notebook while driving. The navigation tools and all the maps (both commercial and proprietary) are installed in the notebook.

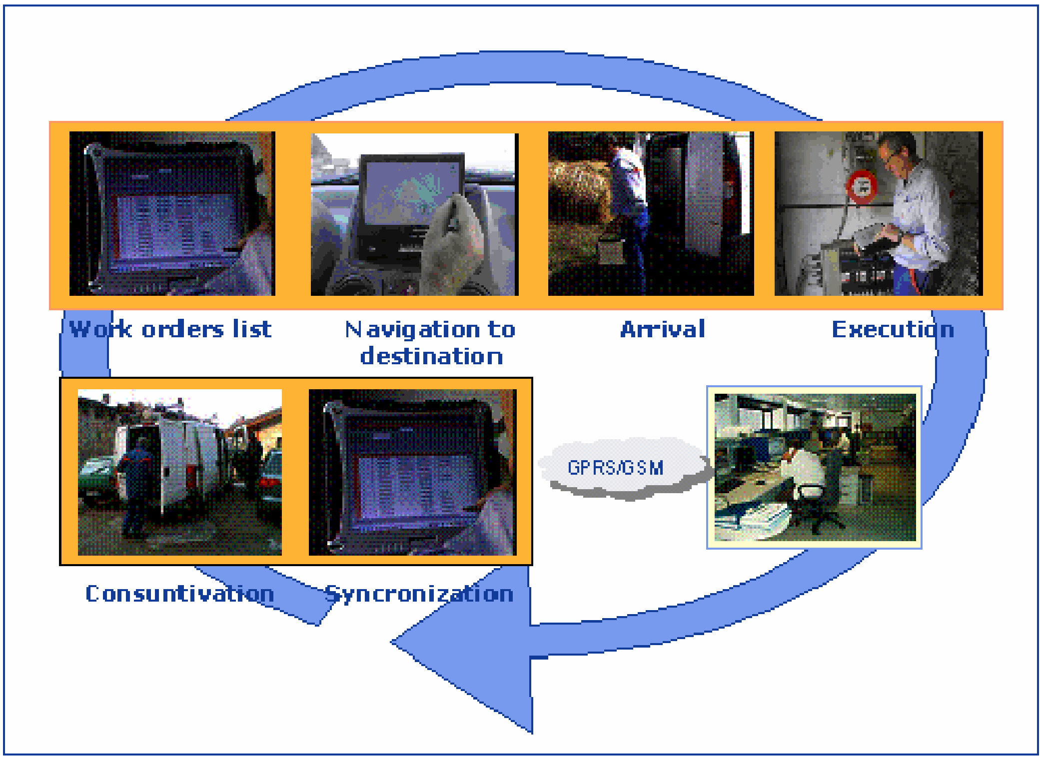
A key element of the project is the set up of an effective communication system between the vehicle and Enel’s Operational Centre. This is achieved by introducing the use of “mobile communication units” that include a GPS box and a GPRS modem. This system allows the Central Operational Centre to localise the vehicles and crews quickly to provide the field engineers with a valued “always on” connection with the Enel Central Systems.

[50] Enel selected rugged notebooks with these specific characteristics: Touch-screen display (the notebook can be used as a Tablet PC or with the keyboard), Windows XP operative system, 1 Gigabyte RAM, 80 Gigabyte Hard Disk. They proved adequate for the environmental requirements, which necessitated machines to ensure a higher degree of survivability. Specifically, rugged notebooks have superior shock and vibration specifications, ideal for moving vehicles.

The GPS/GPRS communication system data was also be visualised on the "in-dash" monitor in each vehicle. The vehicle's position is simultaneously transmitted to the Central System through geo-referenced coordinates. All other applications available in the notebooks are continuously synchronised with Enel's IT systems to guarantee the quality and the consistency of the data.

Vehicles' set up scheme is depicted in Exhibit 5-5.

Exhibit 5-4: The standard daily work of field engineers



Source: Enel

Mobile applications

Mobile applications were developed and installed on the notebooks. Crew members have a single mobile interface for all business processes (called EnelMobile), which is fully integrated with central enterprise applications, and namely: Customer Information System, the ERP System, the Outage Management System, the Network Maintenance System, the Remote Control System, the Automatic Meter Reading and Management System. In this manner data consistency is granted across the organisation from the field to the office.

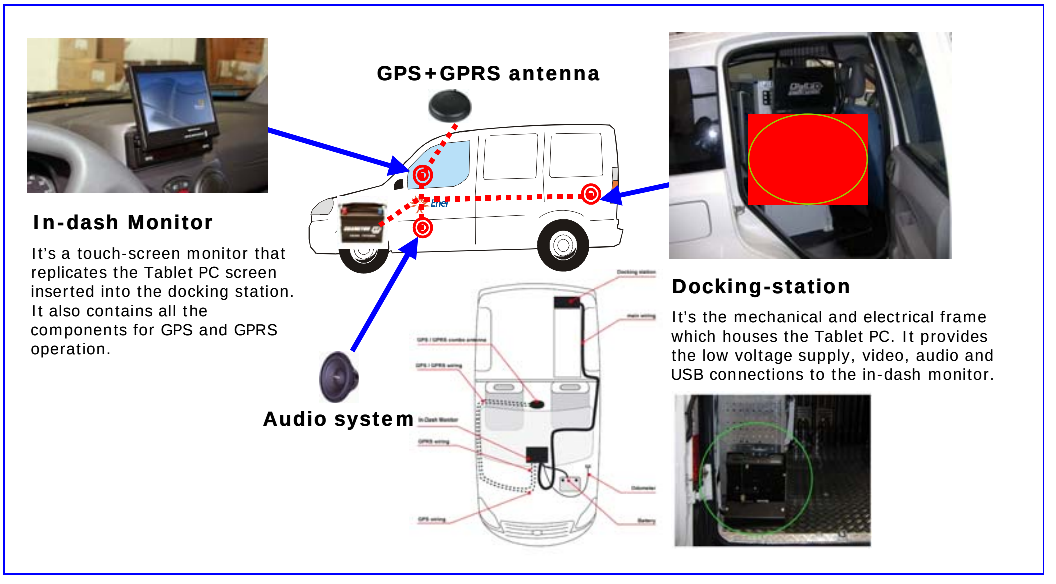
Field force management solution

The project brought on the development of additional applications to be used in control centres to manage vehicles and crews. Major component are:

- ***asset management***: the management of the vehicle set up and maintenance processes need to be supported through dedicated IT applications. Additionally, to help field engineers with the new equipment, Enel has a dedicated website providing answers to FAQs and easy access to up-to-date information (new documentation, new maps, etc.).

- ***vehicle localisation***: vehicle positions are displayed on geographical maps and on the Enel proprietary cartography (GIS System), together with other information related to the crew on the vehicle. The Control Centre can use this information, when an emergency comes up, to identify the crew that is located nearest to the fault or to identify the crews that can provide additional support to the field engineers that are managing the fault.
- ***task assignment***: the daily tasks are assigned in SAP and automatically interfaced into the mobile workforce management solution. Enel is evaluating further deployment towards intelligently automating the assignment of tasks to field engineers.

Exhibit 5-5: Vehicle's set up scheme



Source: Enel

5.4.3 Impacts

The distribution business is a regulated activity (see Section 2.1) and it is not open to competition. Distribution systems operators (DSO) are forced by the regulated tariff mechanisms in place to continuously reduce their operating costs. At the same time they have to meet severe targets in terms of service quality in the physical delivery of energy.

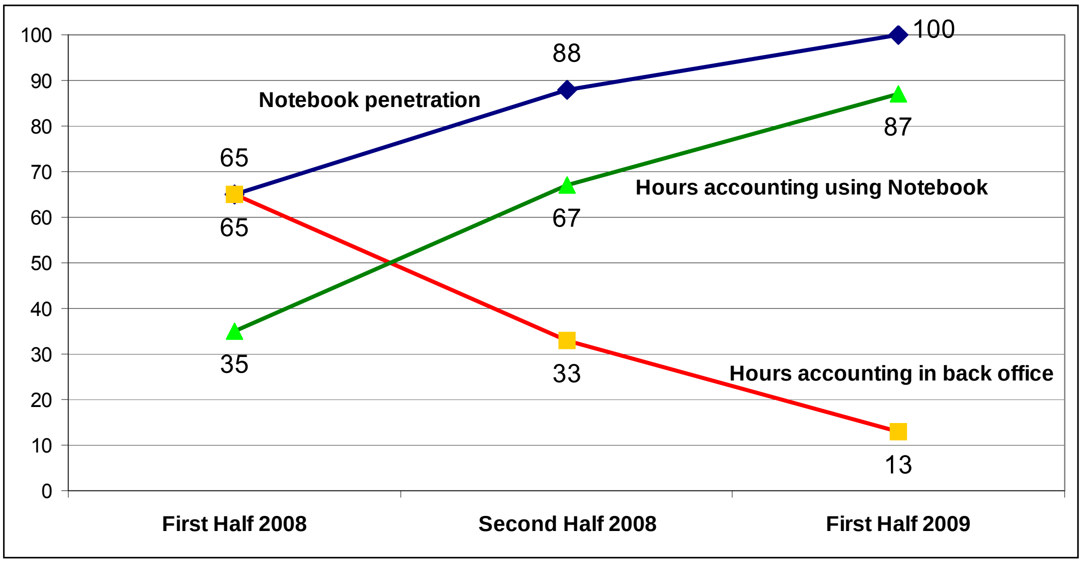
DSO assets are by definition dispersed over large territories (in the Enel case across the entire country) and reducing the cost related to field works is a primary area to examine in order to increase efficiency and improve service quality. Consequently, ICT contribution in redesigning and automating activities of the field force has becoming more and more relevant.

Even if an ROI analysis of the project is not publicly available, major benefits obtained by Enel with the implemented solution can be summarised in two categories: quality of service and operational efficiency.

- ***Quality of service***: reduction of the minutes spent per year per customer (fault management); improvement in managing appointments with customers (i.e. appointment window-time agreed always respected in case of operations that need to be done at customers premises)); all tasks (100%) completed on time in accordance to 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 all electronically. As time progressed the following improvements were experienced:
  - Reduction in back office work. Field engineers immediately after intervention can total time and material used for each project execution using rugged notebook. This information is automatically updated in central systems (i.e. in warehouse management system), eliminating manual activity in the field and the time to be dedicated by field workers for totalling when back to office. The progressive decrease in back office time accounting is depicted in Exhibit 5-6.
  - Optimisation of maintenance processes: more jobs per day and more network inspection completed per year were achieved.
  - Increased efficiency of logistics, in particularly in the reduction of travel costs.
  - Higher effectiveness of interventions: all the information and the necessary documentation (including manuals) is available, allowing field crews to better perform their job.

Exhibit 5-6: Efficiency increase due to ENEL's workforce management system



Source: IDC on Enel's data, 2009

5.4.4 Lessons learned

One of the major success factors of a project like this is to correctly address the change management aspect, as staff is directly affected in their way of working and organisational activities are heavily impacted.

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 any of the components of the new WFM solution. Weekly appointments with the field team involved were planned and maintained to exchange information and progress the implementation of the project.

At the end of the second phase, a meeting with all the teams directly involved was organised to collect and exchange feelings and experiences about the on-going project.

These measures were taken, knowing 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 the project organisation 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.

Also the Human Resources and Organisation unit needed to be a part of the project since the beginning to assure the success of the project and assist the change management phase within the company.

From a more technical perspective Enel identified the following points key aspect for the 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 always and everywhere available. 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 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.

