UTILITIES: POWERHOUSES OF INNOVATION

FULL REPORT

A EURELECTRIC Innovation Action Plan

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The **Union of the Electricity Industry–EURELECTRIC** is the sector association representing the common interests of the electricity industry at pan-European level, plus its affiliates and associates on several other continents.

In line with its mission, EURELECTRIC seeks to contribute to the competitiveness of the electricity industry, to provide effective representation for the industry in public affairs, and to promote the role of electricity both in the advancement of society and in helping provide solutions to the challenges of sustainable development.

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EURELECTRIC pursues in all its activities the application of the following sustainable development values:

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▶ Commitment, innovation, pro-activeness

Social Responsibility
▶ Transparency, ethics, accountability

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Interviewees have provided input in their personal capacity; their opinions do not necessarily reflect official positions of their companies or institutions.

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A EURELECTRIC Innovation Action Plan

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PREFACE

With our Innovation Action Plan, EURELECTRIC, the European power sector association, seeks to address innovation head on. This document presents our findings.

EURELECTRIC is engaging its members in a joint effort to elaborate a common industry-wide perspective on the power sector's transition to 2030 – the most significant changes ahead, the perceived threats and opportunities, and the overall shared vision of what the future sector will look like. As concrete support for discussion and decision-making, we have begun mapping what is required to enable successful change, in terms of both private sector initiatives and public policies. We have also critically assessed EU innovation policy and put forward recommendations for an improved policy framework to enable private sector engagement in the transition of the energy sector.

To guide the overall effort, EURELECTRIC set up a high-level Task Force, including utilities and equipment suppliers as well as independent experts. The Task Force has conducted a large number of interviews with experts, including utility Chief Technology Officers, energy and innovation policymakers, and innovation experts, in Europe as well as internationally.

EURELECTRIC is committed to working with Europe's power sector and policymakers to make the energy transition a success, with innovation as a high priority in our strategy.

Brussels, May 2013

EXECUTIVE SUMMARY

A decade into the twenty-first century, the EU power sector finds itself in the midst of transformative change. A low-carbon and more decentralised electricity generation system is emerging, while smart grid technologies are creating significant new capabilities. At the same time, conventional generation is under pressure, facing a decline in its future value. Change also is coming as a 'new downstream' service model based around energy efficiency offerings, decentralised generation, and new products and services, which are about to take off. Meanwhile, the EU is grappling with how to ensure this transformation achieves decarbonisation and energy security objectives whilst keeping costs at manageable levels.

These changes and pressures have propelled innovation to the fore in the power sector. From a relatively peripheral phenomenon, innovation now is central to fundamental shifts in power sector value creation as well as a precondition for achievement of societal objectives. All power sector participants – from equipment manufacturers to energy retailers – will need to find new ways to improve their products and manage their businesses. EU electric utilities are ready to play their part, and are increasing their investment in innovation.

There is no mistaking the significant potential value of power sector innovation. We estimate that accelerated innovation in power supply technologies and business models for energy efficiency could be worth 70 billion euro to the EU economy in 2030. Additional benefits are also expected in energy security, lower system costs, and consumer convenience. Conversely, if innovation were to slow, the adverse impact could deal a severe blow to EU growth and competitiveness.

Capturing the potential of innovation requires a dynamic power sector, acting within a strong enabling policy framework. The EU has come a long way in creating conditions for innovation. Yet much remains to be done to create the market setting in which innovation can thrive, and to steer public support for innovation effectively.

EURELECTRIC is committed to supporting power sector innovation in both areas – creating the market setting and steering public support for innovation to the most effective uses. Our key findings and recommendations are structured into the following sections:

- Deep and accelerating change makes innovation imperative
- Faster innovation could be worth 70 billion euro in 2030
- Capturing the potential depends on an agile private sector
- Five actions to improve EU enabling of energy innovation.

DEEP AND ACCELERATING CHANGE MAKES INNOVATION IMPERATIVE

The past decade saw changes that left no part of the EU power sector untouched. In a survey of utility executives conducted by the EURELECTRIC Task Force in the context of this study, several themes stand out. To name but a few:

- New renewable energy sources (RES) have advanced from a relatively minor phenomenon to a large majority of 70% in new capacity additions.
- Decentralised RES have or has also emerged as a major force, as more than 3 million Europeans started generating their own electricity.
- Continued liberalisation and market integration have redefined utilities' operating environment, as unbundling and retail competition enable increasing customer engagement.
- The EU has also started laying the foundation for a smart grid, with the installation of 50 million smart meters.

Looking ahead, there is every reason to believe that change will continue and indeed accelerate. EU objectives for continued decarbonisation have set a fundamentally new frame for the sector, complemented by concerns over energy security as well as the overarching need to keep power affordable and the EU economy competitive. Against this backdrop, strong technology trends and new customer demands will significantly expand the set of options available to the sector.

As this change plays out, the EU power sector faces a significant reconfiguration of its sources of value. The current mainstay of conventional generation already has begun to shrink, and little growth can be expected in the next decade.

Traditional utilities feel the impact of this challenge, including through lower and more volatile returns to shareholders. Yet there is a silver lining, as new potential sources of value are emerging, both in large-scale generation from low-carbon sources, and in the new opportunities downstream. The sector will see net growth, but from a very different set of opportunities than in the past.

- **Generation will continue to shift heavily towards low-carbon sources, but with an uncertain future mix.** The EU's long-term targets for decarbonisation require a substantial increase in generation from low-carbon sources by the 2030s. Yet the future generation mix is still highly uncertain. The pace of technology development is fast, spanning multiple rival technologies with different system characteristics and different stages of maturity. It currently appears fair to say that RES will co-exist, with some geographic concentrations, rather than running a "winner takes it all" race. Long-term, the EU will likely need to advance beyond solar and wind towards a wider set of low-carbon sources. The past decade has certainly taught us how quickly new technologies can enter into the mix once costs fall, and financing and regulatory structures are put into place.

- **New downstream offerings could provide new services and transform the approach to energy supply towards a service-based model.** New downstream opportunities are emerging as a number of technologies are on the brink of mass-market take-up. A large set of opportunities across energy efficiency, decentralised generation technologies, and the electrification of transport and heating/ cooling are at or near commercial viability. The next step in capturing their potential is innovation to enable mass-market take-up. In addition, a range of new services built on smart grid functionality will emerge. These developments will benefit customers, and the take-up wave is likely to represent a major advance towards policy objectives for increased energy efficiency and low-carbon supply through decentralised RES generation sources.

Cumulatively, the changes have profound implications for the power sector by redefining fundamental operating parameters:

- **Decarbonisation objectives and resource scarcity are at the centre of new sources of value.** The new sources of value have been created to a large extent through regulatory intervention, especially for decarbonisation. Added to this, high and volatile fossil fuel prices create much of the underlying drive for both RES and energy efficiency.

- **The new technology mix will be highly capex-intensive.** Compared with the current model of electricity supply and consumption, new generation sources as well as energy efficiency solutions require high upfront capital expenditures (capex). New institutions and business models that enable investment on the required scale will be critical to the sector's transformation.

- **Innovation will be at the heart of the transformation.** The new sources of value depend on innovation, understood in the words of the European Commission (EC), as *'change that speeds up and improves the way we conceive, develop, produce and access new products, industrial processes and service'*.[1] Innovation will thus cover the spectrum from technology cost reductions and process performance improvements to new business models, and new service and product offerings to end-users.

FASTER POWER SECTOR INNOVATION COULD BE WORTH 70 BILLION EURO TO THE EU ECONOMY IN 2030

In the EU, financing the power sector transformation is starting to put pressure on companies and consumers, as well as and public budgets. By 2012, European consumers were paying a total of 38 billion euro per year in subsidies for renewable electricity. Support schemes that seemed affordable with smaller volumes of renewables have been difficult to maintain in the protracted economic downturn. Overall, the EU is still feeling its way in balancing decarbonisation and security of supply objectives against the need to manage the increasing cost burden, an essential goal to put Europe back on track to solid economic growth.

Increased innovation has the potential to contribute significantly to resolving the three-way dilemma of decarbonisation, security of supply, and economic viability.

1 European Commission, Press Release Innovation Union. http://europa.eu/rapid/press-release_MEMO-10-473_en.htm?locale=en

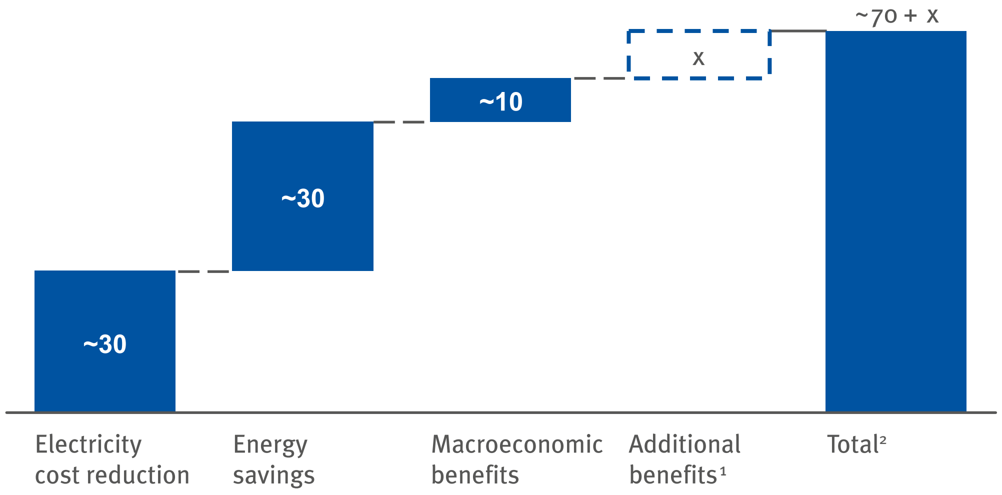
Two mechanisms stand out as particularly important:

- Lower power supply costs: faster technology development could enable extensive continued cost reductions in renewable and other low-carbon electricity generation technologies
- Increased energy efficiency: a switch to a service-based model of energy supply could unlock mass-market adoption of cost-effective energy efficiency technologies.

Initial estimates suggest that breakthrough innovation in these areas could be worth 70 billion euro to the EU economy in increased GDP in the year 2030, or 135 EUR per capita. The additional value would be shared by a range of beneficiaries of innovation: households and companies consuming energy, electric utilities and other companies in the electricity supply chain, and various other actors throughout the wider economy. The new sources of value would be shared by a range of beneficiaries of innovation: households and companies consuming electricity, electric utilities and other companies in the electricity supply chain, and various actors throughout the wider economy. These estimates are based on comparing and contrasting a reference case and high-innovation case for technology cost and energy efficiency capture, using detailed bottom-up models of EU electricity generation costs as well as energy efficiency potential. Electricity cost reductions and energy savings would have a combined value of 60 billion euro in the year 2030. The benefits could be even larger when wider macro-economic effects are considered, including improved competitiveness .

Accelerated innovation in the EU power sector could be worth 70 billion EUR in 2030

Additional EU27 GDP in the year 2030, EUR billion (estimates)



1 Additional innovation benefits not included in this calculation could include reduced costs of balancing the power system, improved consumer convenience and value, additional economic benefits or contributions to EU objectives through accelerated electrification of transport and heat, and clean technology and other business opportunities that could be captured by European industry in the context of an expanded global market.

2 The estimate is of additional gross domestic product, and in total corresponds to 135 EUR per capita in 2030. The benefits would be shared between households and companies consuming energy, electric utilities and other companies in the electricity supply chain, and various other actors throughout the wider economy.

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

These estimates show the importance of power sector innovation. Yet they also omit important additional benefits. Increased innovation also could result in reduced costs of balancing the power system, improved consumer convenience and value, additional economic benefits or contributions to EU objectives through accelerated electrification of transport and heat, and opportunities for EU industry in the context of an expanded global market.

CAPTURING THE INNOVATION POTENTIAL DEPENDS ON AN AGILE PRIVATE SECTOR

The shift in value creation and drive created by policy objectives creates strong innovation imperatives across the power sector. Power sector participants, including utilities, need to innovate on three fronts:

- **Master new technology.** Continued technology development will put an increasing number of technologies within market reach, across electricity generation, power networks, energy efficiency, and end-use applications. Power sector participants will need not only to find the means to finance solutions that require higher capital expenditure upfront, but also to translate technologies into workable end-user offerings in the context of the overall power system.
- **Get close to customers.** The general customer trends observed in developed economies as a whole will also affect the power sector. Specifically, more aware and engaged, customers will demand socially and environmentally responsible practices, place a higher value on convenience and experience, and use more complex criteria for their purchasing decisions. A private sector capable of understanding and responding to these needs will be an important source of innovation in the power sector to ensure consumers benefit from the changes ahead.
- **Develop new business models and services.** The power sector may stand before a significant change in the way energy needs are met. The key will be new business models that simultaneously offer greater financial benefits and improved convenience than the current grid-based supply model. To judge by other sectors, such as telecommunications, future power sector business models could be based on a range of solutions to meet energy service needs, such as heating or cooling comfort, mobility, or lighting. New end-use technology will help, while smart grids and Big data will be indispensable enablers. Future business models could be based on revenue per customer rather than volumetric supply.

Cumulatively, these requirements amount to far-reaching change. Much of the success of the transition thus depends on power sector participants – from equipment manufacturers through to energy retailers – stepping up to innovate their products and the way they manage their business and serve their customers. Innovation at heart will be a private sector creation.

EU utilities will be active participants in this change. In the past, it may have seemed that the EU power sector was slow to embrace change and taking a reactive approach to trends such as increasing opportunities for RES or new downstream opportunities. There are signs that this is starting to change. Utilities now account for a majority of the current pipeline of new large-scale RES capacity. Moreover, EU utilities have nearly doubled their expenditure on R&D in the past decade. A survey of EU utility executives conducted by EURELECTRIC confirms that innovation is becoming a priority for EU utilities.

FIVE ACTIONS TO IMPROVE EU ENABLING OF POWER SECTOR INNOVATION

An important goal of European energy policy is to facilitate a cost-efficient transition to low-carbon power generation, not least in times of economic downturn. Innovation is indispensable to achieving this goal. The European Commission acknowledged this in its Green Paper on the 2030 climate and energy policy framework, stating it will have to ‘recognise the evolution of technologies over time and promote research and innovation’. EURELECTRIC fully supports this recognition.

Yet innovation never flourishes in isolation. It depends on an enabling setting: both a business environment that spurs and rewards private-sector innovation, and a public policy framework for investing in innovation where the business case needs initial support. To begin mapping what is required to enable successful change, the EURELECTRIC Innovation Task Force has assessed EU innovation policy and developed the following five recommendations for an improved policy framework to enable private sector engagement.

1. Adopt a systems approach

Innovation policy should recognise the increasingly important systems nature of the power sector. Power is going from a linear supply-demand model towards a model where power consumers become producers ('prosumers'), one-way electricity and information flows become bidirectional, decentralisation challenges and complements the old centralised architecture, and closer real-time management becomes feasible as well as necessary to handle more variable generation. To enable successful innovation, policy must also reflect this shift to more closely intertwined elements, including links between to other sectors and to other forms of energy:

- **Make innovation policy a strategic tool of energy policy.** The innovation and overall energy policy agenda need to be seamlessly integrated. The policy mix needs to shift to one that better recognises the long-term potential of innovation as a complement to more near-term targets or aims.
- **Adopt a systems approach and broad view of innovation.** On the R&D side, the current EU approach based around

Five actions to improve EU enabling of power sector innovation

1	**Adopt a systems approach.** Innovation policy must become a tool of energy policy, avoiding focus on individual technologies in favour of an expanded and integrated perspective encompassing interconnected impacts on the overall power system.
2	**Nurture public-private dynamics.** The public and private sectors have to work hand in hand to reinvent the power system. Policymakers should harvest the low-hanging fruit: innovation through a competitive, business-friendly, and risk-rewarding market framework.
3	**Prioritise demonstration and commercialisation.** Demonstration and early deployment are indispensable parts of the power sector innovation chain. Further support mechanisms are needed to complement R&D support.
4	**Unlock downstream innovation.** Policy should move quickly to put in place the enablers of a 'new downstream' set of services and offerings: a competitive and fully liberalised market, innovation-friendly regulation, and enabling smart grid infrastructure.
5	**Create supportive governance for the innovation union.** Innovation would benefit greatly from better coordination and governance of both EU-level and Member State support mechanisms, starting with improved joint programming and pooling of resources.

the SET Plan was a welcome step forward but now needs updating, going from an approach based around individual technologies to one that incorporates wider systems issues, cross-sectoral applications, and regional implications. Support is needed not just for technology development, but across business models, processes, and products.

2. Nurture public-private dynamics

RD&D on its own will not support innovation in the power sector. Much critical innovation activity takes place beyond the point of R&D and demonstration – throughout commercialisation, early deployment, and market scaling. Moreover, public funding can only ever be a small share of total RD&D investment, so where the market cannot provide it, policy must create the private business case for investment in innovation.

The public and private sectors thus have to work hand in hand to reinvent the power system successfully, given the EU's renewable energy targets, the need to explore currently immature technologies, and the protracted economic slowdown. Policymakers should harvest the low-hanging fruit: innovation through a competitive, business-friendly, and risk-rewarding market framework. The approach should build on the EU Emissions Trading Scheme (ETS) rather than work around it or against it.

- **Restore the EU ETS as the long-term engine for the market for low-carbon solutions.** The ETS alone has pan-EU reach and preserves technology neutrality that ensures competition between rival solutions. Without this mechanism, other attempts at creating the market requirements for low-carbon innovation are inevitably undermined. The EU should act as soon as possible to ensure an effective carbon price is restored.
- **Tailor demand-side policies to innovation discovery and market adaptation as opposed to mass deployment.** Market support mechanisms (for RES, energy efficiency, or otherwise) should emphasise the value of discovering more about the future potential of currently immature technologies and business models. The tendency towards 'picking winners' needs strong corrective mechanisms to set transparent output-based targets and to preserve competition between different approaches.
- **Expand the innovation policy toolset.** Explore promising additional mechanisms to create a market setting for innovation, such as public procurement. Give a bigger role to public-private partnerships to capture private-sector insight and enable better risk-sharing.
- **Invest in the future.** The past decades saw a deprioritisation of support for energy R&D. Recent growth in funds has been welcome, but at current rates, it will take 20 years for energy RD&D in the EU to reach the priority (as a share of GDP) that it had at the tail-end of the 1970s oil crises. Any steps that can be taken to accelerate the catch-up will also contribute to the long-term cost-effectiveness of achieving current policy objectives.

3. Prioritise demonstration and commercialisation

Demonstration and early deployment are indispensable parts of the power sector innovation chain. Not only does demonstration enable real-world validation of emerging R&D findings, but when integrated within an effective overall innovation policy, it also is a crucial step towards commercialisation and subsequent widespread deployment.

Yet, lack of support for demonstration risks is becoming a significant bottleneck to power sector innovation. To remedy this, EURELECTRIC recommends the following steps:

- **Make demonstration and early deployment a priority.** EU-level policy needs to put demonstration on a secure institutional footing, avoiding recent problems in the NER300 of the uncertainty of ad-hoc programmes, lack of coordination with Member States, and failure to follow through with effective market support. Set the aspiration to **double the 15% share** of national RD&D support currently allocated to demonstration, to avoid creating an innovation bottleneck.
- **Expand support for commercialisation.** Support through venture-style mechanisms could enhance the impact of EU efforts. The EU can learn from influential efforts in

other countries, for example, the ARPA-E programme in the United States.

4. Unlock downstream innovation

There is significant potential value in downstream innovation: new services to meet end-user needs as well system needs, increased contribution towards decarbonisation and energy security objectives, and new sources of value for companies. Many uncertainties about how the downstream opportunity will unfold still exist. What is certain is that much of the most promising future innovation in downstream business models and new services depends on two crucial components: a vibrant market and effective smart infrastructure.

- **Promote competition and tailor regulation conducive to innovation.** Competition is often neglected as a key driver of innovation. The EU should continue to push for effective deregulation in retail markets, avoiding unnecessary price regulation and restrictions on offerings to end-users that will stand in the way of innovation. Market design needs to remain open to multiple approaches to meeting system needs. The EU also should create enabling regulation for Big data, improving certainty and clarity in fields including data security, data privacy, cross-border applications (the cloud), and cyber security.
- **Put in place the infrastructure required for downstream innovation.** Limitations on grid functionality risk becoming an obstacle to downstream innovation as well as effective systems management. If a new downstream market is to develop, however, the enabling smart infrastructure needs to be built ahead of time, providing the enabling setting for continued innovation. This requires EU-wide smart grid standards and better DSO incentives for innovation. At the same time, distribution system operators (DSOs) need sufficient space for investment. Cost-benefit analyses evaluating the investment case for smart grids need to move beyond narrow focus on current applications and benefits and recognise the potential value from future innovation.

5. Create supportive governance for the innovation union

The EU should coordinate its RD&D policies and spend scarce resources prudently, both at national and central EU level. Member States' resources are dedicated to national industrial policy needs and are often not aligned with the joint EU innovation agenda and energy strategy. The result is fragmentation and duplication of efforts.

- **Increase the coordination and functioning of programmes.** The fragmentation of EU and Member State initiatives risks undermining their effectiveness. The EC and Member States should put in place more effective mechanisms to enable Member State coordination and 'joint programming'. EU programmes should improve coordination of initiatives promoted by different Directorates General, and also coordinate power-related RD&D with programmes in other sectors, including ICT and transport.

For the power industry, innovation will be the critical enabler that unlocks new sources of value in the decades to come. More than ever, a thriving industry will depend on finding new ways to improve products and to serve increasingly engaged customers. For policymakers, innovation will be the key to achieving decarbonisation and energy security objectives at acceptable cost. Innovation should, therefore, always be a 'top of mind' goal and inspiration when establishing the wide range of policies that affect the power sector and its customers.

1 THE POWER SECTOR IN EUROPE IS UNDERGOING ONE OF THE MOST PROFOUND CHANGES IN ITS HISTORY

THE POWER SECTOR IN EUROPE IS UNDERGOING ONE OF THE MOST PROFOUND CHANGES IN ITS HISTORY

The EU power sector is going through one of the most profound changes in its history. Today's EU power sector differs in fundamental respects from its profile of just 20 years ago (Figure 1). Yet even a decade ago few observers would have predicted how far-reaching the changes would be.

These changes link back to the three waves of transformation that have shaped the power sector in Europe:

- **1990s: liberalisation and privatisation created a new model for electricity supply.** The decade saw the establishment of generation markets based on competitive principles, in part enabled by gas-fired power generation with smaller units than their coal and nuclear peers. The 1996 EU directive and numerous national initiatives helped set the pace. By the early 2000s, the EU had seen an entire new private utility industry created in several Member States. This was followed by gradual downstream unbundling and the introduction of retail competition. These influences have continued to shape the sector throughout the last decade.
- **2000s: plans to reduce greenhouse gas emissions.** A second wave of change followed upon the EU's adoption of the Kyoto Protocol in 1997. The European Climate Change Programme was in place by 2000, culminating later in the decade in the establishment of the EU Emissions Trading Scheme as well as directives to set targets for renewables. A decade on from Kyoto, RES accounted for the majority of new capacity additions in the EU. In several markets renewables generation reached volumes that affected the functioning of the power system.
- **Late 2000s: an imperative for increased resource productivity.** In the 2000s, unprecedented worldwide economic growth in emerging markets created new demand pressures across a range of resources, not least energy. By the end of the decade, commodity prices were not only higher, but also more volatile and more correlated with each other than before, sharpening the concern with energy security. Meanwhile, technological development has brought higher level of productivity as well as new energy resources within more realistic reach, ranging from energy efficiency to various forms of renewable energy.

In a survey of utility executives conducted by the EURELECTRIC Task Force in the context of this study, respondents identified the top ten factors that have shaped the power sector in the past decade which acknowledges the changes that have just been described (Figure 2).

FIGURE 1

Transformation of the power sector in the last decades

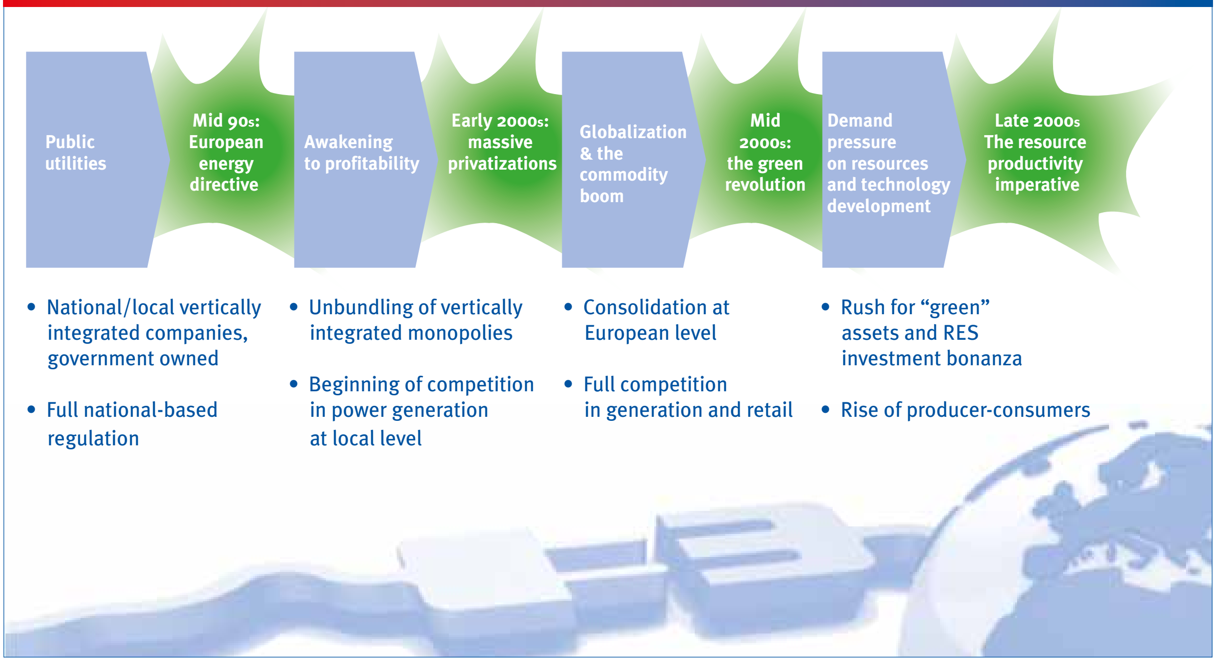
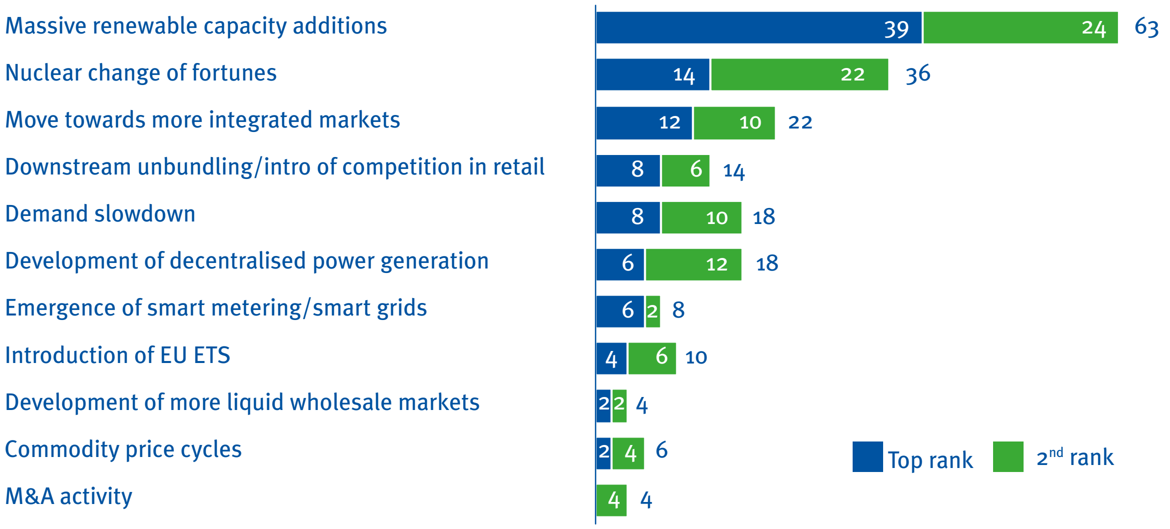


FIGURE 2

Utility executives saw a range of powerful trends acting on the sector in the last decade, with new renewables the single most powerful influence

Utility executives ranking of trends impacting the power sector in the last decade
% of respondents



Source: EURELECTRIC Innovation Action Plan Survey, December 2012

The entry of new renewables emerges as the most important change of the past decade. More than 60% of utility executives point to this as the single most important discontinuity in the past ten years. Other trends given high importance rankings by respondents included the change of fortune of nuclear power, and the move towards more integrated markets as well as downstream unbundling/retail competition.

Of these trends, survey respondents identified four as ones that will be particularly important for future developments and innovation across the power sector:

- The **increase in RES capacity**, and the associated fast pace of technological advances as well as new requirements for overall system arrangements.
- The move towards **a more decentralised power system**, and the resulting shifting role of end-users in the power system.
- The creation of the **foundation of a smart grid**, notably through the deployment of smart meters.
- The introduction of **retail competition** and resulting pressures for electricity suppliers to find new business models to engage with more active customers.

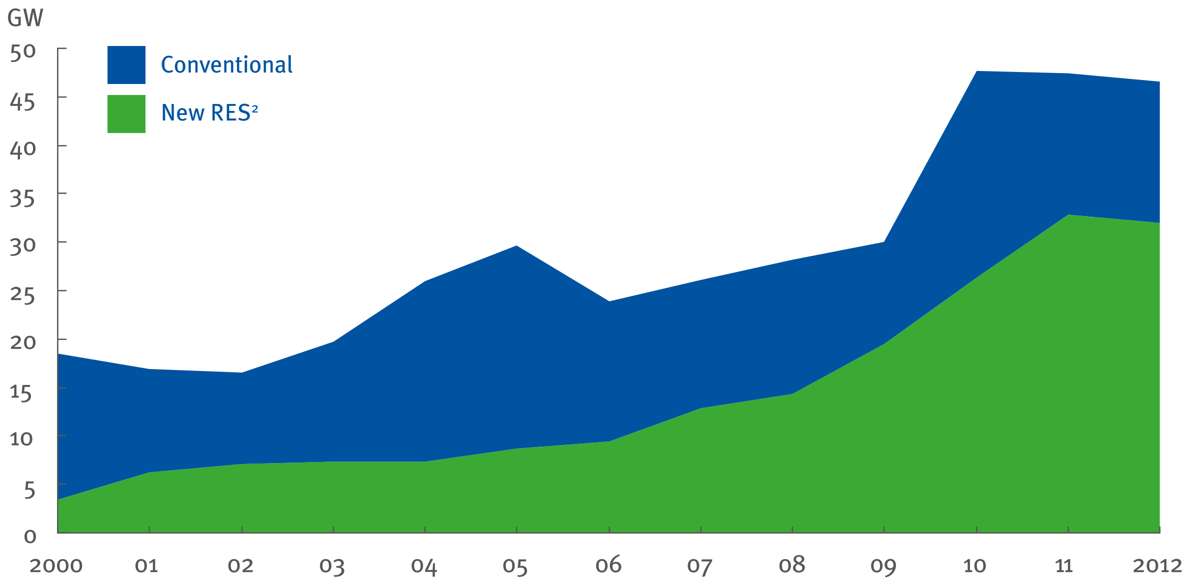
We discuss each of these four in more detail below.

NEW RENEWABLE TECHNOLOGIES HAVE DRAMATICALLY INCREASED THEIR SHARE IN INVESTMENT AND GENERATION

Over the past decade, the technologies dominating the EU power system have shifted from nuclear, hydro, coal, and gas, to a situation in which new capacity has overwhelmingly been directed towards new renewable energy sources: biomass, wind, and solar. At the start of the decade, conventional fossil generation accounted for 80% of new capacity. A decade on, and the shares had nearly reversed, with new RES accounting for 70%. As much new RES capacity as conventional has been added since 2000, with additions amounting to a total of 190 GW from wind, solar, and biomass (Figure 3).