5.4.5 References

Research for this case study was conducted by Roberta Bigliani and Gaia Gallotti (IDC Energy Insights), on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interviews with:
    - Massimo Maffeis, Enel Distribuzione S.p.A., DIR/TER Mobile Work Force Management
- Website:
    - www.enel.it
- Other references:
    - Enel Workforce Management System, Paola Petroni, Fabio Veronese and Eugenio Di Marino. Paper prepared for CIRED 19th International Conference on Electricity Distribution Vienna, 21-24 May 2007
    - Enel company profile

5.5 Smart grid journey at Austin Energy, Texas, USA

Abstract

In 2003, Austin Energy based in Texas, US, began a long journey to explore and deploy the technologies enabling the Smart Grids of the future. The first part of Austin Energy's programme, called Smart Grid 1.0, to be concluded at the end of 2009, focuses on the utility side of the grid, going from the central power plant through the transmission and distribution systems and all the way to the meter and back. In total, the project covered the installation of 410,000 meters, 86,000 thermostats, 2,500 sensors, 1,700 computers and 1,000 network elements. Enterprise system architecture redesign and back-office integration were key to successfully orchestrate all the pieces of the project. Before the project was wrapped up, in December 2008, Austin Energy launched the second phase of the journey towards intelligent grid: Smart Grid 2.0, developed in conjunction with the Pecan Street Project. Smart Grid 2.0 focuses on the grid beyond the meter and into the premise (e.g. home, office, store, mall, and buildings) with integration back to the utility grid. The project is concerned with managing and leveraging distributed generation (e.g. solar, micro wind), storage, electric vehicles, and smart appliances on the customer side of the meter.

Case study fact sheet

• *Full name of the company:*	*Austin Energy*
• *Location (HQ / main branches):*	*Austin, TX (USA)*
• *Main business activity:*	*Electricity company*
• *Year of foundation:*	*1893*
• *Number of employees:*	*1,700*
• *Turnover in last financial year:*	*$1.3 billion (2009)*
• *Primary customers:*	*388,000 residential customers* *43,000 businesses*
• *Most significant geographic market:*	*Austin, TX and surrounding areas*
• *Main e-business applications studied:*	*Smart Grid, Smart Metering*
• *Case contact person(s):*	*Andres Carvallo* *Chief Information Officer* *Austin Energy*

5.5.1 Background and objectives

Austin Energy is the United States' ninth largest community-owned electric utility. The company serves about 410,000 customers and a population of 1,000,000 in an area encompassing 650 square kilometres. As a publicly owned power company and a city department, Austin Energy returns profits to the community annually. Austin Energy powers the capital city of Texas through a diverse generation mix, including nuclear, coal, natural gas, and renewable energy for a total of 2,600 MW. Austin Energy's base electric rates have not increased since 1994 and are the lowest rates among major Texas cities and among the lowest across the US. The company aims to continuously improve its customer satisfaction. By 2020, Austin Energy plans to obtain 700 MW of energy efficiency and a share of 30% of renewable energy in its generation portfolio, of which 100 MW coming from solar.

In 2003, Austin Energy undertook a wide project to revolutionise its enterprise ICT architecture and prepare the company for the construction of a modern energy system - customer-driven, integrated, interactive, optimised, distributed, secure and self-healing[51]. The project, completed in August 2009 is known as Austin Energy Smart Grid 1.0. It was focused on installing about 5,000 digital devices and related ICT solutions going from the central power plant through the transmission and distribution systems and all the way to the meter and back. Even before it wrapped up, Austin Texas had started preparing phase two by launching the “Pecan Street Project” to develop a citywide smart grid.

The Pecan Street project, and consequently Austin Energy Smart Grid 2.0, focuses on the grid beyond the meter and into the premise (e.g. home, office, store, mall, and buildings) with integration back to the utility grid. The project is about managing and leveraging distributed generation (e.g. solar, micro wind), storage, electric vehicles, and smart appliances on the customer side of the meter. The Pecan Street Project is being driven by former Austin Mayor Brewster McCracken, and includes the City of Austin, Austin Energy, the University of Texas' Austin Technology Incubator, the Greater Austin Chamber of Commerce and the Environmental Defence Fund. This last participant is the group leader and has organised resources into twelve teams, with 150 people total, that are delivering recommendations for an Austin-specific smart grid system. Together they are defining what smart grid 2.0 should look like, not just for Austin Energy, but also for industry at large. The results of these working groups will be the basis for Austin Texas' upcoming action plan.

The project has also already garnered eleven corporate partnerships, including Applied Materials, Dell, GE Energy, IBM, Intel, Oracle, Cisco Systems, Microsoft, Freescale Semiconductor and GridPoint. The corporate partners are assisting the project team by providing for free staff resources and strategic guidance within their areas of expertise. Partners are also helping the project team identify technologies that can be pilot-tested on the local electrical grid once the initial phase of the project is completed.

Smart Grid 1.0 took Austin Energy six years to deploy and cost about $150 million, of which $10 million coming from the Department of Energy. The estimated investment for the new project is about $240 million, and Austin Energy has submitted 2 applications to the US Department of Energy to obtain matching funds for around $110 million.

5.5.2 e-Business activities

Starting in 2003, Austin Energy undertook a complete modernisation project 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 its entire household and business clients (completed in August 2009).

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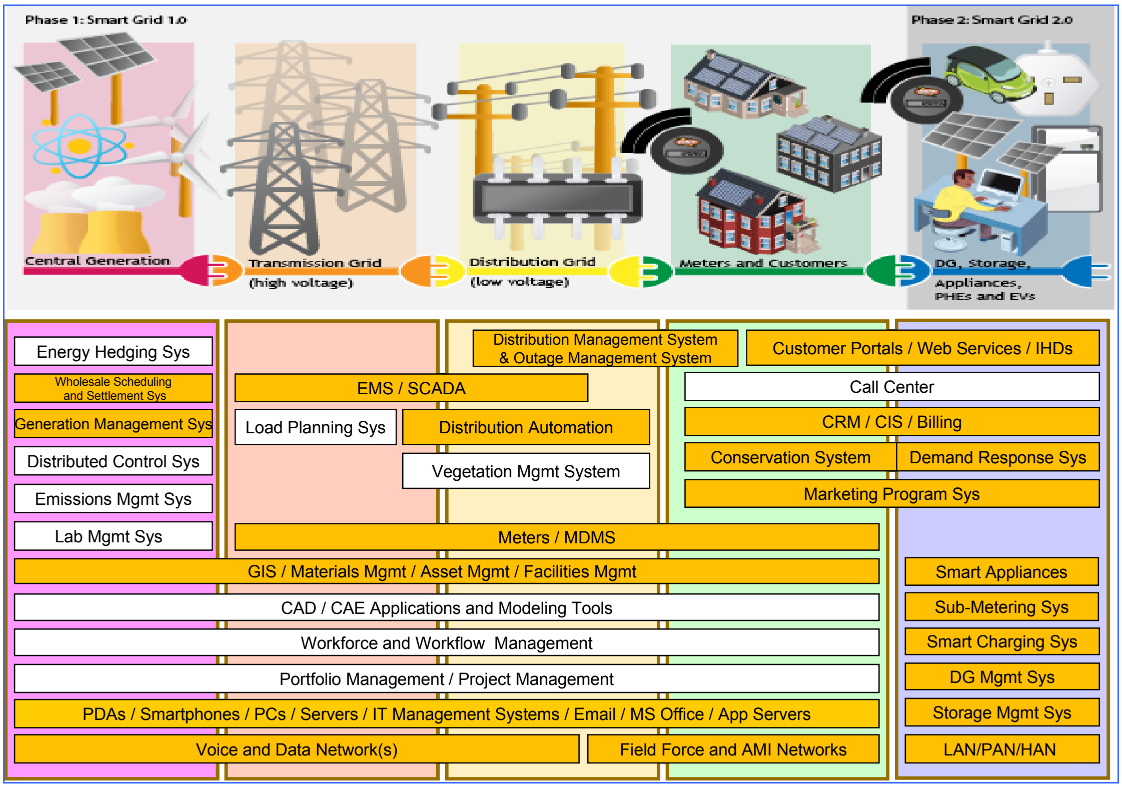
[51] A self-healing network uses real-time information from embedded sensors and automated controls to anticipate, detect, and respond to system problems, automatically avoiding or mitigatigatig power outages, power quality problems, and service disruptions. For more information on smart grid concept see section 3.4.3

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. This feeds into the outage management system, customer information system, distribution planning system, energy efficiency management system and asset management system. All this is accompanied by the rollout of a distribution management system (DMS) and integrates all the elements into a supervisory data acquisition and control system (SCADA) and energy management system. Lastly, the rollout of the new billing system, enabling demand response programmes and new billing rates - e.g. Time of Usage (TOU), net metering, prepayment –, started in May 2009 and will be completed by 2011.

The applications areas depicted in yellow in Exhibit 5-7 are those affected by Smart Grid 1.0 and the ones that are expected to be affected by the 2.0 project.

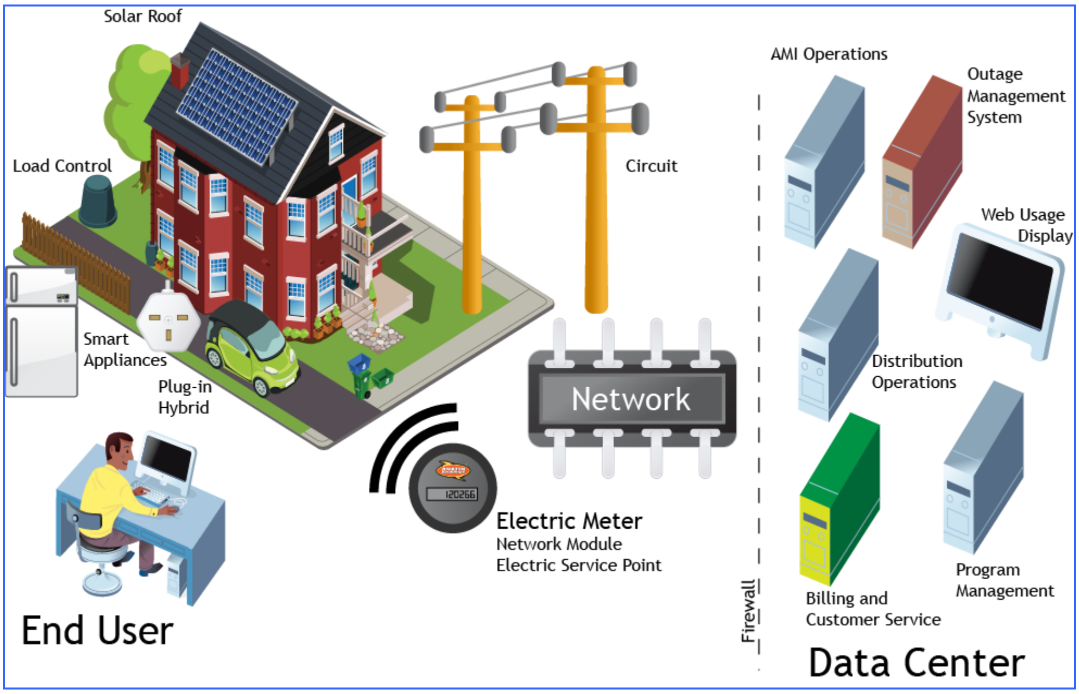
Exhibit 5-7: Austin Energy Systems affected by Smart Grid projects



Source: Austin Energy, June 2009

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. When meter readings will be carried out every 15 minutes for the entire network this figure will reach 100 Terabytes, while when the readings will be carried out every 5 minutes the data will reach a capacity of 400 Terabytes. This represents a serious challenge to be addressed also from a storage perspective. The challenge will be even more complex with the rollout of additional intelligent devices into the customer premises, as planned by the Pecan project and Smart Grid 2.0 (refer to Exhibit 5-8).

Exhibit 5-8: Austin Energy vision of the Smart Premise (Home)



Source: Austin Energy, June 2009

As part of its efforts in going into the customers' premises, the Pecan Street Project will start by leveraging a newly built area, the Mueller development. This is a 3,000-squared meters development in which every new building is green built (either certified through LEED or Austin Energy's nationally recognised Green Building programme). In partnership with Mueller residents and stakeholders, Austin Energy will test smart grid 2.0 by creating a microgrid initially linking 1,000 residential meters, 75 commercial meters, and plug-in electric vehicle charging sites during the five-year project period. The development will integrate smart meters, energy control gateways, advanced billing software, and smart thermostats. The project team will use this technology platform to demonstrate grid integration of distributed clean energy generation, smart water systems, distributed storage, smart appliances and plug-in electric vehicles. The project will also compare different delivery and business models, including dynamic pricing, demand response, decoupled pricing linked with net metering, and rooftop solar leasing. The project will also test different storage technologies, including potentially thermal storage, battery technologies (e.g., lithium ion, lithium iron magnesium phosphate, metal air, and lead acid), and possibly ultracapacitor and fuel cell systems.

The project will collect data and analyse these results against control groups and distribution feeder systems in other locations in the City of Austin to quantify how the integration of these technologies impacts customer electric bills and usage, utility finances, environmental outcomes and electric system performance.

The goal of the demonstration project will be to transform how energy is generated, delivered, and managed so that customers on that part of the system would be carbon neutral – and to do this in a way that creates green collar jobs, efficiently and cost effectively expands use of clean energy, and provides consumers with greater control over their electric bill and environmental impact while saving them money on their electric bill.

5.5.3 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 an ROI analysis of already completed projects is not publicly available, it is worth to mention that all the activities were carried out with no impact on customers' rates, which have not risen for the last 15 years.

Overall, it is still too early to quantify benefits sought after by such a broad implementation. Major results are expected in terms of reduced need for construction of additional generation and transmission capacity, reduction of operating costs, service improvement, realisation of demand response programmes, building automation. A more comprehensive list of expected results, benefiting both customers and the utility are summarised in Exhibit 5-9.

Exhibit 5-9: Expected benefits of Austin Energy Smart Grid 2.0 Project

Benefits for Austin Energy	Benefits for customers
▪ Reduced need for additional generation and transmission capacity ▪ Reduced operating costs ▪ Improved outage management - ability to quickly determine if power is off or on ▪ Reduced number of delayed and estimated bills ▪ Reduced energy theft ▪ Improved load profiler ▪ Improved distribution load management and planning ▪ Greater historical load and usage data available for better load forecasting ▪ Better asset management and maintenance (effectiveness and cost reduction) ▪ Time-of-use, prepaid, and flat bill pricing programmes ▪ Support any market price-responsive tariff requirements	▪ Faster notification and restoration times from outages ▪ Better understanding and management of bills through usage information via a Web portal ▪ Ability to participate in energy efficiency and demand response programmes ▪ Reduced inconvenience by no longer needing to unlock gates and tie up dogs for meter reads ▪ Improvements in timeliness and accuracy of billing with fewer estimated bills ▪ Remote service turn-on and shut-off (e.g. of air conditioning) ▪ Access to real-time meter reads through a call to customer service or via data on a home energy display or Web portal ▪ Manage appliances via Web portal ▪ Ability to participate in alternative tariff options

5.5.4 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 the resistance stubbornness to change 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 participation of customers in the second part of the journey to smart grids into the premise will be 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 pretty good sense of what its customers want and need. However, it is prudent in asserting that it would be able to manage 100% of its clients' thermostats.

Austin Energy has come to the conclusion that utilities alone are not enough to elaborate the answer to the future Smart Grid, as a consortium of experts from various market segments are crucial, not only for best practices, but also to contain costs and spread risks. Utilities need to take on the role of orchestrators to harmonise all the tasks needed to make the Smart Grids of the future a reality.

Finally, Austin Energy highlights that the redesign of enterprise system architecture and back-office integration were key to successfully orchestrate all the pieces of the project.

5.5.5 References

Research for this case study was conducted by Roberta Bigliani and Gaia Gallotti (IDC Energy Insights), on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interviews with:
  - Andres Carvallo, Austin Energy (Texas, USA), Chief Information Officer
- Websites:
  - www.austinenergy.com
  - www.muelleraustin.com
  - www.pecanstreetproject.org
  - www.ciomaster.com
- Other references:
  - Austin Energy Company Profile
  - "Balancing vision & today" article by Andres Carvallo, Intelligent Utilities magazine, January-February 2009, Energy Central
  - "Turning Information into Power: The Smart Grid and Network Operations, Andres Carvallo, CIO of Austin Energy in Austin, TX, on the Pecan Street Project" - Oracle Utilities Live Webcast, June 11th 2009

5.6 Automatic meter management at Gas Natural, Spain

Abstract

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. After defining its own specific requirements Gas Natural carried out two distinct demonstrations with a total scope of 10,000 meters. Each demonstration was defined to test AMM under different conditions: town typology, density of clients, gas network configuration and communication technologies. Through the demonstration phase, Gas Natural was able to build a business case for future deployment. Gas Natural's current near future plans are not a full roll-out for all residential customers but a deployment of 300,000 meters in geographic areas where reading costs exceed €4 / year.

Case study fact sheet

• *Full name of the company:*	*Gas Natural Group*
• *Location (HQ / main branches):*	*Spain (HQ), Italy, France, Latin America and Africa*
• *Main business activity:*	*Exploration, transport, distribution and commercialisation of natural gas.* *Electricity generation and commercialisation.*
• *Year of foundation:*	*1843*
• *Number of employees:*	*6,699 (Gas Natural Group)*
• *Turnover in last financial year:*	*€10.1 billion*
• *Primary customers:*	*Industrial, commercial and residential customers*
• *Most significant geographic market:*	*Spain*
• *Main e-business applications studied:*	*Automatic Meter Management*
• *Case contact person(s):*	*Ramon Jane Crumols* *Engineering and Technology Division* *Gas Natural*

5.6.1 Background and objectives

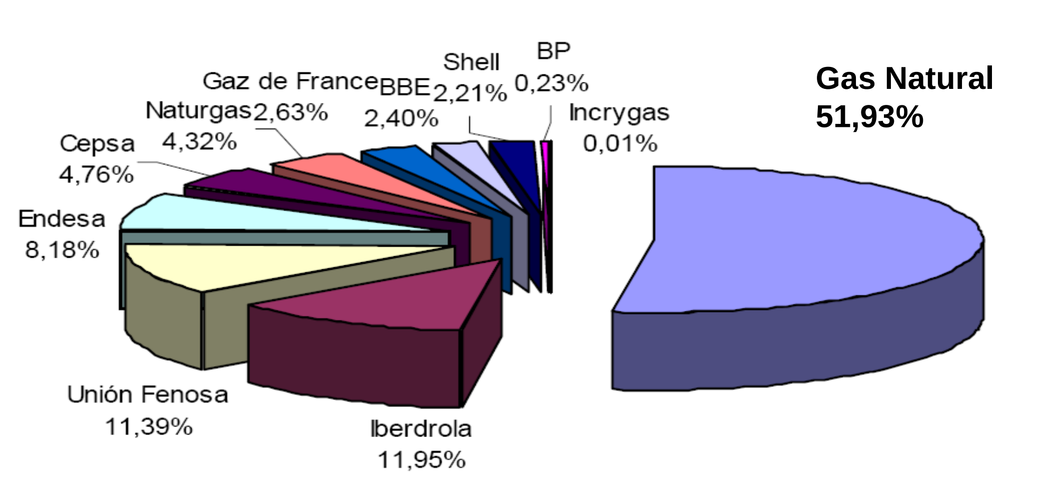
Company background

The Gas Natural Group is an energy services multinational whose activities focus on the supply, distribution and commercialisation of natural gas in Spain, Latin America, Italy and France, where it has more than 11 million customers. As a result of the liberalisation of the energy market, the Group has entered the electricity generation business together with the commercialisation of other energy products and services.

The Gas Natural Group is today the result of a process of reorganisation and restructuring of the gas sector in Spain, which is still undergoing. Last July 2008, Gas Natural acquired from ACS (Actividades de Construcción y Servicios, S.A.) about 45% of Unión Fenosa. At the end of April 2009, both companies' Management Boards approved the merger by integration process of Unión Fenosa and Unión Fenosa Generación into Gas Natural.

Gas Natural is currently the leader in the Spanish gas market, operating through ten distribution companies across 13 autonomous communities, and two sales companies. The number of gas distribution customers in Spain is more than 5.8 million. The company is the fifth biggest operator in the Spanish electricity sector, according to the National Energy Commission (CNE).

Exhibit 5-10: Gas companies market shares in Spain (2007)



Source: National Energy Commission, August 2008

Drivers and objectives of the AMM system

In 2005, Gas Natural began a long process of evaluating, testing, piloting and deploying an automatic meter management (AMM) system for residential customers in Spain.[52] The system serves mainly the gas distribution sector and, on a small scale, also water distribution. External as well as internal forces drove Gas Natural's decision. The most important external driver was European[53] and Spanish[54] legislation, requiring the adoption of meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use.[55] The main internal driver for the AMM project was the need to integrate consumption data and make them available for different corporate information systems in order to improve critical internal processes.

Gas Natural's AMM project has three main objectives: cost reduction, customer satisfaction and energy efficiency. Gas Natural expects to reduce costs on several levels: reducing costs of manual readings, avoiding further verification of readings through high accuracy of first readings. Gas Natural's AMM deployment would also allow better forecasting of demand, enhanced gas network management, and improved network

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[52] AMM for industrial and commercial customers (>5GWh/year) was already in place. A total of 3,280 meters are installed. The AMM allows Gas Natural for daily downloads of hourly readings. It uses General Packet Radio Services (GPRS) and short messaging service (SMS) Communication with a reliability of 98% of readings.

[53] Directive 2006/32/EC on energy end-use efficiency and energy services. Article 13 says: Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity, natural gas, district heating and/or cooling and domestic hot water are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use.

[54] Royal Decree 809/2006.

[55] This implies actual readings and not estimated consumptions.

security due to constant remote monitoring. The improvement of customer satisfaction is mainly related to the possibility to avoid disturbing customers by accessing their homes to make manual readings or to have them calling to provide their readings, and to reduce claiming for billing (no estimation on consumptions). New and more flexible tariffs could also be introduced. Finally, Gas Natural also sought to achieve better energy efficiency from improved consumption control, and providing customers with real consumption data via web applications allowing them for better controlling and forecasting their expenditures.

5.6.2 e-Business activities

Characteristics of deployment

Gas Natural's residential customers in Spain are served with 5.7 million meters. Approximately 70% are located indoors and 30% are located outdoors.[56] The objective of demonstrations was to obtain real and specific data allowing Gas Natural to validate global viability of mass deployment of AMM systems in residential customers and small commercial customers, from both perspectives: installation and operation. The pilot scope was 10,000 meters to be tested under different operations conditions and metering technologies.

One test was conducted in the city of Tarragona, the objective was a crowded urban area where gas distribution is well established. The scope was 5,900 gas meters and 500 water meters. Actaris provided meters and system technology tested was Coronis. The other test was conducted in the region of Murcia, characterised by a low density of customers and recent establishment of gas supply. NURI Telecom system was tested with 4,600 gas meters (Actaris).