FIGURE 3

Renewables account for the large majority of recent capacity additions in Europe[1]



1 Includes EU27, Norway and Switzerland
2 New RES comprises wind, solar, biomass

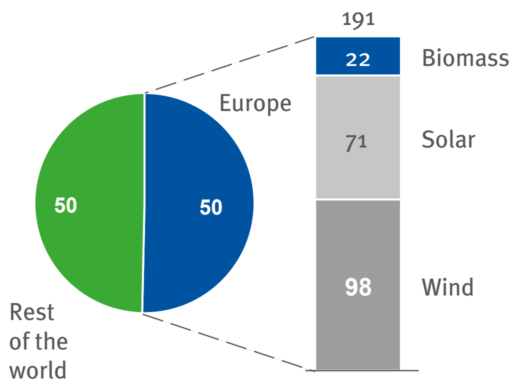
Sources: Platts Powervision; Enerdata; EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 4

Europe is leading in renewables capacity additions and wind turbines manufacturing

Europe[1] is leading in renewables installations...

Renewable capacity installations, 2000-12
Share of global installations – GW installed



... and wind turbines manufacturing

Top wind turbines manufacturers
ranking by MW supplied globally in 2012

European companies

GE Wind	1
Vestas	2
Siemens	3
Enercon	4
Suzlon group	5
Gamesa	6
Goldwind	7
United Power	8
Sinovel	9
Mingyand	10

1 Includes EU27, Norway and Switzerland

Sources: EWEA, Enerdata, EPIA, GlobalData, BTM, EURELECTRIC Innovation Action Plan Taskforce analysis

THE POWER SECTOR IN EUROPE IS UNDERGOING ONE OF THE MOST PROFOUND CHANGES IN ITS HISTORY

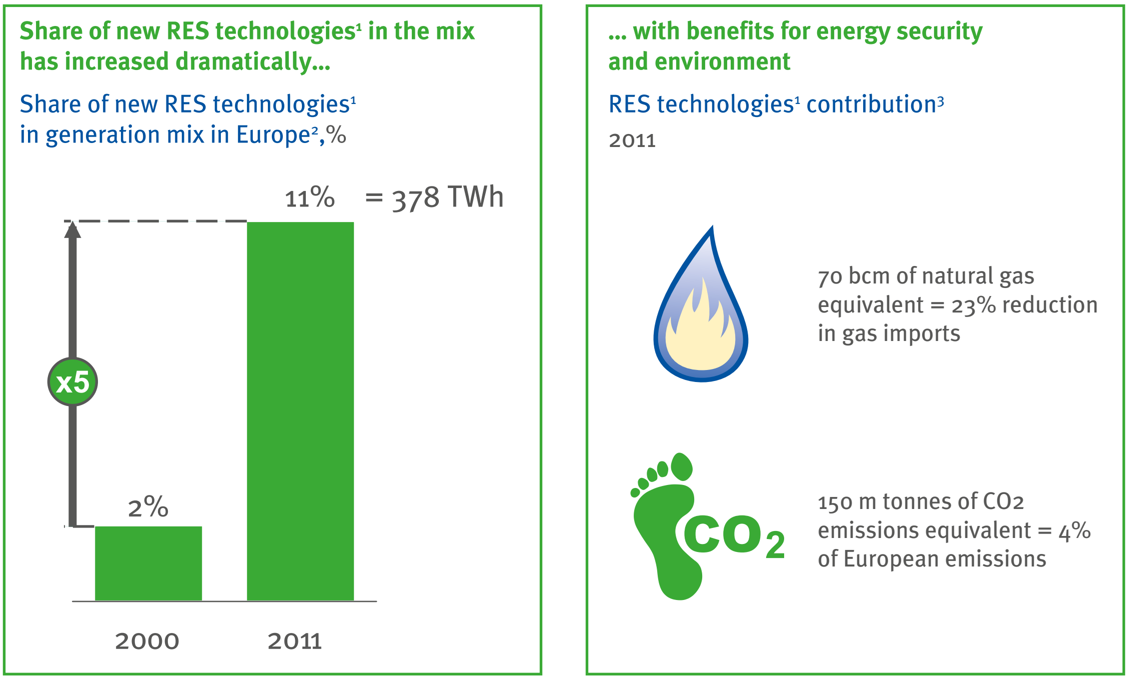
The EU is the largest market for these technologies by far, accounting for half the global total. By the end of the decade, Europe also was home to some of the leading renewable equipment manufacturers, especially in wind power (Figure 4). In solar PV, however, the EU did not keep its previous leading position in manufacturing.

Whereas generation capacity investments were previously undertaken nearly exclusively by electric utilities, the emergence of new RES has brought a number of other categories of investors onto the scene:

- Equipment manufacturers: the expansion of new RES has seen several examples of equipment manufacturers expanding their business by taking joint ownership of generation capacity, most notably in the case of wind power but also for some solar PV.
- Construction companies: as wind power in particular requires significant skill in the execution of large construction projects, companies with strengths in this area have also started to enter as joint owners of new capacity.
- Operation and maintenance providers: the new generation types require a new category of providers of operation and maintenance services. Several of these have seized the opportunity to take an ownership stake in the underlying generation assets.
- Financial investors: with public incentive schemes creating high yields and often low-risk returns, a range of financial investors has been attracted to investing in new RES – including pension funds, infrastructure funds, sovereign wealth funds, private equity firms, and investment banks.

FIGURE 5

The share of new RES in the generation mix has increased five-fold with energy security and environmental benefits



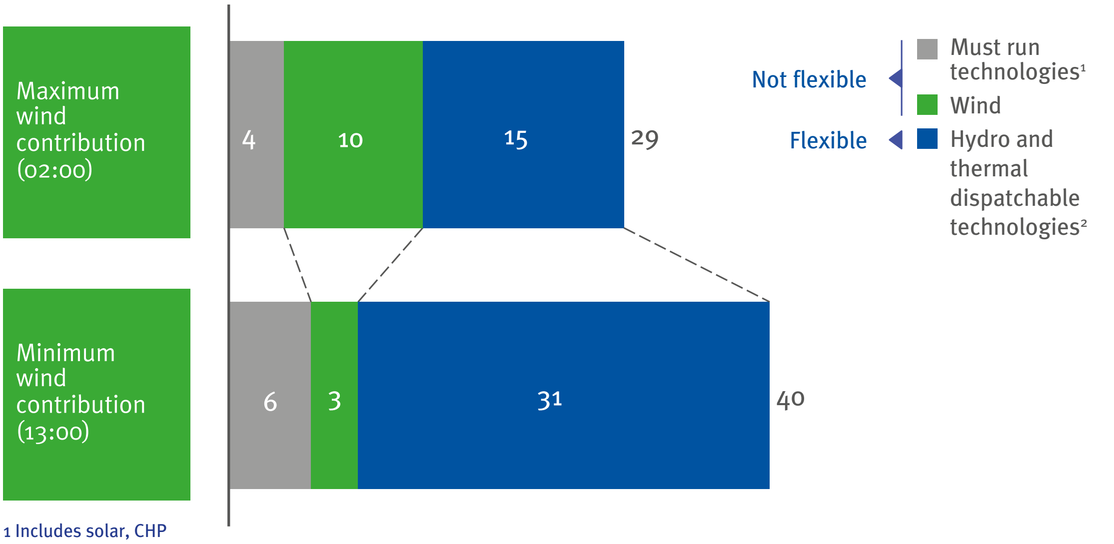
1 RES comprises wind, solar, biomass
2 Includes EU27, Norway and Switzerland
3 assuming gas fired generation with 50% efficiency is displaced and without taking into account indirect impact via ETS

Sources: Enerdata, JRC, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 6

Flexible hydro and thermal assets compensate for the variability of wind power generation

Total hourly production, GW; Spain example 15/02/2011



1 Includes solar, CHP
2 Includes gas, coal, nuclear. Nuclear production was constant in this instance but nuclear plants can also operate with flexibility when needed

Source: Red Eléctrica de España, EURELECTRIC Innovation Action Plan Taskforce analysis

- New entrant electricity suppliers: the new investment opportunity has stimulated the creation of new electricity supply companies, often based around a portfolio of green energy sources.

Steady new RES capacity growth has also triggered changes in EU electricity generation. The share of new RES increased more than five-fold, from 2% in the year 2000 to 11% in 2011. While still modest in the aggregate for the EU as a whole, individual countries have seen significant impact: new RES reached a share of 31% in Denmark and 21% in Spain and in Portugal jointly by the end of the decade. This volume has started having a material impact not just on targets for RES deployment, but also on the other EU energy policy objectives of energy security and emissions reduction (Figure 5).

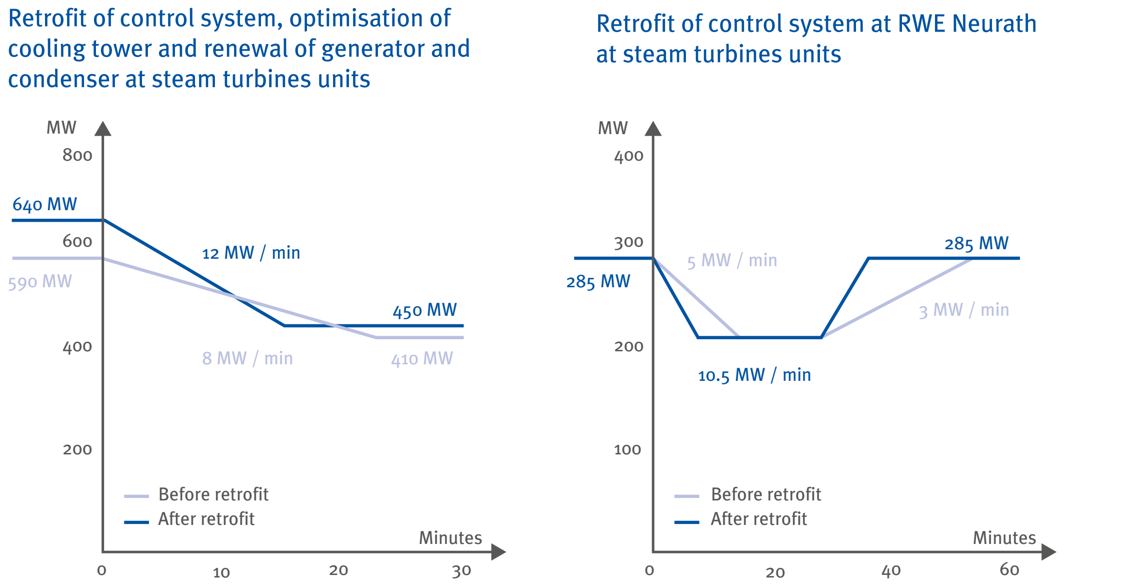
By the end of the decade, the costs of new RES investment were also making themselves felt for end-users. Surcharges on end-user bills to finance feed-in tariffs or other new RES support mechanisms grew to substantial levels in some countries. In several countries, the cost of renewables incentives added 15% to a typical household bill.

At the same time, new RES entry put pressure on conventional generation as well as on the operation of electricity systems. Utilities found themselves in the role of safeguarding system stability by providing essential flexibility in generation – often using plant originally intended for baseload generation (Figure 6). Some 13 GW of flexible hydro capacity has been added in Europe since 2000, and owners of gas plants have undertaken investments to make existing thermal assets more flexible (Figure 7).

FIGURE 7

Utilities are undertaking investments to make their power plant fleet more flexible

Examples

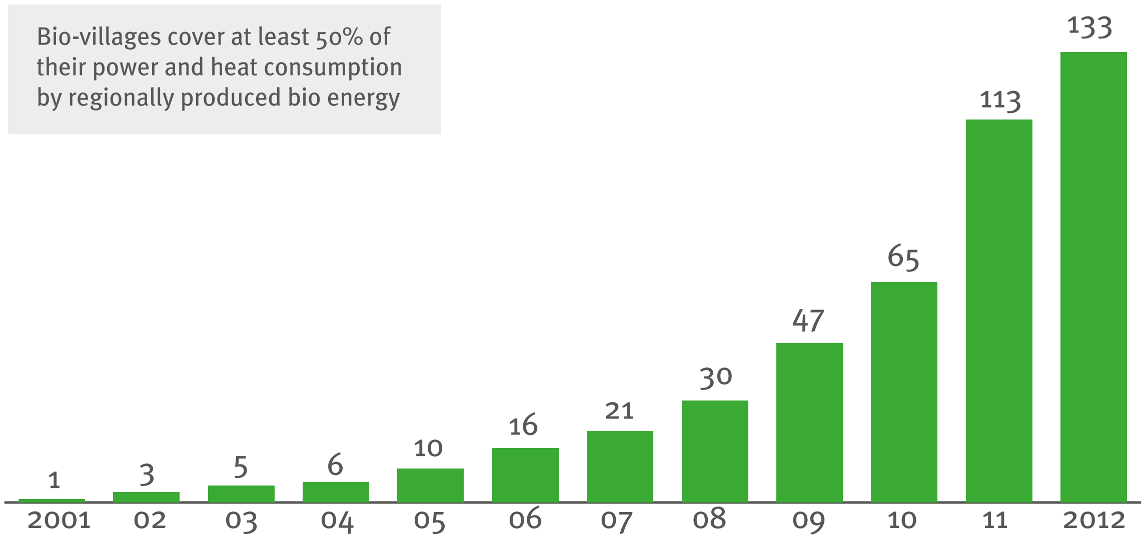


Source: RWE

FIGURE 8

“Bio-energy villages” have emerged as a significant phenomenon in Germany

Number of bio-villages in Germany



Sources: Ministry of Food, Agriculture, and Consumer Protection, Agency for Renewable Resources, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 9

16 European countries have plans to roll out smart meters in the next 10 years

Sweden	*Completed*	2003	2009
Italy	*Completed*	2000	2011
Finland	*Mandated*	2009	2013
Malta	*Mandated*	2010	2013
Spain	*Mandated*	2011	2018
Austria	*Under discussion*	2012	2018
Poland	*Under discussion*	2012	2022
Estonia	*Mandated*	2013	2017
France	*In Planning Stage*	2013	2019
Luxembourg	*Mandated*	?	2018
Romania	*Under discussion*	2013	2022
Norway	*Mandated*	2014	2017
Great Britain	*Mandated*	2014	2019
Netherlands	*In planning stage*	2014	2019
Denmark	*Under discussion*	?	2020
Ireland	*Under discussion*	2012	?

Sources: European Commission, DG Energy, EURELECTRIC Innovation Action Plan Taskforce analysis

GENERATION SYSTEM HAS BECOME MORE DECENTRALISED

In parallel with the increase in large-scale new RES, the European power sector has started moving towards a more decentralised model of power production. Small generation units with capacities of below 10 MW grew significantly in prominence, from around 10 GW in the year 2000 to more than 70 GW currently installed. The strongest factor behind this change was a boom in distributed solar PV. At the end of 2012, Europe had an installed base of 59 GW, 70% of the global total. Other micro-generation solutions also emerged, ranging from wind turbines to small-scale combined heat and power units.

Smaller generation units have created new ownership structures for electricity generating capacity. More than 3 million households have started to produce their own electricity using solar PV. Also, an increasing number of communities are building their own generating capacity. As an illustration, 'bio-energy villages', where more than half of the power and heat consumption is sourced from regionally produced bio-energy resources, have established themselves in Germany (Figure 8).

EU HAS TAKEN STEPS TOWARDS A SMARTER GRID

The past decade also saw the beginning of a significant change in electricity metering. By the end of 2012, 49 million smart meters had been rolled out to EU customers. The change stems largely from the Third Electricity Directive, which requires all Member States to develop plans to equip at least 80% of consumers with intelligent metering systems by 2020 wherever such systems passed a positive cost-benefit test. To date, Sweden and Italy have completed the process, with fourteen other EU Member States at various stages of implementation (Figure 9).

“Advantage of utilities: they currently have the customer base – but they need to act soon before customers switch”

– Policymaker, European Commission’s DG Research and Innovation

The EU also took steps towards developing a smarter distribution grid. Unlike smart meters, the smart grid technologies remain largely at the development and demonstration stage (Figure 10).