Technical specifications

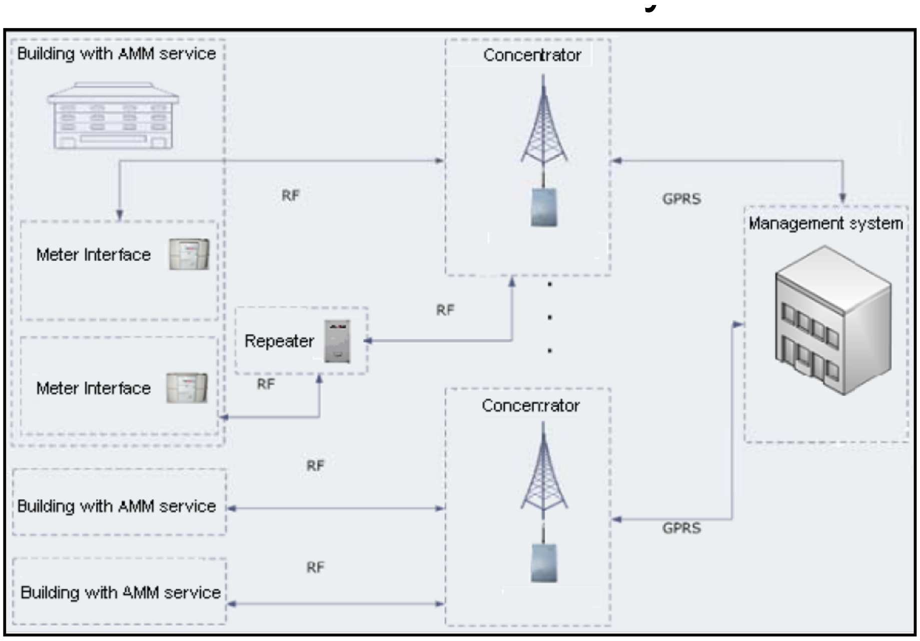
Both installations have a common architecture with four basic components: meter interface, repeater, concentrator and AMM software. The project is based on systems based on Radio Frequency communication from meter interfaces repeaters and concentrators. These last communicate data to Gas Natural's management system via the GPRS network.

- Meter interface: This device fixed to the meter gathers and stores the data readings, and manages the alarms.
- Repeater: This device is used to facilitate the communication between the meter interface and the concentrator in areas where it cannot be done directly. So, the radio range is raised.
- Concentrators: they gather all information from interfaces and repeaters in a certain area, store and process the data and then send them to the Gas Natural management system via the GPRS network.
- AMM management software: the application allows readings management and storage for being handled by the appropriate management tool.

[56] Manual reading of indoor meters require the presence of the homeowner to access the meter.

Exhibit 5-11 shows an overview of the architecture of the AMM system.

Exhibit 5-11: Architecture of AMM system

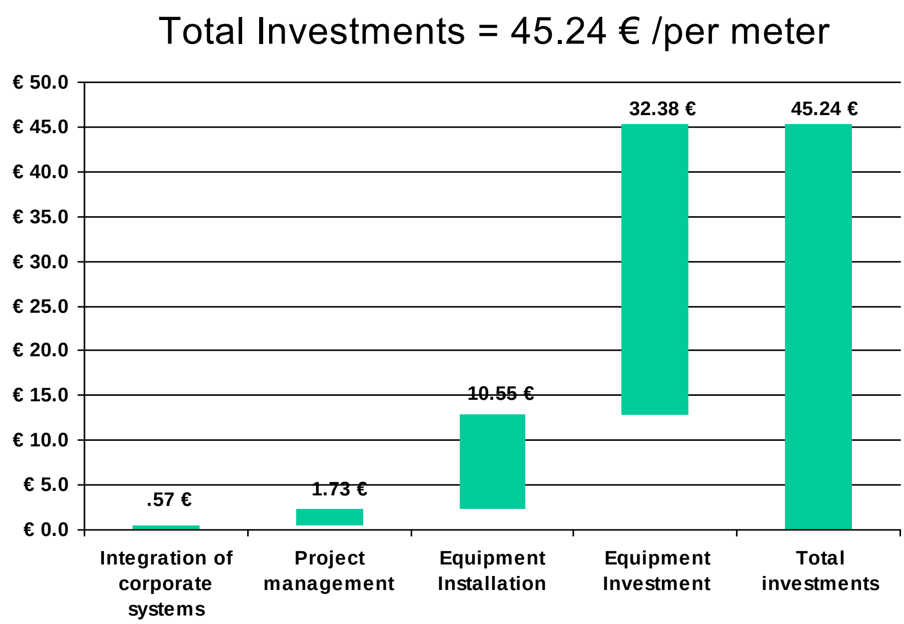


Source: Gas Natural, 2009 (interview)

5.6.3 Impacts

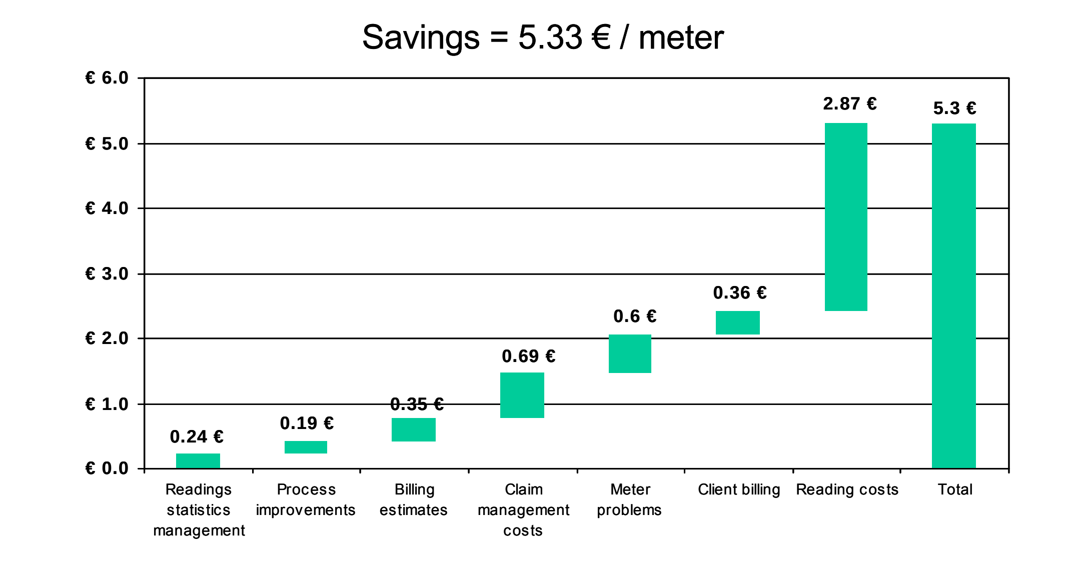
By conducting its extensive pilot, Gas Natural was able to build a very detailed business case on the AMM project, identifying its total investment to be 45.24 euro per meter, and its annual savings to be 5.33 euro per meter (see Exhibits 5-12 and 5-13).

Exhibit 5-12: Gas Natural's AMM total investments per installed meter



Source: Energy Insights redrawing of Gas Natural data (2009 interview)

Exhibit 5-13: Gas Natural's AMM annual savings

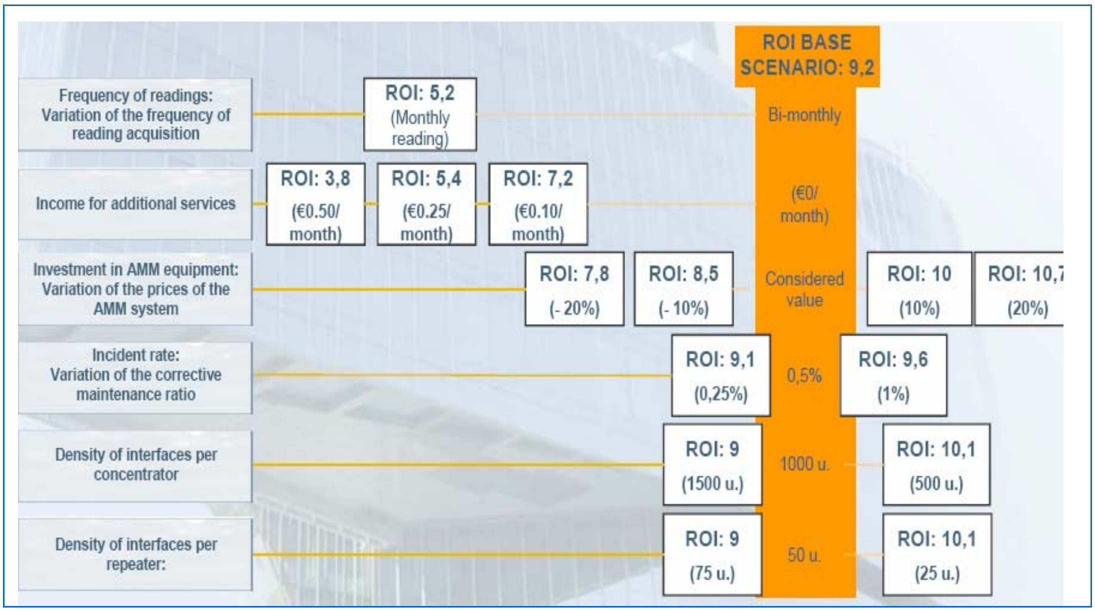


Source: Energy Insights redrawing of Gas Natural data (2009 interview)

Gas Natural performed a return on investment (ROI) analysis to define how to move forward. The reference scenario is build on a ten year plan to cover the roll-out of meters for all its residential customers and it includes meter replacement investments. The company expects an ROI of 9.2 years (for ROI sensitivity, see Exhibit 5-14).

The Gas Natural business case made clear that financial justification of AMM in gas could be more difficult to be proved than for electricity smart metering. This element, together with the fact that gas coverage varies greatly in the different EU countries, could help explaining why the 3rd Energy Package was less demanding for gas implementation (see Section 2.3 "Milestones of energy and climate regulation in EU in recent years").

Exhibit 5-14: ROI sensitivity analysis



Source: Gas Natural, Smart Metering Europe 2008

Based on this analysis Gas Natural decided to postpone full implementation and made the decision to implement AMM in areas where meter-reading costs are higher than 4 euro per year. This translates into the deployment of about 300,000 meters.

5.6.4 Lessons learned

From a technical perspective, the project demonstrated that AMM technological platforms are increasingly less immature, more reliable, open, scalable and price competitive. Radio range is good enough to provide service.

Nevertheless configuration tools and installation process need to be simplified to success in mass deployment rollouts. In fact, many incorrect meter interface installations occurred, requiring additional field force on site visits. And this is one of the most important lessons learned from the demonstration. Gas natural is presently working to define procedure and tools for system installation.

During the pilot, Gas Natural created an internal committee to manage the cooperation of the different business units involved, i.e. engineering and technology, operations, metering and asset management as well as information technology. This has been a very positive aspect to ensure a good and coordinated project management.

Project economics, under the existing regulation scenario, are not good enough to go for a full-scale implementation of AMM.

Finally, from Gas Natural's customers perspective, the increased availability of consumption data has been highly appreciated even if it was not always easy to explain the customers the need of replacing or updating their old meters.

5.6.5 References

Research for this case study was conducted by Roberta Bigliani and Gaia Gallotti, respectively EMEA Research Director and Associate Analyst of IDC Energy Insights, on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interviews with:
  - Ramon Jane Crumols, Engineering and Technology Division, Gas Natural
- Websites:
  - www.gasnatural.com
- Others:
  - Gas Natural Annual Report
  - CNE - National Energy Commission
  - Smart Metering Europe 2008 conference

6 Conclusions and outlook

6.1 Main findings from this report

ESI: the main challenges

A competitive, reliable and sustainable energy sector is essential for the EU, which is presently coping with a vast array of challenges, including dependency on imported primary energy sources and inherent volatility of prices. The national markets lack integration into a single European market, as indicated by the absence of a pan-European price convergence and the low level of cross-border trading. There are still large differences in market structure, competitiveness, public service and customer protection between European countries. The EU is also mandating to fight against climate change, and the European energy supply industry is aiming to shift towards decarbonised power.

The deployment of smart grids, including the pilot and rollout of smart metering, is a key strategic element in order to meet these challenges and transform this industry. To stay competitive, energy supply companies need to increase process efficiency along the liberalised segments of value chain (Section 2.1). It is increasingly necessary to integrate ICT applications and to migrate systems to more cost-effective IT architectures, both for electricity and gas. Moreover, ICT and e-business can contribute to improved energy efficiency across the whole economy, by enabling changes in business models, production and distribution practices and customers' behaviour that are inherently more energy efficient.

ICT for corporate processes in the ESI

Among the solutions supporting enterprise business processes, Enterprise Resource Planning (ERP) has currently the widest adoption within this industry. According to this study, ERP is used by firms representing two thirds (67%) of the industry's employment, followed by computer-aided design systems (CAD, 63%) and document management (DMS 61%). Supply Chain Management systems (SCM), which can be considered an indicator for integration along the value chain, has a limited diffusion. It appears that ESI companies reach a fairly good degree of automation in single processes, but have still a way ahead before reaching cross process integration.

Virtual Power Plant: ICT to integrate distributed energy resources

The distributed and coordinated operation of several small generation units, acting virtually as a single power plant, is an effective approach toward a better integration of distributed energy resources (DER). Generating power close to where it is consumed implies benefits in terms of reduction of network losses; this can lower costs, reduce emissions and expand the energy options of the consumers. If correctly addressed, it may also add redundancy that increases grid security. A VPP (Virtual Power Plant) may significantly enhance the efficiency and reliability of production processes, bring relevant environmentally interesting options and make possible to deliver value added services to customers.

The concept of VPP - basically a scheme to combine decentralised generation and storage through ICT interlinking - has been theoretically developed. It is nevertheless far from being common practice in the ESI. The survey results indicate that ICT solutions for managing distributed energy generations units (monitoring, forecasting and dispatching energy) are in place in companies representing between 40 and 52% of the ESI's employment. Still many companies generating energy through distributed units run these units as "islands" of activity rather than in an integrated way. Leading edge initiatives (such as Fenix, EU-DEEP, the RWE Energy project) presented in Chapter 5 have been implemented in the EU. However, it is not yet possible to illustrate a standard architecture, nor is there consensus about costs and benefits of such implementations.

Complex and ageing transmission systems

European transmission systems are ageing and massive investments will be necessary in the next years, both to replace assets and to solve congestion problems. The current management of transmission assets already relies on the widespread use of ICT. Key ICT technologies for transmission grid management include tele-measures and tele-controls systems, aimed at supporting sector-specific functionalities related to real-time measurement, analysis, forecast and monitoring of operations.

Distribution networks: architecture redesigned

Distribution grids need to be redesigned in order to accommodate distributed generation and bi-directional power flows and to fulfil a broad new range of requirements. A distribution network can no longer be passively and simply attached to the transmission network, instead the entire system has to be designed and operated as an integrated unit, the so called "active network".

Smart metering

Smart metering has been growing steadily and may be boosted by the actual implementation of the Third Internal Energy Market Legislative Package, issued in June 2009 (Chapter 2). However, companies implementing or testing smart metering still face barriers related to the interoperability of devices and systems and need to cope with insufficient regulation of public entities. These challenges are to be met in order to fully exploit the potential for energy savings, process efficiency and new value added services.

Demand side management: high potential for energy efficiency

The potential benefits of demand side management on energy efficiency have been demonstrated in various pilot projects and are clear to ESI companies. The full deployment of such programmes, however, is quite complex as it involves not only the supply side but requires active participation from the customer's side, with considerable organisational and technical implications. This explains the limited adoption among ESI companies detected by the survey and demonstrated by the case study about Austin Energy (Section 5.5). The set up of real time communication channels with end users (via web portals, displays, links with customers' programmes) is instead becoming a more common practice. ESI firms have also started broadening their range of outsourcing services. The study findings demonstrate a large untapped potential for energy efficiency in this field.

ICT and environmental impact at company level

The transition towards a more climate-friendly energy sector is supported by a range of ICT solutions that respond to changing regulatory, safety, and security requirements, while enhancing value chain visibility and ensuring continuity of operations. These include systems for managing electronically health, safety and environment aspects, carbon management. Overall, the diffusion of ICT solutions for monitoring and reducing environmental impact is low, if compared with the general market trends in the ESI and the regulation in place. It appears that a relevant share of firms still do not fully exploit the potential of ICT in contributing to the reduction of environmental impacts.

ICT and innovation

Within this industry ICT is perceived as a major innovation enabler. Companies representing 53% of this industry's employment said they introduced new products or services in the past twelve months, and 76% introduced new processes. The vast majority of these innovators said that the new products or services have ICT components. 89% of innovative ESI companies said that their new products or services have ICT components, and 97% said that their new processes are supported by ICT. These are the highest values for ICT-enabled innovation that the e-Business Watch has ever found in an industry.

ICT for gas pipelines

The efficient, safe and secure management of gas pipelines can largely benefit from the usage of ICT solutions, covering and integrating the main business processes. These may include: SCADA for pipeline operations, solutions integrating SCADA with asset and sales management and work force management, specific pipeline applications such as leak detection, gas management, pipeline simulation, GIS, satellite imagery (for pipeline monitoring), disaster management and recovery.

6.2 Outlook on ICT investments

Chapters 2 and 3 of this report have illustrated that ICT and e-business can contribute to improved efficiency both at company level and across the whole economy. It is therefore insightful to have a closer look at planned investments into ICT and e-business in this industry. 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 a reduction of the 2009 budgets and the cancellation of many ICT projects. On the other hand, the majority of interviewees believe their investments will increase in the near future, specifically in innovative applications areas such as smart handheld devices, electronic billing systems and the integration of IT systems. But these plans may prove overly optimistic, if economic conditions do not improve as fast as expected.

General ICT investments planned

ESI companies were asked to indicate if their ICT budget for 2009 has increased, stayed the same or decreased. Companies representing 52% of employment decreased their budgets in 2009, for 21% of the firms the ICT budget stayed the same and for 27% it increased. Companies representing 42% of employment indicated that the economic crisis has an impact on ICT investment plans and out of these 51% actually cut or cancelled ICT projects. Not surprisingly, the economic crisis has largely affected the decision for investments in ICT.

Exhibit 6-1: General ICT investments in 2009

Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	Companies whose ICT budget for 2009 ...					
	has increased		stayed the same		has decreased	
Weighting:	% of empl.	% of firms	% of empl.	% of firms	% of empl.	% of firms
Total	**27**	**27**	**21**	**12**	**52**	**61**
By sector						
NACE 35.1 (Electricity)	26	27	23	10	51	63
NACE 35.2 (Gas)	27	20	18	18	55	62
NACE 35.3 (Heating/cooling)	31	30	19	15	50	54
By company size						
Small (10-49)		23		9		68
Medium (50-249)		35		12		52
Large (250+)		25		25		50
Base (100%)	All excl. "don't know"		All excl. "don't know"		All excl. "don't know"	
N (Base, total)	326		326		326	
Questionnaire reference	G2a		G2b		G2c	

Source: SeBW-Energy Supply Survey 2009

Exhibit 6-2: Effects of the economic crisis on ICT investments in 2009

Energy supply (NACE Rev. 2 35.1-3, 6 EU countries)	Companies for which the economic crisis has an impact on ICT investment plans		Companies having cancelled / downsized ICT projects due to economic crisis	
Weighting:	% of empl.	% of firms	% of empl.	% of firms
Total	**42**	**37**	**51**	**45**
By sector				
NACE 35.1 (Electricity)	44	33	45	52
NACE 35.2 (Gas)	19	33	(--)**	(--)**
NACE 35.3 (Heating/cooling)	57	52	(63)*	(29)*
By company size				
Small (10-49)		36		44
Medium (50-249)		37		(44)*
Large (250+)		42		(55)*
Base (100%)	All		All	
N (Base, total)	351		126	
Questionnaire reference	G3		G4	

Source: SeBW-Energy Supply Survey 2009

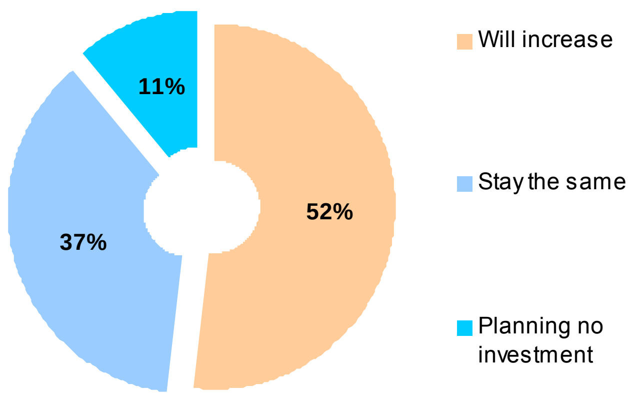
Planned specific investments

ESI companies were asked if they expect that their investment level for smart handheld devices would increase, stay the same or if no investment was planned in the two following years. Similar questions were asked about electronic billing and about investments for integrating monitoring and control systems with business systems.

Smart handled devices allow field force to communicate directly with the company's information systems in an efficient and integrated way. Electronic billing is an important component of customer service, besides allowing relevant efficiency gains. Integrating monitoring and control systems with business systems may increase the overall efficiency of business processes.

Companies representing 52% of employment stated that they will increase their investments in smart handled devices (Exhibit 6-3), 47% will increase investments in electronic billing (Exhibit 6-4) and 48% in integrating systems for monitoring and control with business systems (Exhibit 6-5). A share of companies ranging from 11% -for smart handled devices- to 20% -for integrating systems- plan no investment and the rest will continue to spend the same amount of money as in previous years.

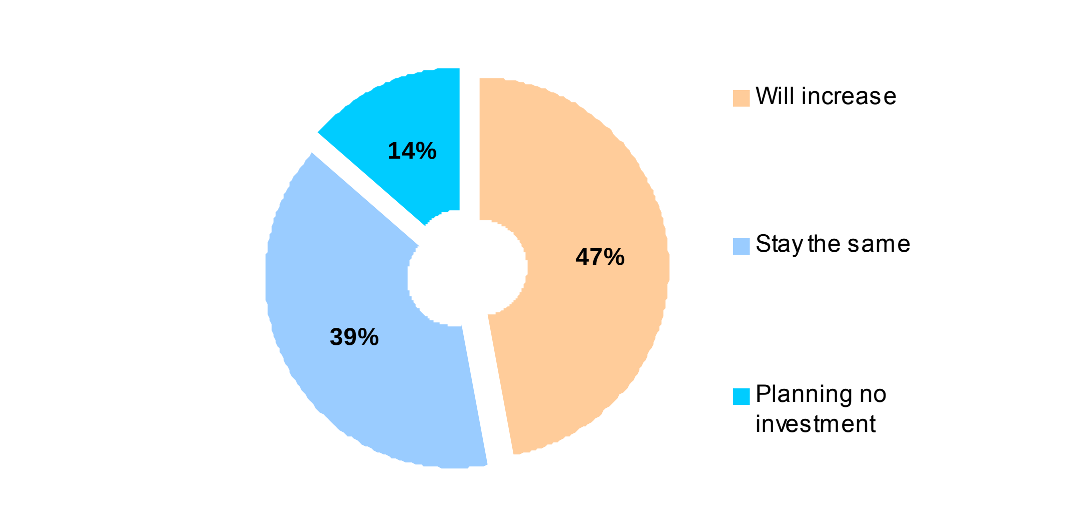
Exhibit 6-3: Expected investment into smart handheld devices in ESI companies in the next two years