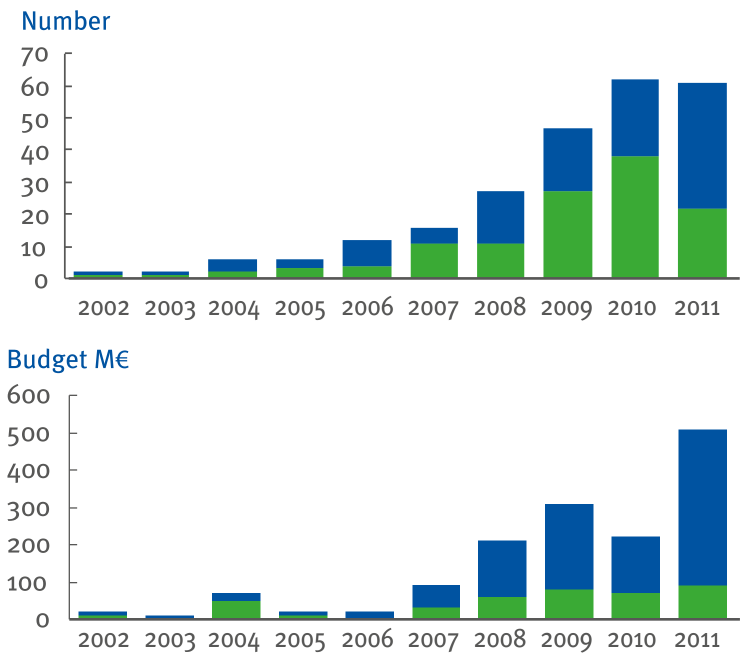
PROGRESS TOWARDS RETAIL COMPETITION HAS INCREASED CUSTOMER ENGAGEMENT

Over the past decade, the EU has also seen most Member States open their retail electricity markets to competition (Figure 11). No other region in the world has taken this process as far (Figure 12).

Progress towards competition in retail has given customers a new, active role in managing their power supplies. In 2011, around 16 million European households (about 6% of the total) switched to a different electricity supplier.

FIGURE 10

Investment in Smart Grid[1] R&D and Demonstration projects has increased significantly in the last few years



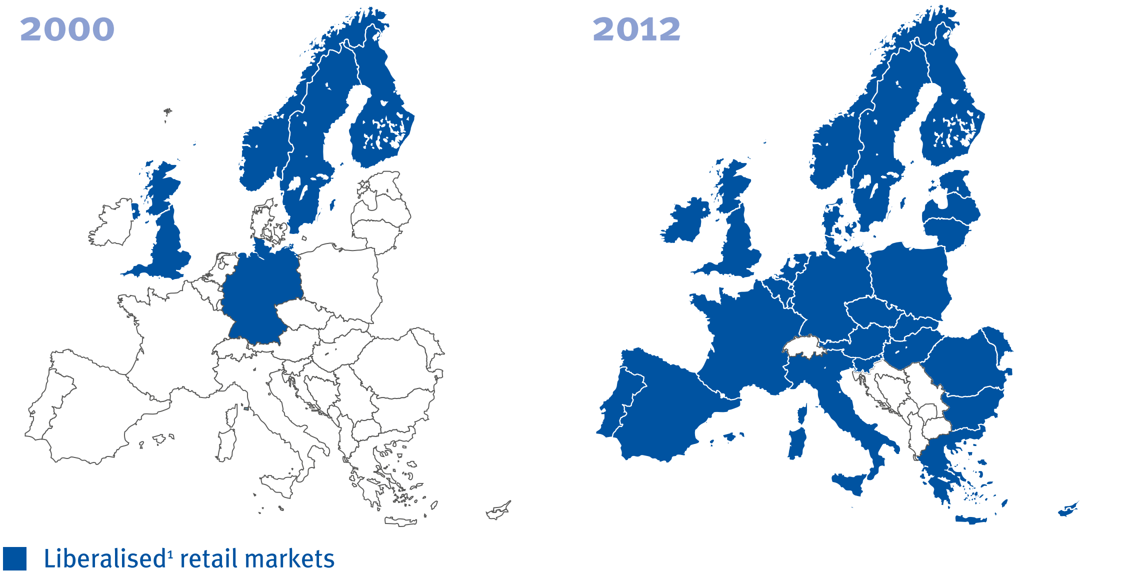
- 281 projects
- EUR 1.8 billion investments
- Average budget EUR 6.5 million
- Over EUR 200 million of investment per year in the last four years
- Projects lead by DSOs/utilities amount to over 50% of the total budget

1 Excluding smart metering

Source: JRC

FIGURE 11

Markets are increasingly liberalised

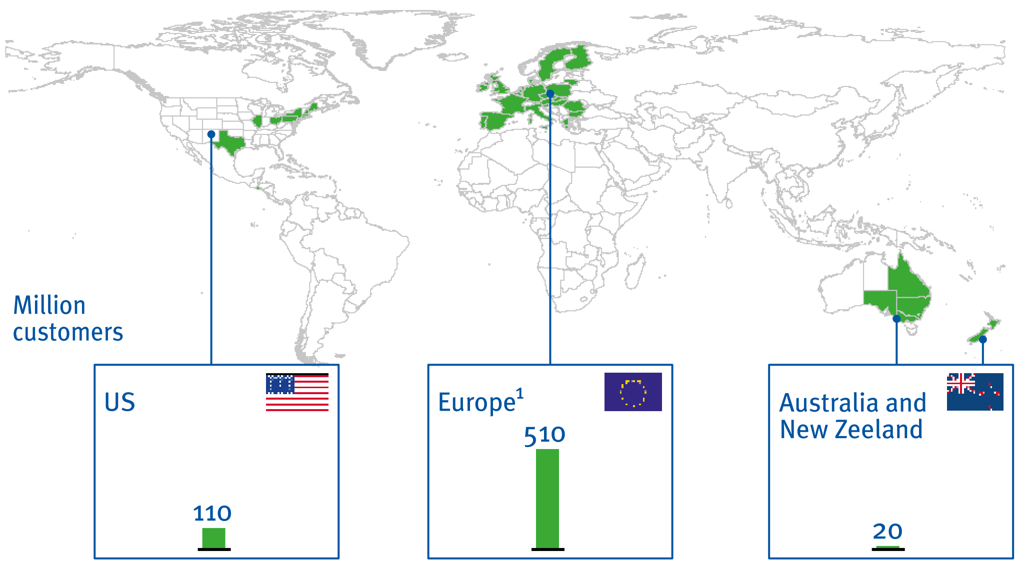


1 Liberalisation is not yet fully implemented throughout the EU. A communication by the EU Commission from November 2012 (COM(2012) 663) highlights the need to progress faster, especially in the run-up to the envisaged completion of the Internal Energy Market in 2014.

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 12

Europe leads on liberalisation, with more than 500 million customers in liberalised supply and retail markets

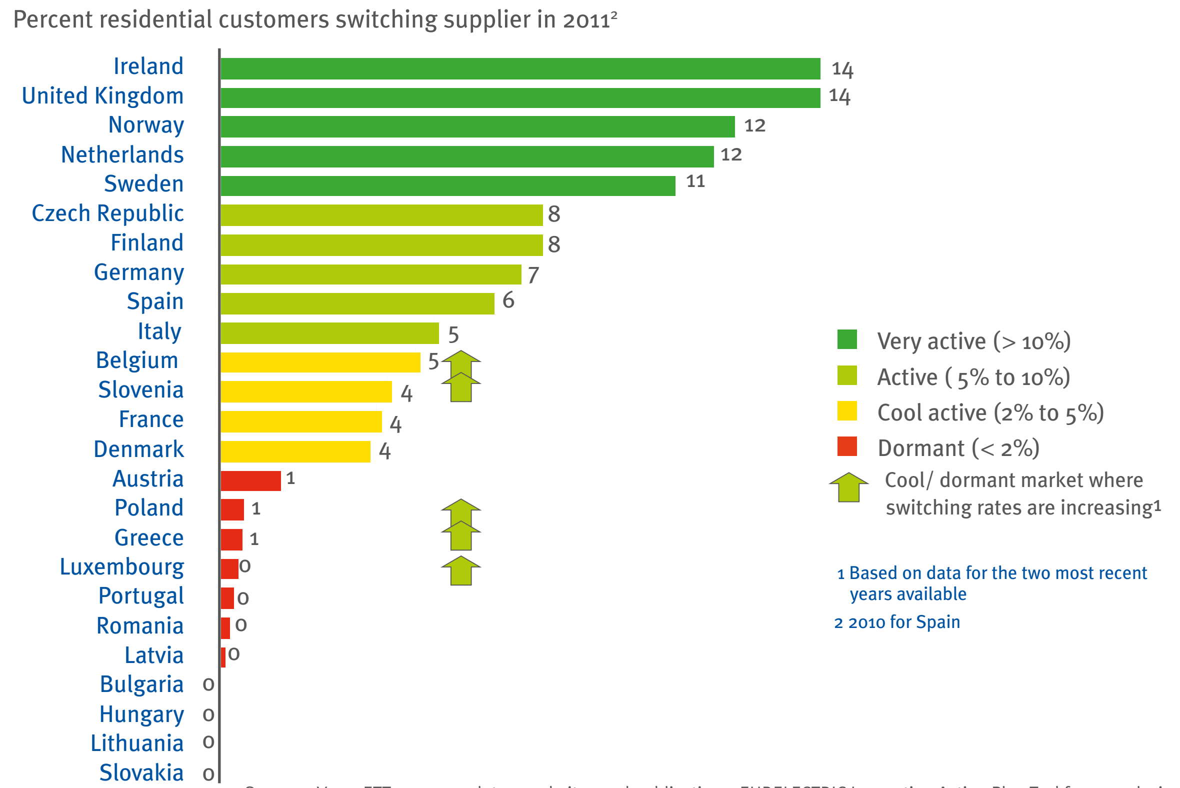


1 Scope of countries with full competition corresponds roughly to EU27 (excludes Estonia, Latvia, Malta, Cyprus and includes Norway, Switzerland and Iceland)

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 13

Switching rates for residential customers are high or increasing in a number of European countries



Sources: VaasaETT 2012, regulators websites and publications, EURELECTRIC Innovation Action Plan Taskforce analysis

While barriers remain in some countries, switching rates for residential customers are high or increasing across most of Europe (Figure 13).

RAPID CHANGE IS SHRINKING UTILITIES' CORE BUSINESS– YET GROWTH IS STILL POSSIBLE

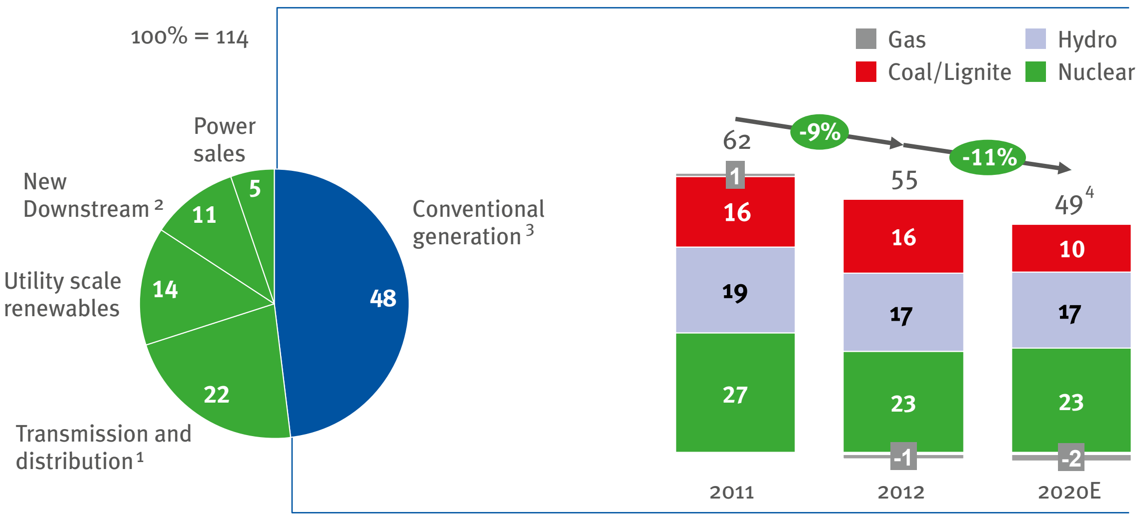
These profound changes have had significant adverse impact on utilities' core business. In particular, EBIT value in conventional generation – historically, the core profit pool of the industry – is declining and looks set to continue to do so. Between 2011 and 2012, the profit pool in this segment fell by nearly 10%, from an aggregate EBIT of 62 billion euro to 55 billion EUR, and it may fall to less than 50 billion EUR in 2020 (Figure 14). The decline is due to several factors: slow underlying demand growth, energy efficiency gains, and the entry of new RES capacity. Even with possible changes such as the introduction of capacity payments, higher commodity prices, or large-scale industry consolidation, the 2020 profit pool appears unlikely to grow larger than that seen in 2012.

This outlook means European utilities are falling out of investor favour. Whereas earlier in the decade utilities enjoyed some of the highest and least risky returns to shareholders, they now offer among the worst and more volatile. In terms of total shareholder return (TSR, the sum of the increase in the share price and dividends paid as an annualised percentage of the share price), they are near the bottom, second only to banks heavily hit by financial crisis. Likewise, the utility sector ranks much worse than it used to in terms of the volatility of the return (Figure 15).

FIGURE 14

The value creation of conventional generation, the core profit pool of the industry, is declining

European EBIT pool, EUR billions, Percentage, 2012 real



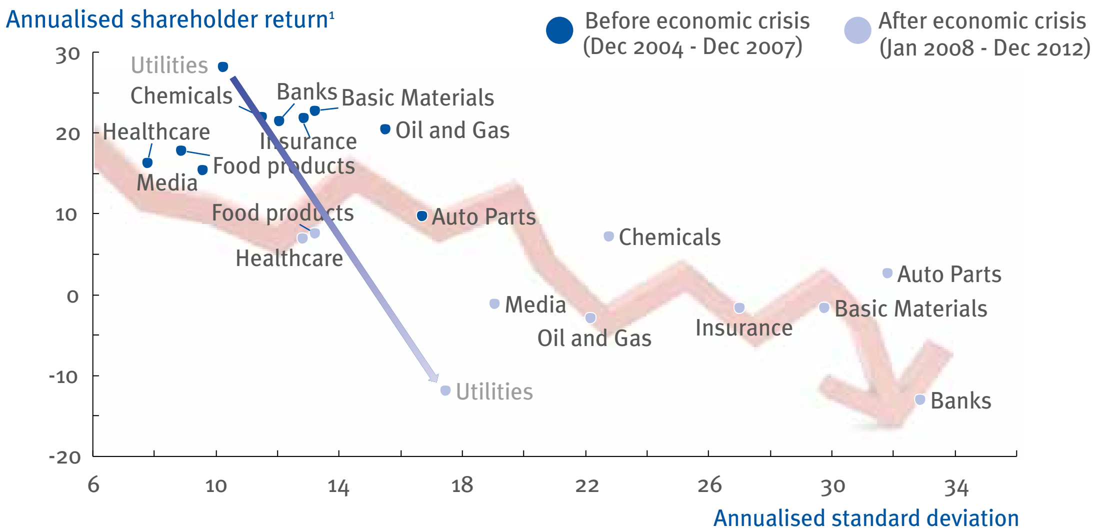
1 Includes transmission, conventional distribution, and smart grids
2 Includes distributed generation, EV infrastructure, new downstream products and services
3 Excludes earnings from ancillary services
4 Assuming no change in commodity prices vs. today

Source: McKinsey Industry Vision

FIGURE 15

European utilities' stock market performance has deteriorated after the economic crisis

Percent per year

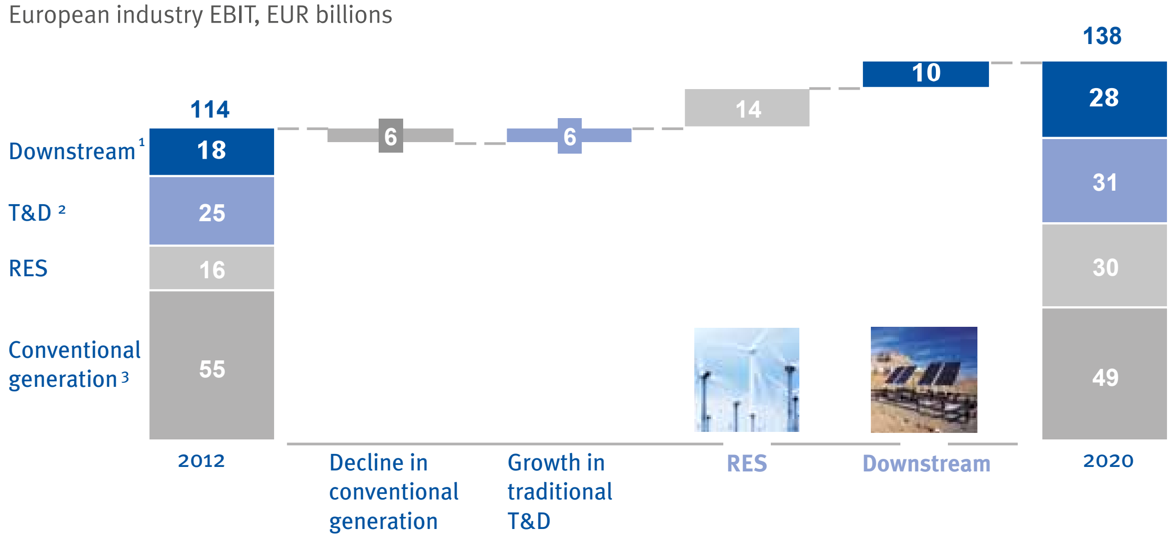


1 Utilities includes grid companies. Shareholder return shown is total shareholder return, calculated as the change in the share price plus the dividends paid, divided by the initial share price, and calculated on an annual basis