Base (100%) excluding "don't know" , N (Base, total) 331
Weighting: Figures are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW-Energy Supply Survey 2009

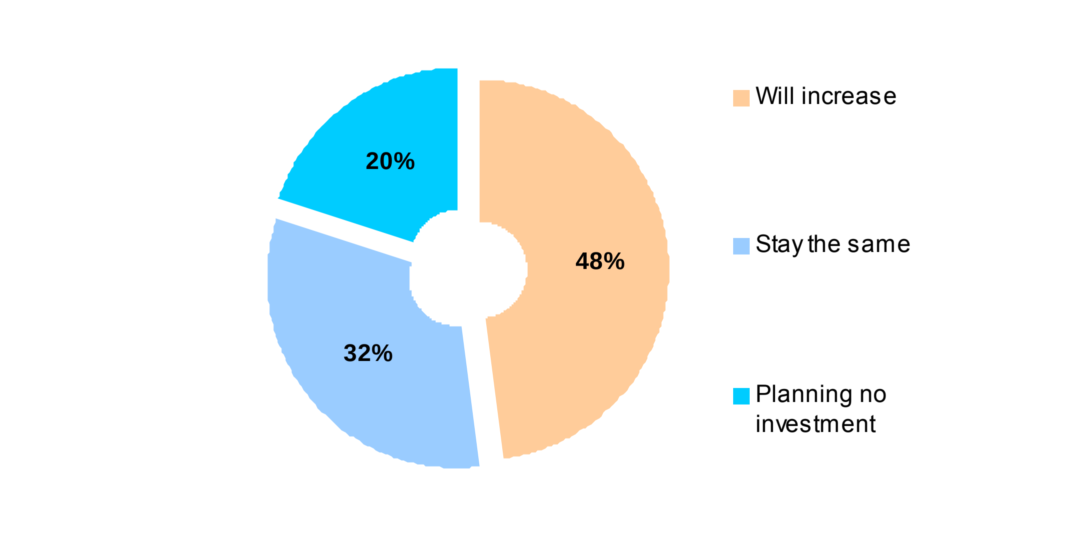
Exhibit 6-4: Expected Investments in electronic billing in the next two years



Base (100%) excluding "don't know" , N (Base, total) 331
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW Energy Supply Survey 2009

Exhibit 6-5: Expected investments for integration of monitoring and control systems with business systems in the next two years



Base (100%) excluding "don't know" , N (Base, total) 341
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector).

Source: SeBW Energy Supply Survey 2009

Overall, it appears that investments in sector-specific devices and application, such as smart handheld devices, electronic billing and integration of monitoring and control systems with business systems, will continue to be targeted by ESI, due to their relevance for cost reduction.

6.3 Policy implications for ICT and e-business in the ESI

6.3.1 Overview

This report illustrates how ICT and e-business can play a major role in achieving the objectives of sustainability, security, efficiency, and innovation in the ESI. It also highlights 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 heavily deteriorated the plans for investments.

There is a risk that the uneven or delayed adoption of ICT-based innovation in the industry may weaken the ESI's competitive positioning and prevent the achievement of main benefits for the European socioeconomic system. The following paragraphs analyse the policy implications of the main findings of this study, that is whether or not there may be a need for policy intervention to avoid these risks and promote positive developments. This will focus on the main policy actors, the European Commission and EU Governments. The energy sector is heavily regulated and several important energy policies have been introduced, like the one related to security of supply and fight against climate change. A comparative analysis of all the policy initiatives relevant for the sector would go beyond the scope of this study. This chapter will focus on the role of ICT for the ESI and the policies that may respond to market failures or market imbalances for this specific topic, according to the findings of this study.

Addressees of policy implications and general policy areas

The following implications address in the first instance the European Commission. In second instance, national and regional governments as well as European and national industry associations are also addressed.

e-Business developments can have implications for several policy areas, including for example overall industrial policy, education policy, research and technology transfer policy. Relevant considerations made in this context can be grouped around two overall objectives, which may to some extent be antagonistic:

- **Promote ICT adoption**: Policy may have an interest in accelerating the adoption and competent use of ICT and e-business activity among companies, particularly among SMEs. Such political activity is based on the assumption that ICT are a driver of productivity and competitiveness, leading to increased economic growth, wealth and employment. In this specific industry, thee is also evidence that ICT capital intensity can significantly decrease emissions per output in the energy supply sector
- **Counteract ICT induced undesirable effects**: At the same time, policy will have to consider intervention if ICT use or e-business activity causes undesirable effects on the aggregate level of the industry.

A basic assumption of this report is that it is generally the enterprises' decision to use or not use ICT and e-business and the extent to which they invest in it. Policy initiatives should target areas in which market failures occur, which include issues related to research, development and technology transfer, knowledge and skills development, standardisation, and environment protection.

Current major policy initiatives of the EU for the ESI

The European Union has addressed the area of energy policy for many years, aiming at the creation of a liberalised and carbon neutral pan-European energy market. A common European energy policy is acknowledged as the most effective response to the challenges faced by all Member States.

This section of the report focuses only on policy initiatives running at the European level, and in particular on those setting high level objectives and providing general guidelines. Firstly, because EU-level initiatives have been driving and shaping those issued by national and regional governments. Although large differences of market structure, competitive level, public service and customer protection still exist between European countries, progress toward liberalisation and implementation of an integrated and common market have been achieved over the past years. Secondly, because an analysis of ESI policy initiatives at a more detailed level would exceed the scope of this report.

The most recent EU policy initiatives about the ESI are the EU's climate package and the Third Internal Energy Market legislative package. A picture of the milestones of energy and climate regulation in EU in recent years is provided in Section 2.3.

The EU's climate package, issued in December 2008, sets new EU rules promoting the use of energy from renewable sources, with the aim to achieve by 2020 a 20% share of energy from renewable sources in the EU's final consumption of energy. It issues a revised EU Emissions Trading System. It defines the "effort-sharing" to make carbon emissions reductions across a wide range of activities including transport, agriculture and housing. It adopts new rules for cleaner cars and sets new environmental quality standards for fuels and bio fuels. It sets up a regulatory framework for the geological storage of carbon dioxide aimed at supporting the deployment of this technology.

The **Third Internal Energy Market legislative package** includes five legislative acts. Overall, it puts in place the regulatory framework needed to make market opening fully effective. The Electricity Directive set new rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EU. The Gas Directive establishes common rules for the transmission, distribution, supply and storage of natural gas. Fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal electricity market are also established. The package also contains a very relevant element to stimulate the adoption of new metering devices: it mandates implementing intelligent metering systems with a target of 80% of the population to be covered by 2020.

In summary, the EU policy currently in place addresses the major energy challenges of emissions cuts, renewables and energy efficiency, as well as of market regulation and cross-border exchanges. All these issues are ultimately enabled and influenced by ICT and technological developments, as extensively illustrated along this entire report.

In addition to energy policy initiatives, the European Commission has addressed the issue of ICT for the energy sector and for energy efficiency in particular. In May 2008 the Commission published the Communication **"addressing the challenge of energy efficiency through Information and Communication Technologies"** – (COM (2008) 241), followed by a Public Consultation on «**Information and Communication Technologies enabling energy efficiency**" on 20th May 2008. Building on the results of the Public Consultation, a new Communication was issued in March 2009 entitled

"mobilising Information and Communication Technology to facilitate the transition to an energy-efficient low carbon economy" – (COM (2009) 111 final)**.**

These Communications aim to raise awareness of the current and potential impact of ICT as an enabler for energy efficiency, stimulating an open debate among the relevant stakeholders in a number of selected areas. Their focus is on two main areas: ICT itself and ICT as an enabler to improve energy efficiency across the economy, through enabling new business models and improved monitoring and finer control of all processes and activities. Although all sectors may benefit, the initial focus will be on the power grid, on energy-smart homes and buildings and on smart lighting due to their relative importance and potential for improvement.

On September 29th, 2009, the European Commission published the Communication "**preparing for our future: developing a common strategy for key enabling technologies in the EU**" COM (2009)512. This Communication analyses key-enabling technologies, such as nanotechnology, micro- and nanoelectronics including semiconductors, advanced materials, biotechnology and photonics and suggests that they can be applied also in the energy and utilities sectors to tackle issues such as smart grids, renewable energy sources, and climate change. The Communication identifies short-term measures that can be adopted[57], but also suggests the set-up of a High Level Expert Group tasked with devising an action plan for the deployment of these key-enabling technologies in the longer term. The conclusion is that an advanced use of key-enabling technologies is systematically relevant for the development of new services and goods needed to modernise EU industries towards a low carbon, knowledge-based economy.

6.3.2 Key issues to be addressed

Distributed energy resources and renewable energy

The potential benefits of distributed energy resources, virtual power plants (VPP) and their relevance for energy efficiency and reduction of emissions have been illustrated in Section 3.3. Both the survey results and the business examples, however, indicate the need to **better and further conceptualise, design and demonstrate the technical architecture and commercial implications of distributed energy resources (DER) and VPP**. From a technical point of view, the main challenge is inherent to the characteristics of distributed energy generation units, which mostly deal with renewable sources and are, therefore, dispersed and variable and have different technical profiles. The management of distributed energy resources, and most importantly their aggregation in a VPP, requires the adoption of ICT for **monitoring,** planning and management of the decentralised units. This includes a broad range of systems, e.g. to forecast generation and load capacity of renewable energy power plants, for data management, for demand management, including analysis and assessment of customers' purchase behaviour and contract management. Cost-optimal planning, **management and control of the units**, conformity with and integration into the grid, including adherence to planned schedules, are the main features that such decentralised energy systems must fulfil. They require the installation of measurement facilities, communication channels and remote control for all

[57] For more details see "Preparing for our future: Developing a common strategy for key enabling technologies in the EU" COM(2009)512.

the units involved. This calls for efficient ICT solutions that should be able to integrate and exploit the infrastructure already in place.

Energy efficiency

Section 3.5.2 illustrates that demand side management and demand response management can bring relevant benefits in achieving the goals of energy efficiency and, in turn, reduction of emissions. ICT can facilitate the efficient use of energy by helping energy suppliers to analyse consumption data and to stimulate consumers to respond to energy prices at specific times. The full deployment of demand side management and demand response management, however, is quite complex as it involves not only the supply side but requires active participation from the customer's side, with relevant organisation and technical implications. Business examples and the case study about Austin Energy (Section 5.5) indicate that both appropriate technologies have to be developed in the houses or at the interface with the aggregator, and relevant accompanying measures have to be studied to deal with societal, cultural and behavioural factors. On the technological side, a call for **actions could include: standardisation, i.e. open and agreed standards for integration of devices, harmonisation of regulatory framework and the development of business models demonstrating the benefits for the various stakeholders involved.**

Smart grids

The enablement of smart grids, a pillar of the EU's energy policy, needs to be supported by technological transformations (Section 3.4.3). This involves enhancing and upgrading of existing infrastructure, implementing new systems and improving integration throughout the ICT operating environment. As a smart power grid is essentially an intelligent electricity delivery system where power providers (TSOs and DSOs) and consumers are all connected and can interact in real time, it requires the widespread adoption of **ICT for monitoring, and control** There is a need for **open and agreed standards** for integration of **different tools and devices** in place. It is also necessary to improve architectures for integrating the data communications networks and the intelligent equipment in place. Besides mere technology, there is also a **need for** methods and tools that can assure **interoperability, flexibility, effective security and expandability** of the systems. Decision support systems to increase predictive reliability would also be needed.