Sources: Datastream; McKinsey Industry Vision

FIGURE 16

Utilities' traditional core business is shrinking, but new growth areas can offset the decline



1 Includes power sales and new downstream (distributed generation and storage, electric vehicle infrastructure, new downstream products and services, power flow optimization)
2 Includes smart grids
3 Assuming no change in commodity prices vs. today

Source: McKinsey Industry Vision

Even if the above picture of the industry appears gloomy, growth is possible nonetheless in the EU power sector. In particular, there are two main opportunities to increase the overall value pool (Figure 16):

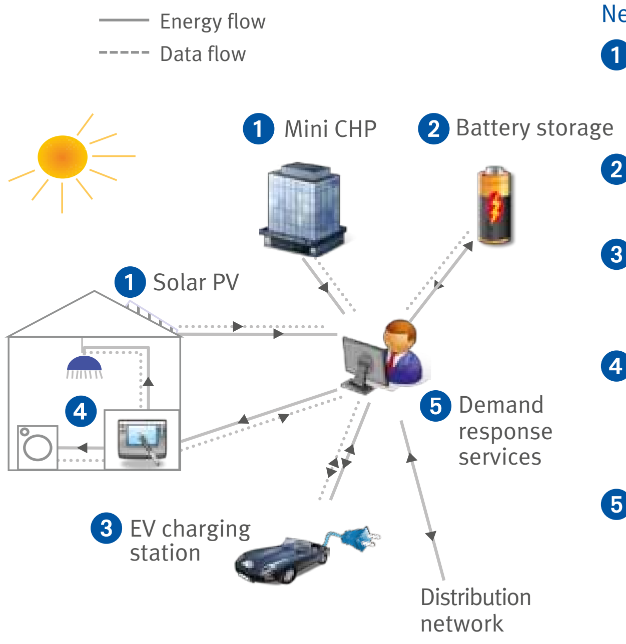
- **Large-scale RES** will continue to grow in value. By 2020, the EU will add some 135 GW of new renewables capacity, creating an additional 14 billion euro value pool.
- **A new downstream market** could be worth 10 billion euros across a range of fields, including decentralised generation, energy efficiency, and new consumer offerings.

The RES expansion will take place mainly in onshore wind, across multiple markets, but with contributions also from offshore wind, biomass, and large-scale solar PV. In total, National Renewable Energy Action Plans published by EU Member States have the ambition to add 135 GW of capacity across these technologies by 2020. The expected growth will be driven by continued regulatory support for renewables as well as by continued reduction in technology costs. Only China is likely to add more renewables capacity in the coming decade.

In downstream markets, the potential growth opportunity lies in a number of new products and business models (Figure 17): 1) distributed generation, 2) battery storage, 3) electric vehicle infrastructure, 4) new products and services at customer premises, such as energy-efficient appliances, and 5) new business models based on Big data, such as demand response and power flow optimisation.

FIGURE 17

New downstream value pools are expected to emerge from the green agenda and new technologies



New downstream value pools

1. Distributed generation
   Installation, maintenance, and possibly ownership of:
   - Solar PV systems
   - Mini/micro CHPs
2. Battery storage
   - Ownership, installation, and maintenance of battery storage at local distribution level
3. Public infrastructure for electric vehicles
   - Grid connection works
   - Ownership, installation, and maintenance of public charging points
4. New products and services at customer premises
   - Installation, maintenance, and possibly ownership of products that:
     - Increase customer comfort and enable new services
     - Make home and other buildings more efficient
5. Power flow optimization
   - Leverage local sources of net load flexibility (distributed storage, EV batteries, DSM, DG) to:
     - Optimize power flow at local and system level to manage congestions and stabilize grid
     - Shift net system load to capture price arbitrage opportunities

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

A retrospective on the past decade reveals major changes in the EU power sector. Many of the key forces for change emerged very fast: new RES capacity, growth in distributed generation, smart grid technologies, and increased retail competition all became major forces for change within just ten years. Changes made considerable demands on existing power sector participants, as the share of conventional generation declined even as it became more important for system stability. The changes left no part of the power sector untouched and have sparked many different renewal and adjustment efforts across generation, grid operation, and retail sales. These changes have already had a significant impact on the core business of utilities, which is shrinking fast. However, they are also creating new opportunities for growth by the EU power sector, above all in new large-scale renewables and in new businesses arising with the emergent 'new downstream' segment.

2

CAPTURING UPCOMING OPPORTUNITIES MAKES INNOVATION IMPERATIVE

As change in the sector accelerates, it will also increase the importance of innovation. In order to capture the opportunities related to the growing value pools, the power sector will need to create new products, processes, and business models. Innovation will be a precondition for the sector to grow. Three innovation imperatives stand out:

- **Master new technology**. Advances in technology as well as cross-sector interactions will result in a larger set of solutions to provide customers with clean, secure, and affordable energy.
- **Get close to customers.** Customers will be increasingly aware and demanding, as well as increasingly engaged and active, resulting in the need for utilities to better understand customer needs.
- **Develop new business models and services.** In the task of turning technological advances into products and services that meet customer needs, utilities have often been faster to understand technology ('the hardware') than new business models and services ('the software') and will likely need the support of partners as well as regulators to successfully address the need for new business models and services.

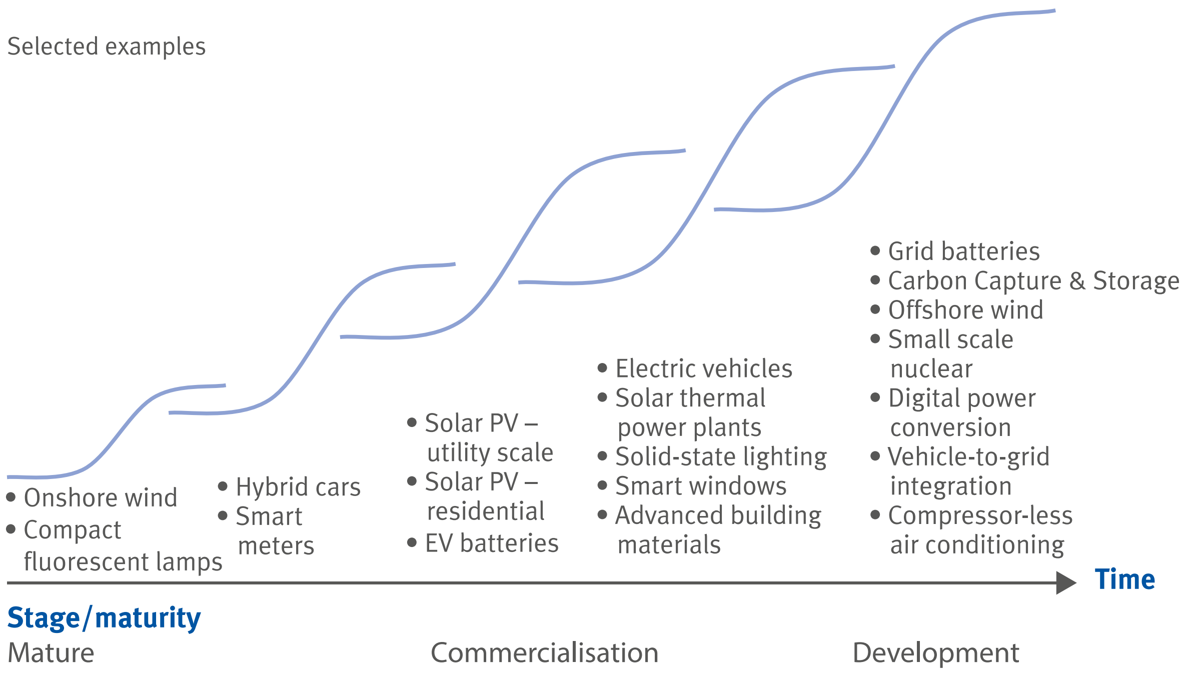
Utilities have been instrumental in bringing innovations to customers in the past and, after a slow start, the EU power sector is now showing innovation initiative.

MASTER NEW TECHNOLOGY TO ENABLE NEW SOLUTIONS ACROSS THE POWER SECTOR

Technology is changing fast, transforming the way the world produces and consumes power. A number of technologies across generation, storage, and end-use already see sharply declining cost, and over time a large number of technologies have the potential to pass through the stage of commercialisation and towards maturity and much large market size (Figure 18). The intrinsically uncertain nature of the innovation process makes it impossible to predict the extent to which the different solutions will flourish, but it is already apparent that the successful ones have the potential to transform the power sector landscape.

FIGURE 18

Continuous development of a large range of technologies could have a disruptive impact on the power sector



Source: EURELECTRIC Innovation Action Plan Taskforce analysis

Generation mix: greener and more decentralised

The EU's energy and climate targets will underpin continued RES growth. Progress towards 2020 targets continues, and most signs indicate continued post-2020 commitment to RES to 2030 and beyond.

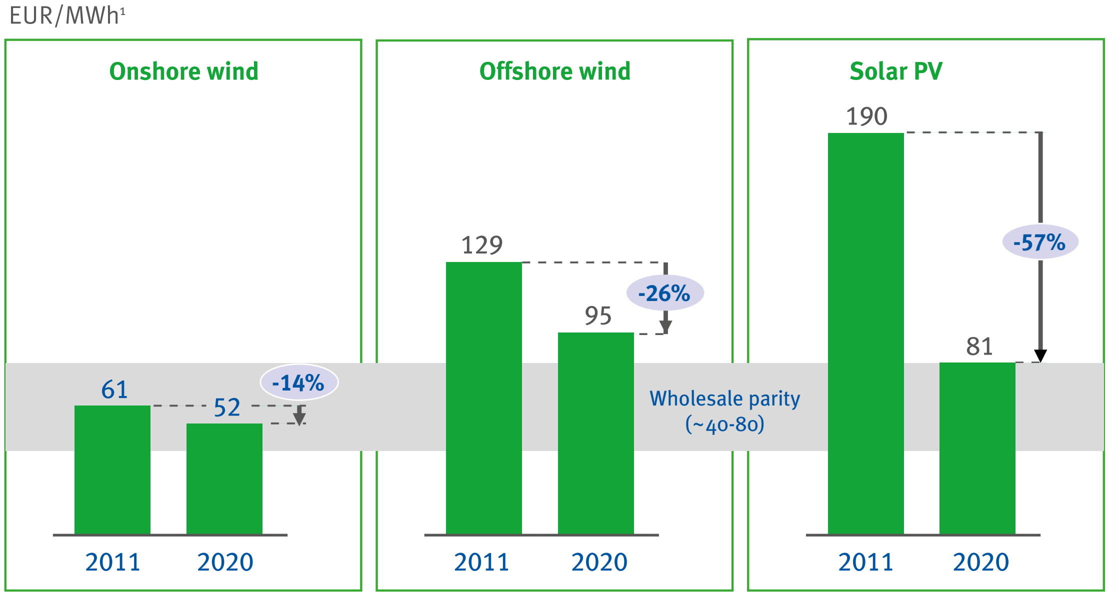
Meanwhile, further cost reductions expected in onshore wind and solar PV should increase their competitiveness with conventional technologies (Figure 19). Offshore wind is also expected to go through a phase of significant cost reduction, and several European countries have ambitious deployment programs: by 2020, the UK has set a target of 18 GW, Germany 10 GW, the Netherlands 5 GW.

When developed at large scale, onshore wind is already reaching the point where it can produce electricity at a cost that is in line with prevailing wholesale prices in some markets ('wholesale parity'). Continued cost reductions will strengthen this trend. Meanwhile, small scale PV has already fallen to levels similar to residential power prices in some countries, and very substantial demand segments are opening up (Figure 20). For example, the take-up in new real estate developments might

> *"PV will be commoditised (e.g., bought in supermarkets like TV screens and installed directly by users). DC applications are likely to make inverters unnecessary, and surplus production could be stored on site. Even without subsidies we will see further development of PV in the commercial and industrial sector as well"*
>
> *– CTO utility company*

FIGURE 19

The cost of key renewable technologies is expected to decrease by as much as 60% to 2020

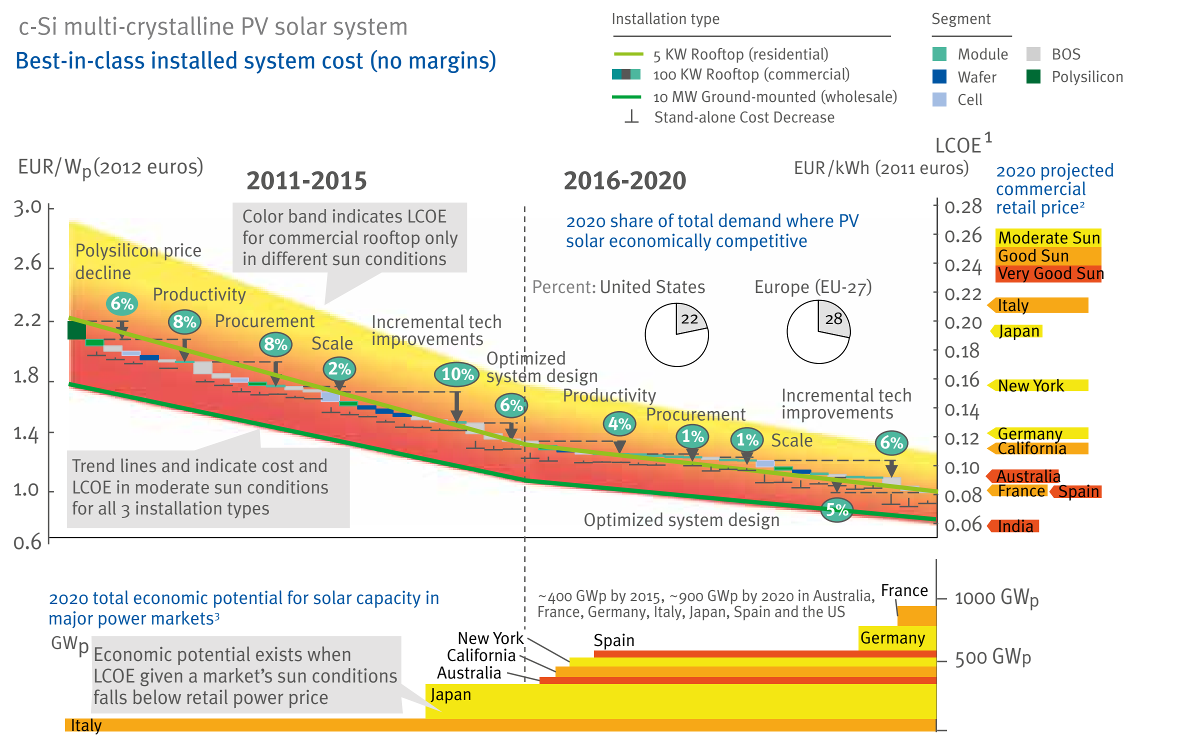


1 Cost refers to the levelised cost of energy attainable using leading technology in favourable conditions. Assumptions include (2011, 2020): Onshore wind capex in EUR/kW (1188, 1108), load factor (36%, 39%), WACC 9%; Offshore wind capex in EUR/kW (3772, 2830), load factor (51%, 54%), WACC 10%; Solar PV capex in EUR/kW (2162, 927) , load factor (16%, 16%), WACC 7%

Source: McKinsey Clean Technology Performance Initiative

FIGURE 20

Solar PV exported to grid will become increasingly competitive



1 Assumed 7% WACC, annual O&M equivalent to 1% of system cost 0.9% degradation per year, constant 2011 euros, 15% margin at module level (EPC margin included in BOS costs).
2 Very good sun conditions = 19% capacity factor; good sun conditions = 16% capacity factor; moderate sun conditions = 11% capacity factor.
3 Amount of total installed solar capacity required to meet demand in all market segments (residential, commercial, industrial) where PV will be cost competitive with retail prices by 2020

Sources: McKinsey (based on industry expert interviews, Photon, GTM, NREL, EIA, Enerdata, press search, company websites)

be accelerated by the adoption of a number of solutions now under development for integrating photovoltaic into buildings.

The last decade has taught us how little can be known for certain about the future generation mix. Other renewable technologies currently on the far horizon (concentrated solar power, marine technologies, enhanced geothermal) could also play a role in the future, as the EU seeks new ways to reach the objectives of sector decarbonisation and energy mix diversification. Other contributions could come from non-renewable technologies, notably carbon capture and storage and a range of nuclear technologies currently at different stages of maturity.

On the decentralised generation front, a number of distributed generation technologies other than solar PV are being studied or deployed (e.g., micro-wind, fuel cells, and micro- and mini-CHP), and technology advances could one day make some of them more economically attractive.

Both supply and demand will need to meet increased flexibility requirements

The changing technology composition in both generation and consumption will make new demands on the overall power system. Variable renewable energy sources will require rapid ramp-up of other power sources, while the emergence of new demand loads (e.g., fast charging of electric vehicles) will also create a need for much more active system management. A number of solutions have the potential to contribute to greater system flexibility requirements:

- Operation of conventional generation assets will be increasingly dynamic to ensure back-up and balancing.
- Storage technologies will spread into different levels in the value chain (at customer premises, at local distribution and system transmission level).

- Demand response can greatly contribute to flexibility requirements through remote control of end-user loads.

A smarter power network will enable new services and solutions

Smart grids will enable power suppliers and distributors to operate more efficiently. Cost to serve will be reduced by remote reading, detection of non-technical losses, and the possibility of remote disconnection. Quality of service will improve thanks to automatic fault detection and fault clearance, resulting in reduced frequency and duration of outages, and through better monitoring and stabilisation of power quality. New grid investment and operating costs will be reduced through active system management, and condition-based asset maintenance and lifecycle management.

Many smart grid technologies are already available but still some time away from deployment. Systematic roll-out could drive cost reductions in equipment and project execution. Advances in power electronics technologies, which already benefit from the fast learning rates in the semiconductor industry, could also better support the development of smart grids.

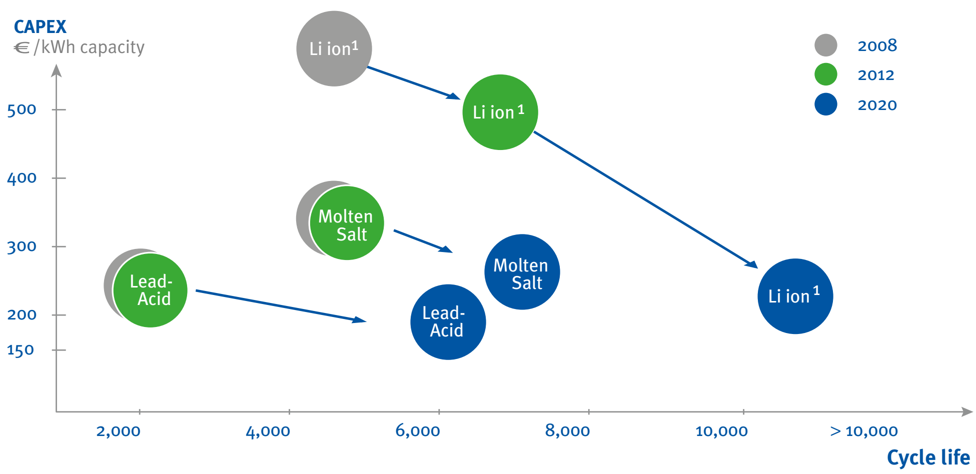
The cost of battery storage is expected to decrease rapidly, with sharp learning rates (Figure 21). This has the potential to make a number of power sector applications (in networks and beyond) economical:

- Primary reserve, with batteries displacing the most expensive spinning reserve solutions.
- Off-grid PV installations, which store solar PV production during the day and use it at night to replace need for diesel generators.
- New grid-connected PV installations, which, depending on retail prices and regulation, allow users to avoid paying the power retail tariff by storing solar PV production during the day and using it when retail prices are high.
- Transmission and distribution deferral or avoidance, by smoothing out peak demand, hence reducing pressure on existing lines for long-distance line projects with low utilisation.

Combined solar PV and battery systems are already starting to appear. If taken up at large scale this and other similarly decentralised generation-and-storage solutions could herald a sea-change in how the electricity grid is configured. Such a scenario would raise the question of the nature, if not the very existence, of the centralised electricity grid.

FIGURE 21

Improvement in costs and performance of battery technologies will continue, with Li-ion showing the largest potential

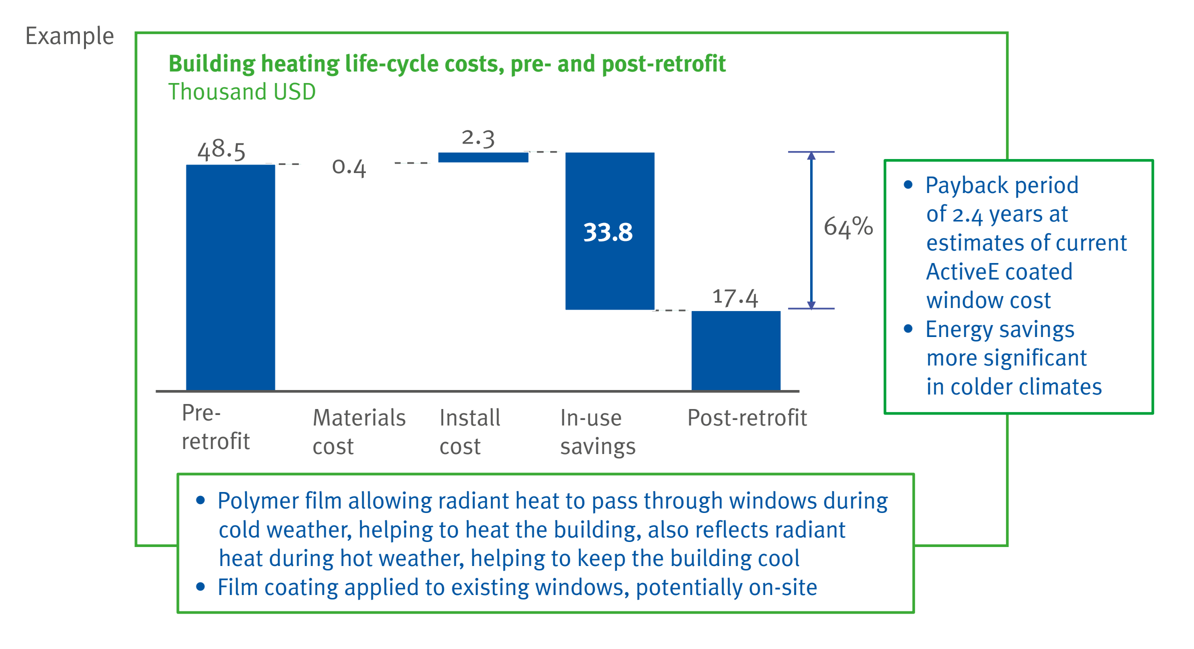


1 LFP/C Chemistry; based on costs for automotive applications

Sources: ESA, McKinsey Impact of Storage on the Power Sector Initiative

FIGURE 22

Retrofitting homes with new coated windows could cut heating costs dramatically



Sources: RSMeans, expert interviews

> *Networks are the key area requiring innovation, also due to the expected significant take-up of more distributed generation*
>
> *– National EU policymaker*

Energy consumption will evolve and become more efficient

A number of customer-facing technology changes are also expected. Advances in battery technologies could boost the adoptions of electric vehicles. End-user energy efficiency has the potential increase dramatically. Heat pump technologies are increasingly efficient and adoption rates are on the rise. Buildings envelopes will be increasingly energy efficient thanks to a combination of existing and disruptive technologies, from simple cavity-wall insulation to advanced photochromic windows (Figure 22). In cooling (Figure 23), liquid desiccant and evaporative technologies that can reduce energy consumption by 60 to 80% are close to commercialisation, and other disruptive technologies are at earlier stages of development. With costs decreasing rapidly, LEDs are expected to become the dominant lighting solution, with significant energy savings over incandescent and compact-fluorescent bulbs. Appliances will be increasingly energy efficient, interconnected, and remotely controllable.

These are just examples of current technology trends. The future will hold more, and utilities and other power sector participants need to understand and master them to thrive. Those at the forefront of technological innovation also will be in a prime position to create the customer offerings that will enable tomorrow's growth in value.

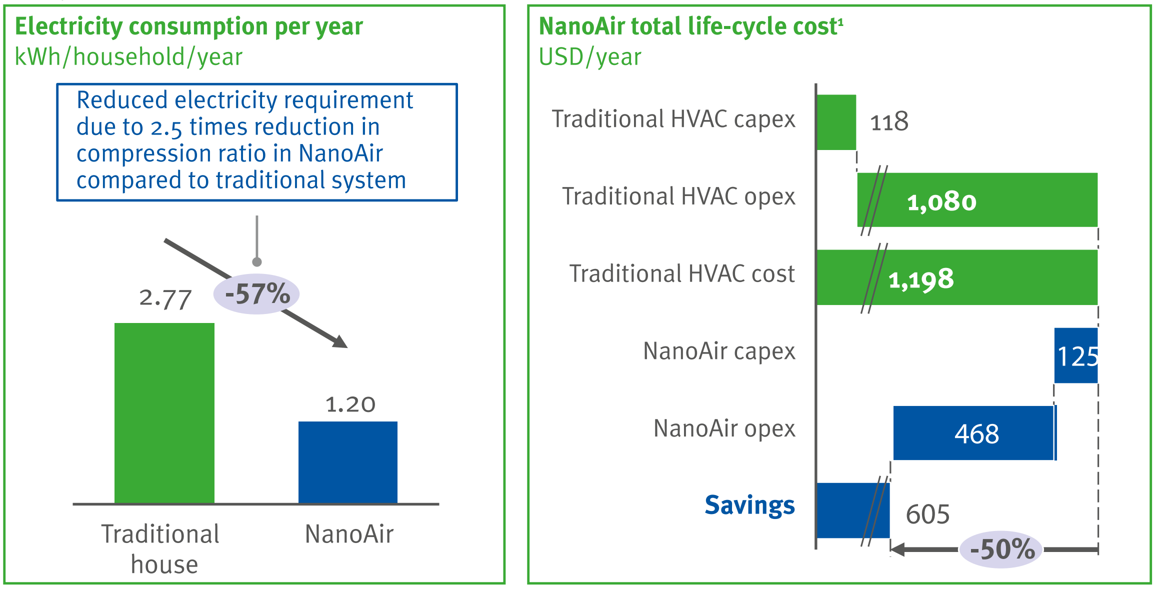
GET CLOSE TO CONSUMERS TO UNDERSTAND THEIR NEEDS

The power sector has only started to feel the impact of the type of active and engaged customer that has exerted a core influence on many other sectors for some time. Moreover, a number of changes are already taking place in

FIGURE 23

New features are expected to increase energy efficiency significantly – such as new approaches to air conditioning

Example: NanoAir



1 Using a three-ton system

Source: NanoAir

FIGURE 24

Seven consumer trends in developed countries

More decision units
- Growth of single-persons households, and increase in age for having children, population aging, and increased participation of women in the workforce lead to higher number of households, smaller in size, and more decision units within each household

Green consumer & Social responsibility
- Importance of the environment and socially responsible practices is increasingly reflected in consumer choices

Lifestyle consumer
- Focus on health and wellness, convenience and shopping experience as key decision criteria, and resulting in blurring of traditional age and gender categories

Individuation/ Me-centricity
- Rise of customisation, ready-to-buy products tailored for the consumer, which are 'unique' (by the consumer and for the consumer or as a service)

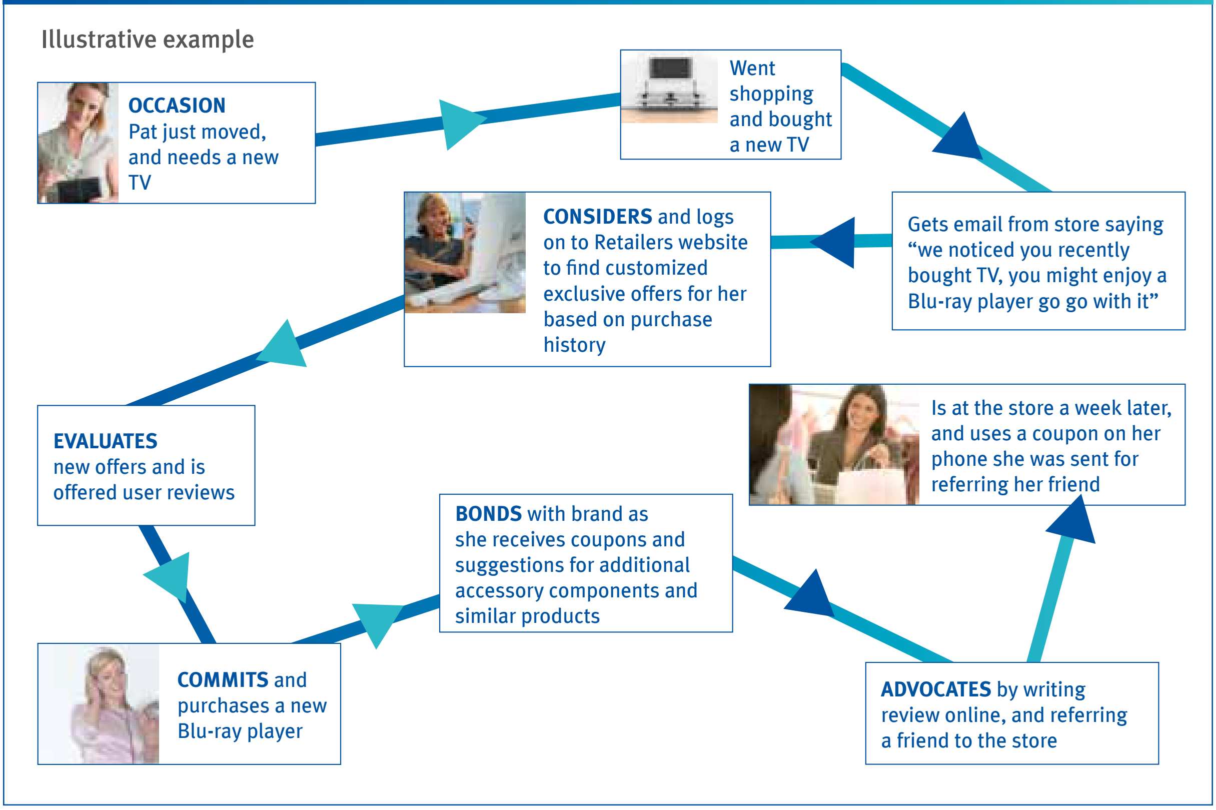
Polarization to low and high-end
- Consumers increasingly making a distinct choice between low price goods vs. high quality/value, squeezing the middle market (reinforced by rising income inequality)

Sophistication
- Consumers using complex criteria and channels for decision making, valuing control and the ability to influence companies' actions

Pervasive digital life
- The web placed first in the world's media, intensively engaging consumers through digital environments such as participatory media, virtual worlds and games, and through an increasing self-disclosure mode of consumers, with short attention span

FIGURE 25

The customer buying process is becoming less linear



developed economies that change the way customers behave (Figure 24). The following trends are of particular importance to the power sector:

- Consumer choices are increasingly linked to environmental sustainability and socially responsible practices.
- Consumers are seeking more convenience and giving greater weight to shopping experience, with preferences for tailored products and services.
- Consumers are using complex criteria and channels for decision making, and attaching greater value to their ability to control influence companies' actions.
- Customers are 'always online', with online information and decision pathways influencing nearly all stages and facets of customer behaviour.

In short, a new customer archetype is emerging in the power sector landscape: more aware and demanding, more engaged and active. Innovation in engaging with this customer will be a precondition for future success.

> "Utilities need to partner with equipment manufacturers as well as players from customer-focused and ICT-heavy industries to drive innovation"
>
> – CTO utility company

As an example, customer product choices are changing. The 'customer decision journey' is increasingly complex (Figure 25). Before purchasing, customers now go through consideration and evaluation processes that span multiple information channels: company websites, blogs, online forums, community advice, and many others.