As smart grids involve various players along the value chain, this calls for **coordination and harmonisation both at technical and at regulatory level.**

Smart metering

The findings of this report (Section 3.5.1) about the deployment of smart metering in the EU lead to **recommendations for actions addressing technical standards that may support interoperability between different systems and devices, and the definition of the required functionalities**. Smart metering may embed advanced functionalities, such as real time information to customers about pricing, remote change of tariffs, control of the usage of electrical devices inside the customer's premises. 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, as well as a data storage and processing system(s) capable of dealing with the large amounts of data. Data needs then to be integrated in other utilities systems: not only billing systems but geographic information systems (GIS), outage management systems (OMS), load forecasting/balancing, load research, distribution/facility design, 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 in case where micro-generation, such as PV, is installed. All this relies on the available ICT infrastructure, potentially including all the technologies that may support connectivity, for instance the Internet, the various wireless technologies, optical fibres. Interoperability of smart metering solutions is, therefore, a key to fully exploit the opportunity for expanded deployment and new added value services.

Exploiting ICT to reduce greenhouse gas emissions

From the analysis of this report about ICT and environmental impact, (Section 3.5) it appears that a relevant share of firms still do not fully exploit the potential of ICT in contributing to the reduction of environmental impacts. There seems to be an **awareness gap** that needs to be filled if the environmental goals of the EU policy are to be met.

6.4 Implication for policies arising from this study

ICT is part of the challenges faced by the ESI, as ICT operates within an economic, social and political framework that influences the development and the take up of technologies as well as the usage behaviour. Besides the need for the technological developments described in the previous section, a set of targeted actions and measures have been identified here that may help to realise the potential of ICT in tackling the energy and environmental problems.

Promote stakeholders' cooperation

The successful development and implementation of *smart* applications can only rely on the close cooperation of all the players involved, 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 industry, scientists, academia, public administrations and the consumers (both business and final). A few examples have been provided in this report, illustrating this issue (see Edison Consortium case study, Section 5.3). These include, for instance, the joint research effort needed for electric vehicles in developing technologies and standardisation of key elements such as plugs and charging station characteristics. This involves, among the others, the car manufacturers' cooperation.

Cooperation among stakeholders is not only necessary for technical developments and standardisation, although these remain the most important areas, but also for knowledge management and information sharing.

At policy level, therefore, it would be important to identify the opportunities for agreements and cooperation and to establish measures for favouring the actual involvement of the relevant stakeholders, for encouraging the development of better solutions and for dissemination of best practices. From this point of view, this study highlighted the role that local governments, under the umbrella of EU sustainability policies and targets, may play in pioneer projects, establishing frameworks that can be replicated on a larger scale. This is the case for instance of the implementation of smart grid and smart metering initiatives. The Austin Energy case study (see Section 5.5) 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 modes of stakeholders' cooperation is the private public partnership (PPP). At the time of writing this report, the publication of the European Commission's Communication on the Future Internet PPP is 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[58]. Initially funded under the ICT part 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. Based on the conclusions of this study, the launch of the PPP for the future internet with a focus on smart energy grids could provide a solution to many of the problems identified; the need for cooperative technological development and standardisation, the need for pan-European developments to facilitate diffusion at the EU level, the need to increase ICT-related research investments in a phase of scarce resources. Furthermore, a high-profile PPP could overcome the traditional European problem for research and innovation, that is 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

Most innovative and commercially immature energy technologies (among them the VPP examined in this report) may benefit from EU stimulus co-funding. This is related to the concern that normal market forces will not deliver technologies and solutions in time to reach the EU energy policy targets (low carbon, secure and competitive energy system). The key-enabling role of ICT in the implementation of these solutions needs to be highlighted upfront 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 most 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. This will not, however be achieved without action and appropriate policy support.

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[58] Viviane Reding, Internet of the Future: What policies to make it happen?, Future of the Internet Conference, Prague, 11 May 2009.

Promoting the adoption of common technical standards

The analysis carried out by this study provided consistent evidence for a need of action in the area of standards:

- **Standardisation of interfaces**, between different players, transmission service operators (TSOs), distribution service operators (DSOs), generation units, traders, customers, eliminating proprietary protocols that inhibit integration and management and development of critical communication standards. This should include efforts on standardisation of data formats and database management to facilitate data exchange across the entire value chain.
- **Interoperability standards** between various devices of different vendors. This may, for instance, facilitate supplier switch and deployment of smart metering in the EU.

It is not the role of 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 to be implemented to reach the energy policies objectives, the pressure to preserve existing investments and other facors it appears that the market and the ESI industry itself are encountering difficulties in setting the basis. The lack of standards and interoperability is hampering innovation: it is, for instance, one of the barriers highlighted by the study in the smart metering rollout.

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

Visibility and demand engagement

Increased visibility and awareness of the benefits that can be achieved through the usage of ICT should be considered as a pillar of energy policies. This, ultimately, should lead to a deeper engagement of the demand side, both businesses and consumers. The analysis in this report about demand side and response management demonstrated that the full deployment of such programmes is complex, as it requires active participation from the customer's side, with considerable organisational and technical implications.

There is a need of action for increasing visibility and awareness, including the development and dissemination of ICT-based platforms and users' tools. These could be used for widely informing consumers and other stakeholders about consumptions and emissions of various economic activities or for making available design and simulation tools, as well as for dissemination of best practices.

Interactive users' tools could also be developed addressing final consumers, based e.g. on Web 2.0 technology. The provision of feedback to users on their consumptions proves to be an effective means of reducing consumptions, as it is demonstrated by business examples about demand response management (see Section 3.5.2) and by the Austin Energy case study (see Section 5.5). The availability of user-friendly and easily accessible tools of this kind may significantly impact on behaviour changes and, ultimately, on the level of consumptions.

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 report pointed out that for some of most innovative ICT implementation analysed in this study (for instance VPP, but also smart metering) a positive business case is difficult to be proven. As far as smart metering is concerned, e.g., the distribution of cost and benefits among the various players along the value chain is a central theme. If investors may not be able to retain the full benefits of the roll out (for instance if suppliers invest in smart meters and the customer changes supplier afterwards), this limits the deployment of smart metering projects. The same applies to VPP. It is not yet possible to illustrate a standard architecture, nor there is consensus about costs and benefits of VPP, although the potential benefits appear to be potentially relevant. Therefore, an implication for policies arising from this report is that demonstration projects are needed for establishing and disseminating 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.[59] As for awareness actions, the development of business cases requires the active support and cooperation of the industry.

Contrast the ICT skills gap in ESI

This report highlights that ICT proves to support energy efficiency and favour the reduction of emissions but this requires the adoption of complex solutions and organisation changes within the ESI firms that rely on qualified skills. Another finding from research for this report is that ESI companies are actually experiencing difficulties both at recruiting skills and at properly exploiting their internal skills as for ICT. A skills shortage may hamper the full exploitation of the ICT potential in this industry. Therefore a finding from this study is that there appears to be a need for continuing actions and support to ICT education and training, especially in the areas where ICT can enable energy efficiency.

Overall conclusions

Supply of energy requires complex interactions of generation, transmission distribution and retail facilities, which can be greatly facilitated through information and communication technology (ICT).

ICT can facilitate efficiency of processes as demonstrated by both survey results and the case study on Enel's Mobile Work Force management. Most importantly the study proves that ICT supports the ESI's transformation towards a smart grid vision, active customer participation in the energy market, and a transition towards a low-carbon economy.

[59] Call ENERGY-2010-2.

The study highlights that stakeholder cooperation, demand awareness and engagement, standards and regulation are the key areas for policy intervention in this industry. Measures should include: private-public partnerships, support to RD&D on less mature technologies, development and dissemination of best practices.

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Annex I: SeBW Energy Supply Survey 2009 – methodology report

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. The survey of 2009 among companies from the energy supply industry consisted of 351 telephone interviews with ICT decision-makers in six EU countries. Interviews were carried out in March 2009, using computer-aided telephone interview (CATI) technology.

Questionnaire

The questionnaire contained about 70 questions, which were structured into the following modules:

- A: Infrastructure and ICT systems
- B: Automated data exchange with suppliers and customers
- C: Special computer systems for energy supply
- D: e-Business impact, drivers and inhibitors
- E: Innovation activity and the role of ICT
- F: ICT skills
- G: ICT investment and future trends
- H: Background information about the company

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 particular focus in this survey was to assess the use and impacts of computer systems and applications special to the energy supply industry.

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

The survey population was defined as companies with at least ten employees which used computers[60], were active within the national territory of one of the six countries covered, and which had their primary business activity in energy supply as specified by NACE Rev. 2 Groups 35.1-3. The following Exhibit A-1 shows the distribution of interviews across the different sub-sectors. 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.

60 Evidence from previous surveys shows that computer use can be expected to be 99% or more in all sectors among medium-sized and large firms.

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 A-1).

As highlighted in the exhibit, in the SeBW 2009 survey sample, the electricity sector accounts for about 60% of the surveyed population, while gas and heating/cooling represent 20% respectively.

Exhibit A-1: Population coverage of the e-Business Survey 2009 in the energy supply industry

No.	Sector name	NACE Rev. 2 activities covered	Population definition	No. of interviews conducted
1	Electricity	35.1	Companies using computers and having at least 10 employees	212
2	Gas	35.2		69
3	Heating/cooling	35.3		70

The composition of the sample by size class, mirrors the composition of the industry, where a large number of small companies operate. Large companies nevertheless dominate this industry and represent a large share of employment (see also Exhibit 2-7). For this reason and to better represent the picture in this industry, most of the data provided in the following sections are presented as employment weighted, i.e. representing % of employment in the sector in such a way to take into account the economic importance of businesses of different sizes in some way.

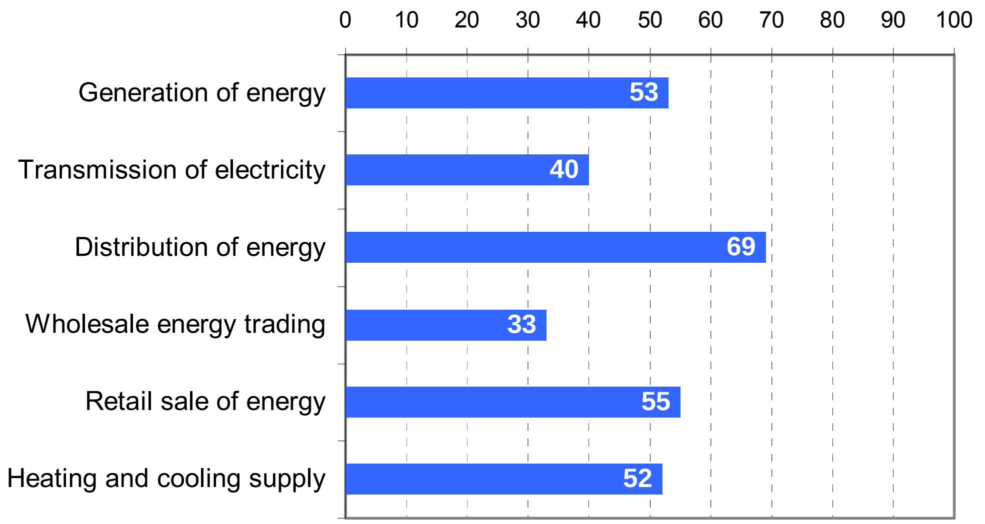
Exhibit A-2: Strata by company-size

Size-band	Quota	
	Target quota	Actual quota (int. conducted)
Micro enterprises (up to 9 employees)	--	--
Small companies (10-49 employees)	up to 55%*	46% (160)
Medium-sized companies (50-250 employees)	at least 35%*	38% (133)
Large companies I (250-999 employees)	at least 10%*	11% (40)
Large companies II (1000+ employees)	as many as possible	5% (18)

Out of the total sample, about 20% of the firms stated that they are part of an international group; this figure demonstrates quite a high degree of internationalisation of this sector.