“A key trend is the changing role of the consumer in the energy system. Regulators have often taken a paternalistic view. There is a need to let the market play, to let consumers be consumers”

– EU policymaker

The power sector is no exception in the trend towards the increasing importance of online interaction. In a recent survey, electricity supply to end users ranks as one of the sectors with highest share of digital ‘touchpoints’. This spans several steps of the customer decision process: initial consideration, evaluation, and purchase (Figure 26). Customers are already interacting with utilities in a totally different way than they did ten years ago, when digital touchpoints were almost non-existent in the power sector.

An indispensable part of the response to this situation will be to make use of Big data capabilities. They include efficient, stable, and flexible operations platforms supporting real-time automated processing. Power companies will need to use information from the power system and other sources, and apply the resulting insights to create new business practices and customer offerings. Big data capabilities will also enhance demand forecasting capabilities and generate insights to capture value not only in the retail business (e.g., demand side management solutions) but also in distribution, trading, and generation optimisation.

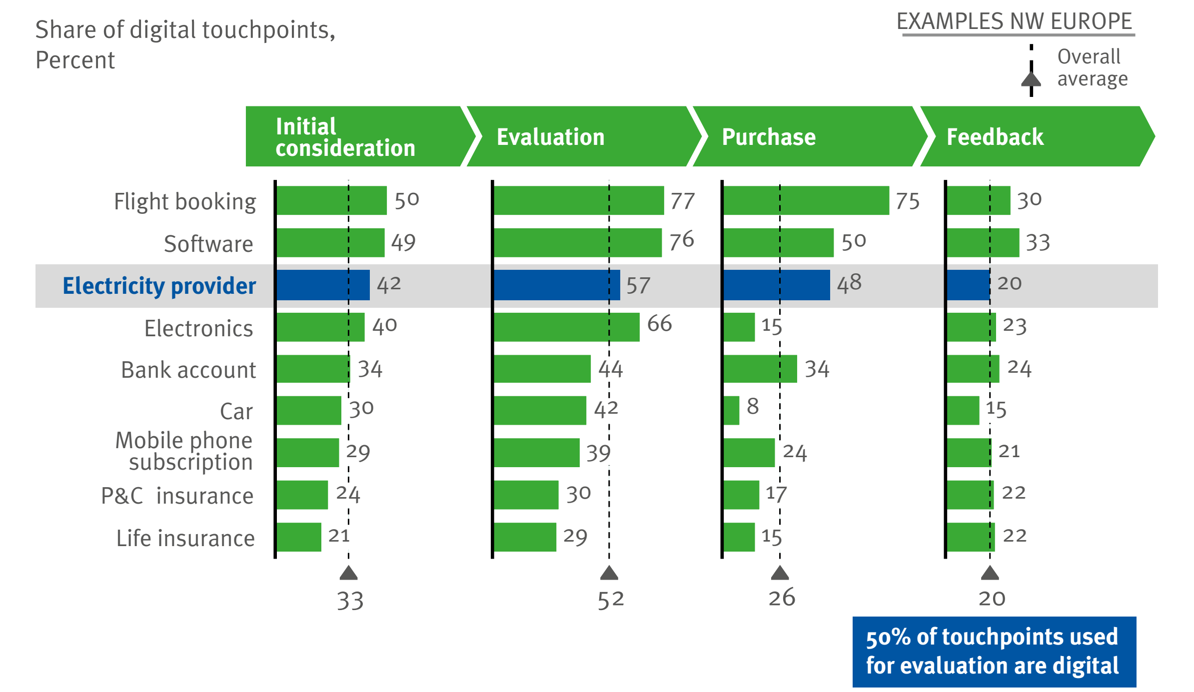
A recent study examining the potential value that big data can create for organisations and sectors of the economy shows that the availability of big data in the power sector is high compared to many other industries. Moreover, its potential value is high and on the rise (Figure 27).

“ICT will play a central role in enabling various technology changes in the industry”

– CTO of energy services provider

FIGURE 26

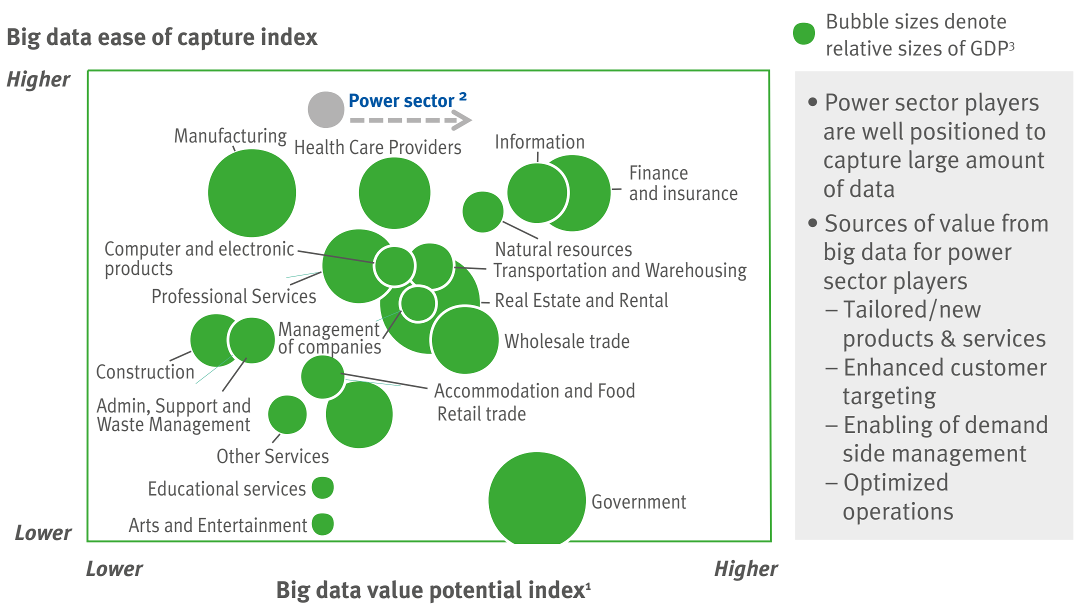
Digital touchpoints are becoming mainstream in many sectors – including with electricity providers



Source: McKinsey digital marketing survey 2012

FIGURE 27

Big data is easier to capture in the power sector than in many other industries, and its potential value is rising



1 Potential to create value. Some portion of the value created can be captured as profits
2 Electricity and gas utilities
3 based on US GDP data

Source: McKinsey Global Institute

DEVELOP NEW BUSINESS MODELS AND SERVICES TO BENEFIT FROM THE EMERGING NEW SECTOR VALUE CHAIN

Several new downstream products and services can already be discerned as likely developments in the next decade:

- The ongoing take-up of distributed generation creates business opportunities to provide, install, and maintain new equipment at customers' premises, as well as additional potential services, such as virtual power plant generation models.
- Continued energy efficiency improvement will create a market for a wide range of technical solutions and, equally importantly, new business models to unlock the potential value that energy-saving solutions entail.
- As part of providing system flexibility, the importance of demand response aggregation will grow. A market involving B2B customers is already emerging and is likely to extend to the B2C segment through two-way digital communication enabled by smart grids and the increased penetration of smart appliances and home control technologies.
- Future adoption of electric vehicles will require e-mobility solutions for private and fleet customers, spanning the development of charging infrastructure (public charging stations and private charging boxes), power supply, and automatic billing and data management.

The transformative potential of these developments emerges clearly when considering the potential energy profile of the 'home of the future'. In terms of technology potential, energy efficiency technologies such as building shell improvements, LED lighting, and efficient heating and cooling could reduce energy needs by as much as 65%. Adding microgeneration, the energy consumption level from the grid could fall as low as 10% of the current value (Figure 28).

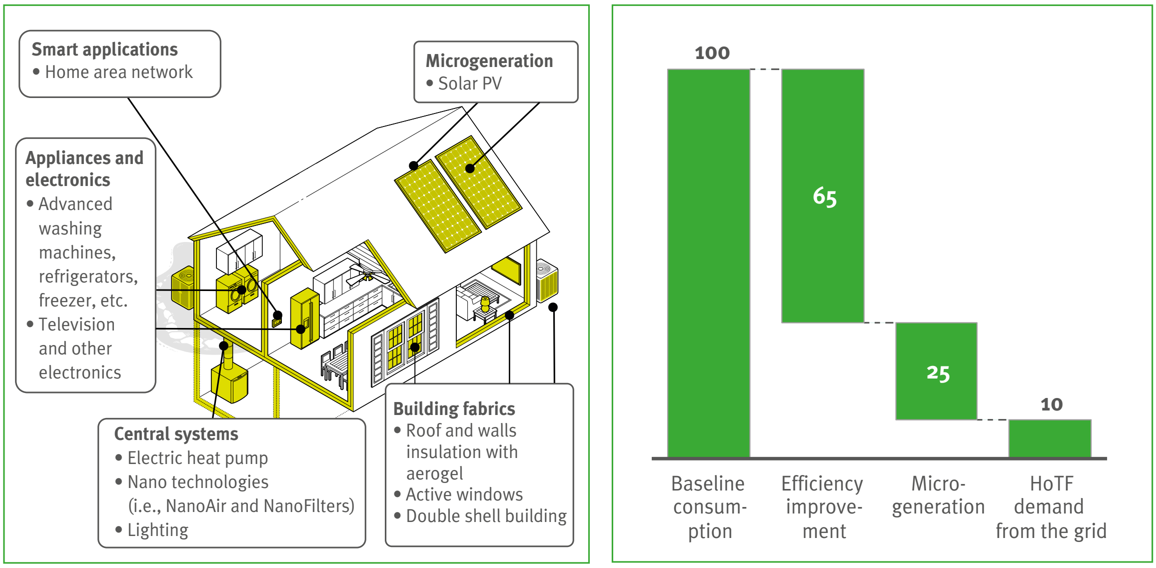
In this situation, energy *services* (heating and lighting, but also mobility, etc.) would be met not solely, or even primarily, through the supply of energy – but through a range

FIGURE 28

The 'home of the future' may feature smart meters, microgeneration, and a host of new services and appliances

The home of the future: example of a new single house

Decrease in energy needed from the grid by the HotF
2020, indexed, 100 = kWh of household consumption



Source: McKinsey Home of the Future Initiative

of channels including decentralised generation technology, improved energy efficiency across a range of applications, and sophisticated control technologies. At the end of this journey, therefore, lies a potentially dramatically different business model for serving customer needs, defined not in terms of energy supplied, but directly in terms of the benefits that end-users perceive themselves to be deriving from various energy-consuming services.

> *"Utilities today are in a similar situation as the telecom industry in the 1990s: we need to understand what technology can do"*
>
> *– CTO utility company*

> *"In 2030, the utility business model will be about delivering reliability of service (not kWh throughput)"*
>
> *– US policymaker/expert*

This type of transformation has already been seen in other sectors. Telecommunications offers the most direct parallel. Only 20 to 30 years ago, telecom companies managed centralised switching and commuting centres. They were asset-based companies with extensive networks of unidirectional copper wires. Revenues were largely volumetric, through connection fees and high call prices. Today, the situation is radically different. The network is bidirectional to allow for data transmission. The number of end-points has grown far beyond the previous copper-wire network. Flat fees on calls are the new normal. The previous sole use of the network – voice traffic – now accounts for only a minority share, as companies offer a broad array of services spanning data, media, security, and others.

> *Utilities are trying to position themselves in the new businesses emerging downstream. Their customer base is an entry gate but there are other players 'already in the living room': telcos, electricians, heating system installers. Other players could also emerge*
>
> *– CTO utility company*

Similar change in the energy sector would simultaneously put current business models under significant pressure and open up a range of new opportunities to provide customers with products and services. In place of today's volumetric model of supply, underpinned by asset ownership, energy would be service-based. A different logic then would apply for customers: instead of revenues for the energy consumed, the business of meeting energy needs (like telecoms now) would be denominated in average revenue per unit – that is, from euro per MWh to euro per customer.

The power sector will have to go through a significant transformation to reach a similar change in business practices. In particular, a smart grid – in the sense of a bidirectional network that allows for real-term responses – will be a precondition for this scenario. Moreover, the 'smarts' would need to be put in place ahead of the innovation and the value it creates. Ultimately, this process will result in the consolidation of the emerging electricity value chain.

Another impact is that industry boundaries will become increasingly blurred. The combination of power supply offers with distributed generation solutions, e-mobility solutions, and energy efficiency solutions, coupled with equal access to energy markets and to increasingly available information about supply and demand all along the value chain, is likely to foster the convergence of the power sector with other industries. These could include automotive companies, facility managers or energy service companies, telecom operators, and IT companies, as well as a range of innovative start-ups.

Various business models already are emerging:

- The pure-play energy manager, offering energy management packages, including smart devices and appliance controls for a monthly fee.
- The energy retailer, bundling the above with traditional energy commodity sales.
- The digital home provider, combining the first model with telco services and home automation.
- The demand aggregator, treating customers as part of a virtual power plant, managing their demand through curtailment.
- The energy consulting service, advising both residential and commercial customers on how to reduce consumption relating to heating, lighting, and electrical appliances.

> *New entrants such as Google, Microsoft are potential competitors in distributed generation. Venture capital funds are getting into renewable energy. Google does more energy R&D than all US utilities combined*
>
> *– US CTO*

These are merely selected examples; the business models are still nascent. The timing for the transition is also very uncertain. Many of the technologies and needs have been around for a long time, but the capabilities and innovation (in smart grids, business models, technology enablers) are not yet fully in place.

What will be utilities' role in this change? In a survey conducted by EURELECTRIC, industry executives give a mixed response. Given the experience of the past decade, there understandably is some apprehension. The overall message nonetheless is that utilities expect to remain the core of the sector (Figure 29) and recognise that significant innovation is required for this scenario to play out.

> *"The role for utilities is key. It's clear that SMEs also have a role, but it is clear that only the big players can leverage the large scale required for change. They have a central role to play. They need to deploy, to use, to demonstrate the inventions"*
>
> *– EU national policymaker*

AFTER A SLOW START, THE EU POWER SECTOR IS NOW STARTING TO SHOW INNOVATION INITIATIVE

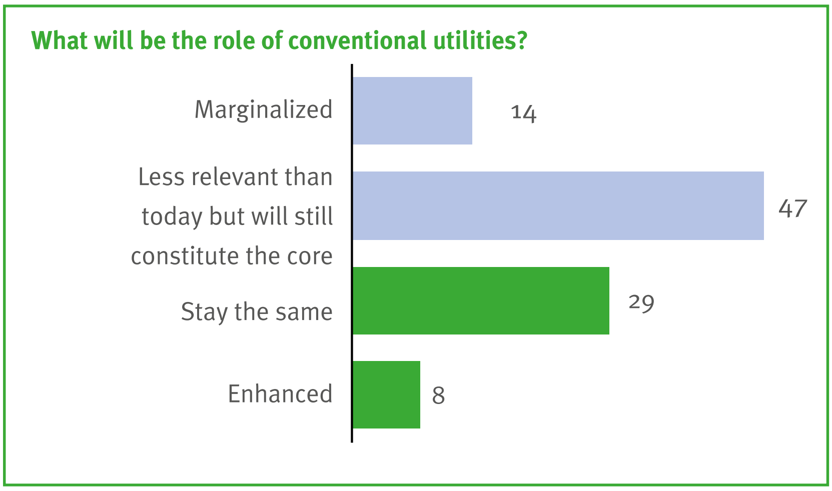
Utilities have been instrumental in bringing innovations to customers in the past. In the 'dash for gas', they adopted the technological innovations of OEMs and integrated these into the overall power system. As new trading and new risk management entered the sector, the original impetus came from outside parties but utilities adopted the innovations and now are at the core of the energy trading and risk management landscape.

Yet utilities' role in the more recent EU power sector changes arguably has been more marginal. At times, it may have seemed as though the sector would be slow to embrace ongoing innovation. For example, utilities have accounted for only 25% of investment in new renewable capacity in the EU over the past decade, and far less (on the order of 5%) for solar PV and other distributed generation capacity. Underlying this, industry expert interviewees identified a slow realisation that fundamental innovation trends were affecting the sector.