The following exhibit (Exhibit A-3) illustrates the composition of the sample by business activity; it indicates that most companies interviewed are engaged in various activities along the ESI value chain.

Exhibit A-3: Activities carried out by interviewed companies (%)



Base (100%), All; N (Base, total) 351
Weighting: Figures for sector totals are weighted by employment ("firms representing x% of employment in the sector)

Source: SeBW-Energy Supply Survey 2009

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 by the German branch of Ipsos GmbH (www.ipsos.de) and conducted in cooperation with its local partner organisations (see Exhibit A-4) on behalf of the Sectoral e-Business Watch.

Exhibit A-4: Institutes that conducted the fieldwork of the e-Business Survey 2009 in the glass, ceramics and cement industry and number of interviews conducted per country

Country	Institute conducting the interviews	No. of interviews conducted
France	IPSOS GmbH, 23879 Mölln	20
Germany	IPSOS GmbH, 23879 Mölln	149
Italy	Demoskopea S.p.A., 20123 Milano	50
Poland	IQS and Quant Group Sp.z.o.o, 00-610 Warszawa	60
Spain	IPSOS Spain, 28036 Madrid	58
UK	IPSOS GmbH, 23879 Mölln	14
TOTAL		**351**

Pilot interviews prior to the regular fieldwork were conducted with about ten 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 A-5 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).

Exhibit A-5: Interview contact protocol, completion rates and non-response reasons

		DE	ES	FR	IT	PL	UK
1	Sample (gross)	1182	422	126	464	378	236
1.1	Telephone number not valid	83	0	10	32	13	32
1.2	Not a company (e.g. private household)	6	30	2	3	8	1
1.3	Fax machine / modem	1	0	7	2	0	1
1.4	Quota completed → address not used	1	19	0	16	9	0
1.5	No target person in company	74	3	26	26	19	27
1.6	Language problems	0	0	1	0	0	0
1.7	No answer on no. of employees	0	0	0	0	0	0
1.8	Company does not use computers	0	3	0	1	0	0
1.9	Company <10 employees	1	2	0	0	0	0
1.10	Not targeted sub-sector	16	16	11	2	2	7
	Sum 1.1 – 1.10	182	73	57	82	51	68
2	Sample (net)	1000	349	69	382	327	168
2.1	Nobody picks up phone	216	80	0	0	45	9
2.2	Line busy, engaged	0	0	1	0	3	0
2.3	Answering machine	*in Pos. 2.1*	0	*in Pos. 2.1*	0	5	*in Pos. 2.1*
2.4	Contact person refuses	216	130	35	56	81	79
2.5	Target person refuses	231	26	2	45	15	31
2.6	no appointment during fieldwork possible	1	0	1	9	9	30
2.7	open appointment	173	23	6	215	101	4
2.8	target person is ill / cannot follow the interview	1	0	0	0	0	0
2.9	Interview abandoned	13	32	4	7	6	1
2.10	Interview error (→ interview cannot be used)	0	0	0	0	2	0
	Sum 2.1 – 2.10	851	291	49	332	267	154
3	Successful interviews	149	58	20	50	60	14
	Completion rate (= [3]/[2])	**14.90%**	**16.62%**	**28.99%**	**13.09%**	**18.35%**	**8.33%**
	Average interview time (min:sec)	**17:20**	**15:51**	**17:23**	**18 : 15**	**21:06**	**14:24**

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 at (www.ebusiness-watch.org/about/methodology.htm).

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.[61]

- 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 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 A-6 gives some indication about the level of accuracy that can be expected for industry totals (based on all respondents) and for specific breakdowns, depending on the weighting scheme applied. The confidence intervals differ depending on the breakdown, the respective value and the weighting scheme; on average, it is about +/- 4 percentage points (firm-based weighting scheme) and about +/- 4-9 percentage points (employment-based weighting scheme). Confidence intervals are fairly small for totals and for the electricity sub-sector but higher for the gas and heating/cooling sub-sectors. Data for the gas and heating/cooling sub-sectors are therefore indicative and cannot claim to have statistical accuracy.

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 higher 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.

[61] 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.

Exhibit A-6: Confidence intervals

	Survey result	Confidence interval								
		if weighted as "% of firms"			if weighted by employment			Unweighted		
Energy total	**10%**	**7.5%**	**-**	**13.2%**	**5.7%**	**-**	**17.1%**	**7.7%**	**-**	**13.0%**
NACE 35.1 (Electricity)	10%	6.9%	-	14.2%	4.8%	-	19.7%	7.1%	-	13.9%
NACE 35.2 (Gas)	10%	5.3%	-	17.9%	2.8%	-	30.2%	5.5%	-	17.6%
NACE 35.3 (Heating/cooling)	10%	5.3%	-	18.1%	3.1%	-	27.7%	5.5%	-	17.5%
Energy total	**30%**	**25.9%**	**-**	**34.4%**	**22.2%**	**-**	**39.2%**	**26.1%**	**-**	**34.2%**
NACE 35.1 (Electricity)	30%	24.8%	-	35.8%	20.2%	-	42.1%	25.1%	-	35.4%
NACE 35.2 (Gas)	30%	21.5%	-	40.2%	14.5%	-	52.0%	21.8%	-	39.7%
NACE 35.3 (Heating/cooling)	30%	21.4%	-	40.3%	15.7%	-	49.7%	21.9%	-	39.6%
Energy total	**50%**	**45.3%**	**-**	**54.7%**	**40.8%**	**-**	**59.2%**	**45.6%**	**-**	**54.4%**
NACE 35.1 (Electricity)	50%	44.0%	-	56.0%	38.1%	-	61.9%	44.4%	-	55.6%
NACE 35.2 (Gas)	50%	39.9%	-	60.1%	29.9%	-	70.1%	40.3%	-	59.7%
NACE 35.3 (Heating/cooling)	50%	39.7%	-	60.3%	31.6%	-	68.4%	40.3%	-	59.7%
Energy total	**70%**	**65.6%**	**-**	**74.1%**	**60.8%**	**-**	**77.8%**	**65.8%**	**-**	**73.9%**
NACE 35.1 (Electricity)	70%	64.2%	-	75.2%	57.9%	-	79.8%	64.6%	-	74.9%
NACE 35.2 (Gas)	70%	59.8%	-	78.5%	48.0%	-	85.5%	60.3%	-	78.2%
NACE 35.3 (Heating/cooling)	70%	59.7%	-	78.6%	50.3%	-	84.3%	60.4%	-	78.1%
Energy total	**90%**	**86.8%**	**-**	**92.5%**	**82.9%**	**-**	**94.3%**	**87.0%**	**-**	**92.3%**
NACE 35.1 (Electricity)	90%	85.8%	-	93.1%	80.3%	-	95.2%	86.1%	-	92.9%
NACE 35.2 (Gas)	90%	82.1%	-	94.7%	69.8%	-	97.2%	82.4%	-	94.5%
NACE 35.3 (Heating/cooling)	90%	81.9%	-	94.7%	72.3%	-	96.9%	82.5%	-	94.5%

confidence intervals at α=.90

Annex II: Energy sector statistics by country

Exhibit A-7: ESI, number of enterprises by country (EU27 and Norway), 2005-2007

Countries	2005	2006	2007
EU 27	28000(e)	31378	n.a
EU 25 (e)	n.a	n.a	n.a
Austria	1417	1496	n.a
Belgium	156	164	176
Bulgaria	279	309	n.a
Czech Republic	1083	1090	n.a
Denmark	3828	3670	3671
Germany	3322	3305	3359
Estonia	262	268	269
Finland	1149	1236	n.a
Ireland	(c)	70	n.a
Greece	93	95	n.a
Spain	3543	6412	n.a
France	2649	2875	n.a
Italy	2643	2783	n.a
Cyprus	11	11	11
Latvia	308	296	n.a
Lithuania	277	274	n.a
Luxembourg	47	55	59
Hungary	651	710	n.a
Malta	n.a	n.a	n.a
Netherlands	515	550	565
Poland	2078	1933	1596
Portugal	676	704	756
Romania	484	507	615
Slovenia	371	396	n.a
Slovakia	207	209	194
Sweden	1379	1428	n.a
United Kingdom	507	529	n.a
Norway	*847*	*1093*	n.a
Legend: n.a.=not available; e=Estimated value; p=Provisional value; c=Confidential; U=unreliable/uncertain			

Source: Eurostat (SBS) 2009

Exhibit A-8: ESI, number[62] of persons employed by country (EU27, Norway and Switzerland), 2005-2007

Countries	2005	2006	2007
EU (27 countries)	16000(eu)	15981	n.a
EU (25 countries)	n.a.	n.a	n.a
Austria	31620	31459	30537
Belgium	24409	22789	25134
Bulgaria	58278	56747	n.a
Czech Republic	60721	56993	n.a
Denmark	17187	17089	16296
Germany	277710	276226	272464
Estonia	8553	8253	8046
Finland	14900	16067	n.a
Ireland	(c)	9018	n.a
Greece	24766	24318	n.a
Spain	65768	69653	n.a
France	195862	195113	n.a
Italy	117867	114856	n.a
Cyprus	1725	1760	1783
Latvia	16156	15060	n.a
Lithuania	26545	25378	n.a
Luxembourg	1029	1060	1082
Hungary	57204	54129	n.a
Malta	n.a	n.a	n.a
Netherlands	26885	24054	25010
Poland	205717	204353	n.a
Portugal	23483	23848	23906
Romania	149005	131384	126589
Slovenia	11695	11709	n.a
Slovakia	39980	38772	36303
Sweden	30008	30242	31467
United Kingdom	131498	136666	n.a
Norway	*14347*	*15268*	n.a
Switzerland	*n.a*	*n.a*	n.a
Legend: n.a.=not available; e=Estimated value; p=Provisional value; c=Confidential; U=unreliable/uncertain			

Source: Eurostat (SBS) 2009

62 The number of persons employed is defined as the total number of persons working in the industry: employees, non employees (e.g. family workers, delivery personnel) with the exception of agency workers. European aggregates (EU-27, EU-25) are expressed in 100.

Exhibit A-9: ESI, turnover by country (EU27, Norway and Switzerland), 2005-2007 (million Euros)

Countries	2005	2006	2007
EU27	800000(eu)	932431.0	n.a
EU25	n.a.	n.a.	n.a
Austria	17789.2	22709.3	23267.4
Belgium	29951.0	36263.0	36607.1
Bulgaria	4127.0	4662.0	n.a
Cyprus	542.7	635	664
Czech Republic	n.a.	20538.1	n.a
Denmark	15855.9	19125.5	17806
Estonia	1131.6	1197.1	1446.8
Finland	8987.0	11248.6	n.a
France	75967.7	84328.7	n.a
Germany	225394.6	267616.7	298905.5
Greece	4825.7	5362.1	n.a
Hungary	11472.1	12031.7	n.a
Ireland	(c)	5471.6	n.a
Italy	115786.8	142465.9	n.a
Latvia	812.5	1084.1	n.a
Lithuania	1783.7	1979.4	n.a
Luxembourg	1400.5	1887.8	2118.7
Malta	n.a.	n.a.	n.a
Netherlands	n.a.	37093.0	39303.1
Poland	29379.1	32935.7	n.a
Portugal	11769.8	12877.9	15942
Romania	9209.0	10564.4	12305.7
Slovakia	6384.7	7542.2	8601.4
Slovenia	2010.6	2379.2	n.a
Spain	53250.9	59177.4	n.a
Sweden	20558.2	23028.8	22608.5
Norway	*10668.3*	*13712.9*	n.a
Switzerland	*n.a.*	*n.a.*	n.a
United Kingdom	90673.6	108213.7	n.a
Legend: n.a.=not available; e=estimated value; p=provisional value; c=confidential; u=unreliable/uncertain			

Source: Eurostat (SBS) 2009