FIGURE 29

Over 60% of survey respondents expect industry changes to have a negative impact on conventional utilities

Percent of respondents, N=51

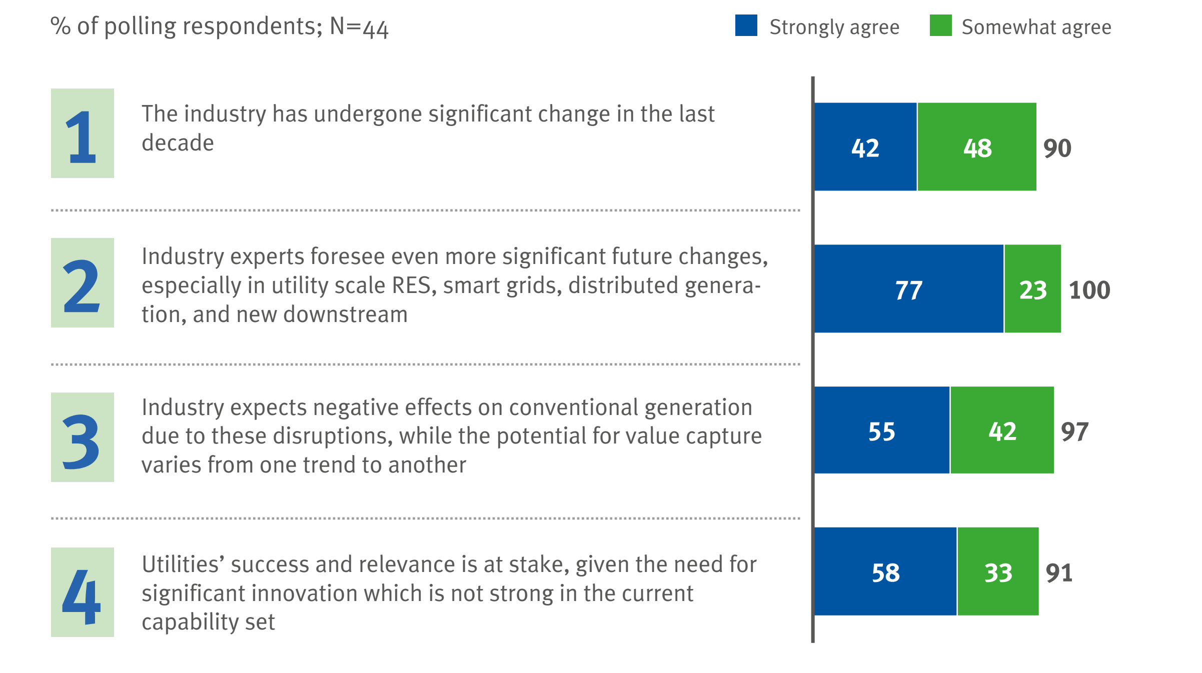


Note: Not applicable = 2%

Source: EURELECTRIC Innovation Action Plan Survey, December 2012

FIGURE 30

Utilities see the continued rapid change with significant and challenging need for innovation



Source: EURELECTRIC Innovation Action Plan polling of utility industry representatives

> *Utilities are large and could be innovation engines but often they are too conservative. Innovation generally comes from much smaller entities. Utilities only adopt new trends slowly, which in turn slows them down and prevents them from taking the lead*
>
> *– National EU policymaker*

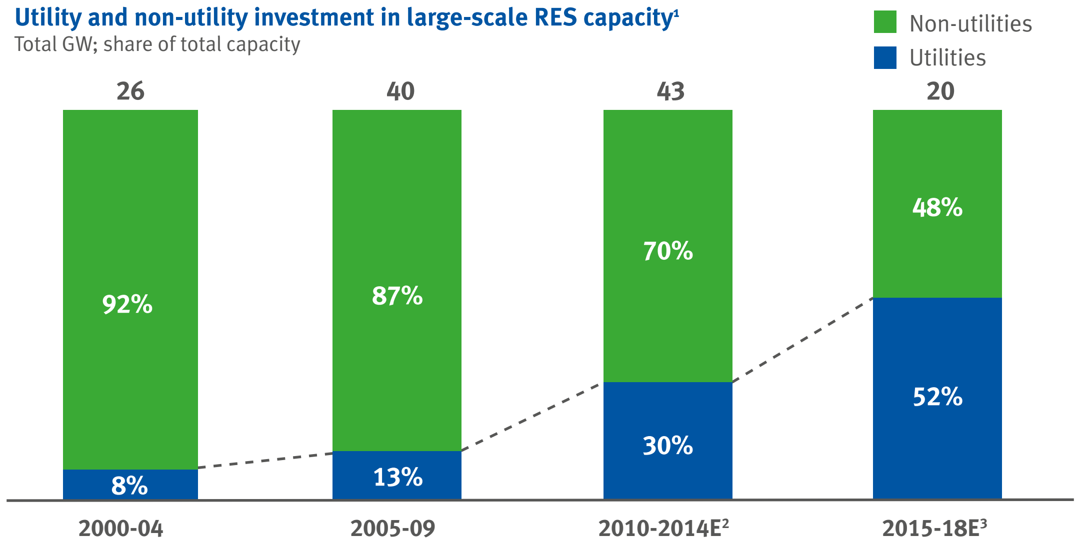
This has now begun to change. A survey of the utility industry conducted by EURELECTRIC shows consensus on a strong innovation imperative. Utilities see that the significant change of the past decade will only accelerate. They agree that all of the power sector will be affected: generation reshaped by continued expansion of renewables and distributed capacity; grid management through smart grids; and retail through a range of new consumer offerings and business models beyond traditional electricity sales. Utility experts also agreed that their existing business is challenged, and on the need for change to enable utilities to capture the new sources of value that change will bring. More than 90% of respondents saw innovation as a key capability for their future success (Figure 30).

> *Innovation efforts are too "atomised" within utilities' organisations. To be more effective, they should be more coordinated among the different business units*
>
> *– EU utility CTO*

This shift in mindset can already be seen in utilities' changing business strategies. The key trend of renewables offers an instructive example. Whereas a decade ago utilities accounted for less than 10% of large-scale RES investment, they account for half or more of the future pipeline of projects (Figure 31). This reflects both an increasing complexity of projects that plays to utilities' strengths, and a change in utility strategy.

FIGURE 31

After a slow start, utilities now account for a majority of the pipeline of large-scale RES investment

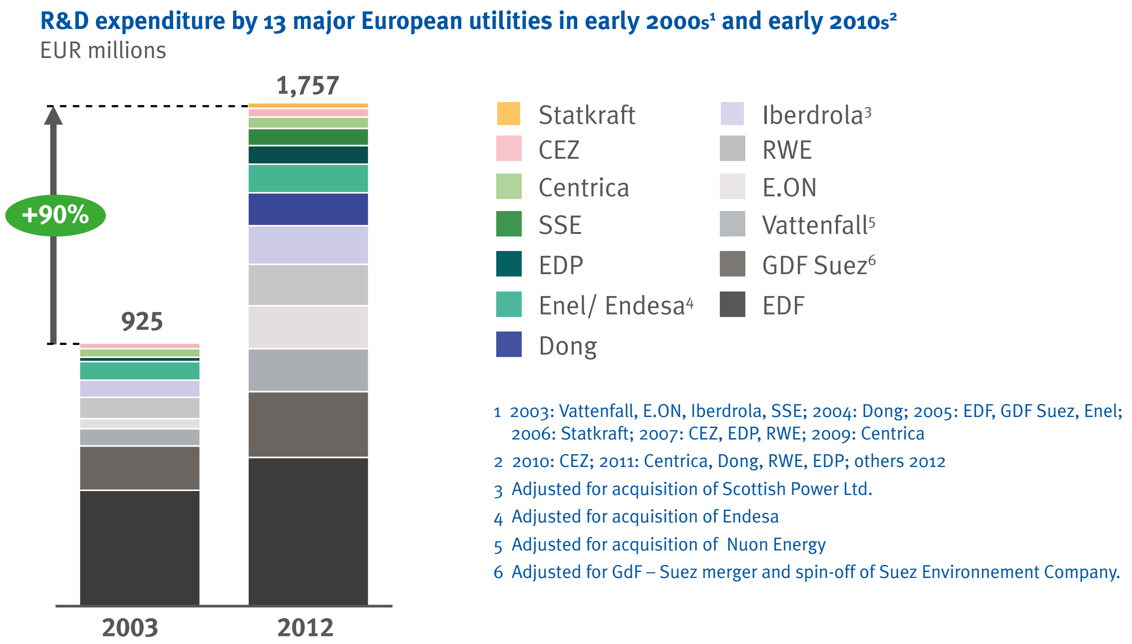


1 Includes installations of 10 MW or more across solar, biomass, and wind power
2 Based on completed projects and pipeline
3 Based on project pipeline

Sources: Platts Powervision, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 32

R&D expenditure by large European utilities has nearly doubled over the last decade to over EUR 1.7 billion



1 2003: Vattenfall, E.ON, Iberdrola, SSE; 2004: Dong; 2005: EDF, GDF Suez, Enel; 2006: Statkraft; 2007: CEZ, EDP, RWE; 2009: Centrica
2 2010: CEZ; 2011: Centrica, Dong, RWE, EDP; others 2012
3 Adjusted for acquisition of Scottish Power Ltd.
4 Adjusted for acquisition of Endesa
5 Adjusted for acquisition of Nuon Energy
6 Adjusted for GdF – Suez merger and spin-off of Suez Environnement Company.

Sources: Capital IQ, company annual reports; EURELECTRIC Innovation Action Plan Taskforce analysis

"Utilities often see innovation as a risky activity and often prefer not to take such risk. Some progress can be acknowledged in the last few years on utilities' attitude towards innovation, but it is incremental, not disruptive"

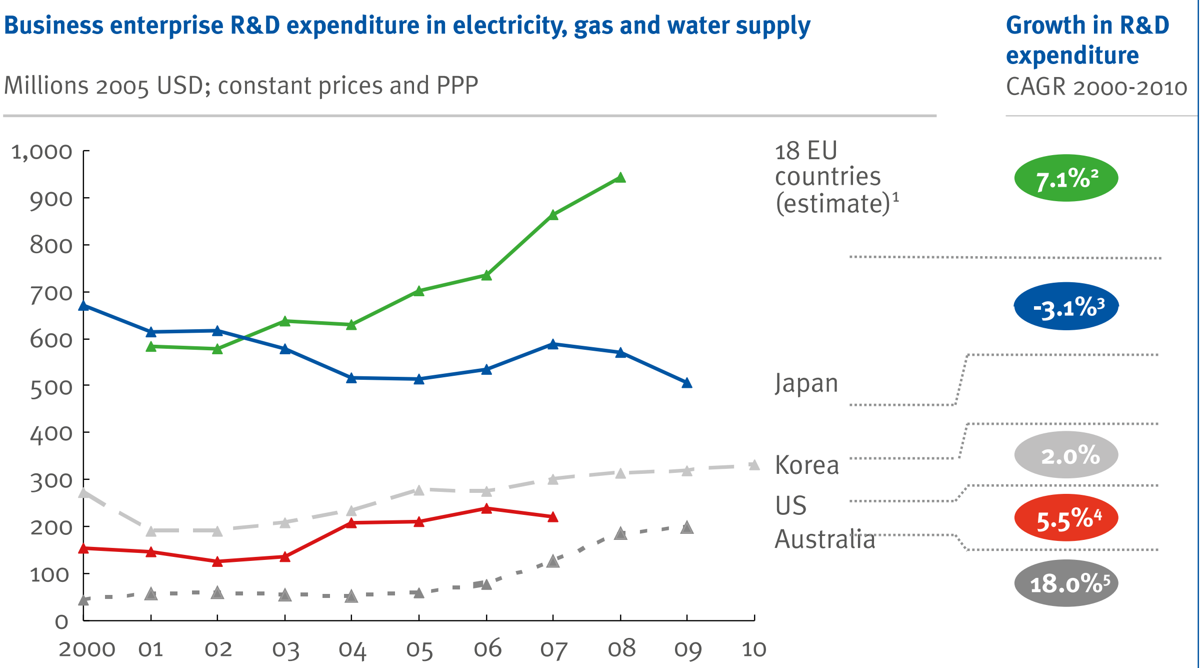
– EU energy innovation expert

Another relevant indicator is R&D expenditure. The level of spending by utilities as a whole has nearly doubled in the past decade – an increase of 90% from 2003 to 2012 (Figure 32).

As a result, European utilities are far more active in R&D investment than their international peers, spending as much as utilities in Japan and the United States combined (Figure 33).

FIGURE 33

EU utilities are more active in R&D than international peers, with significant growth in R&D investment in the last decade

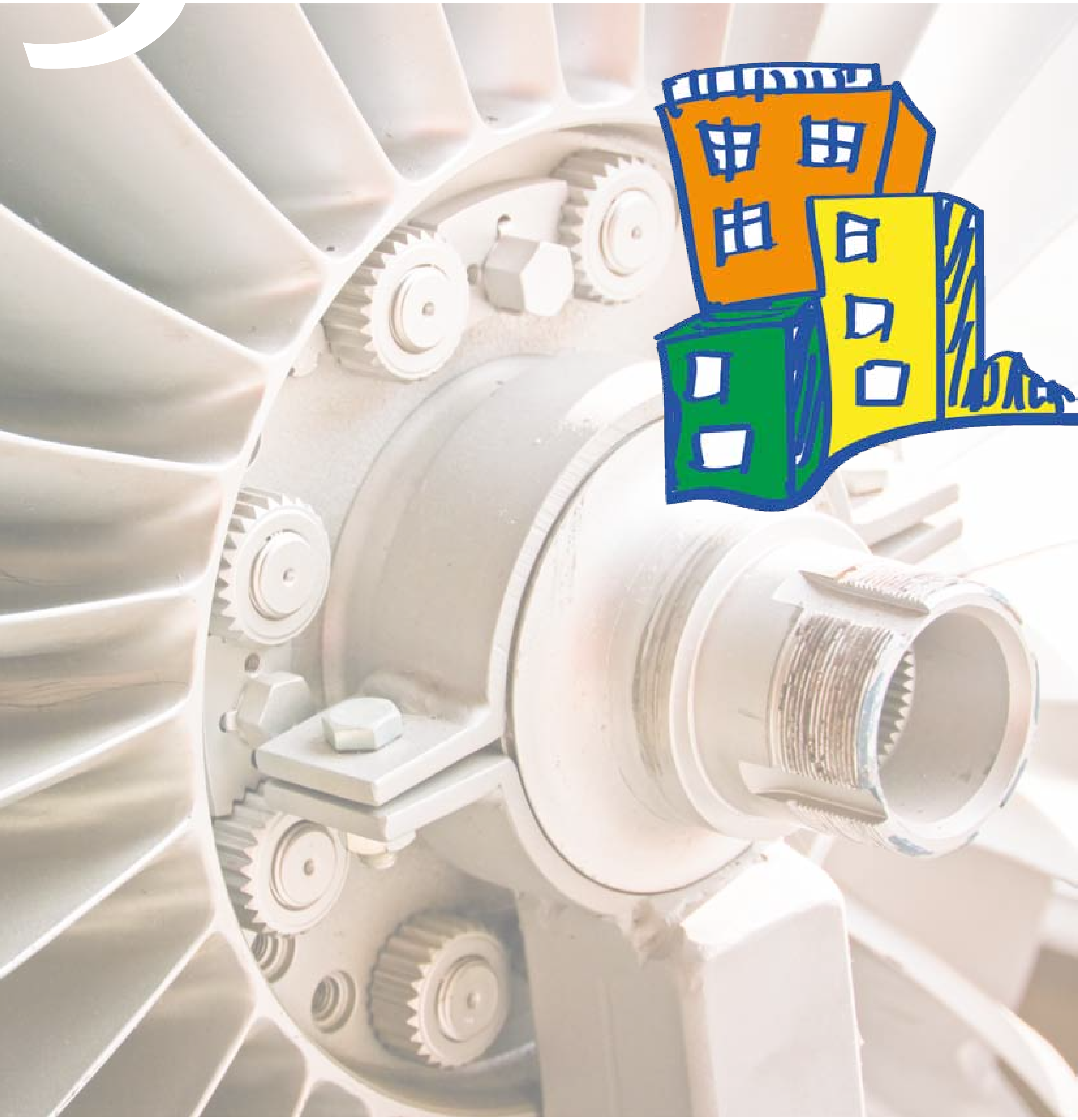


1 Estimate for Austria, Belgium, Czech Republic, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Slovakia, Slovenia, Spain, Sweden, Romania.
2 CAGR 01-08. 3 CAGR 01-09; 4 CAGR 00-07; 5 CAGR 00-09

Sources: OECD, Eurostat, EURELECTRIC Innovation Action Plan Taskforce analysis

The complexity of the power system will increase, from one-way electricity to bidirectional decentralised production, and to closer and real-time management of the grid. In order to capture the opportunities related to the growing value pools, the power sector will need to create new products, processes, and business models. Three innovation imperatives stand out: mastering new technology, getting closer to consumers, and developing new business models and services. Competition is intensifying, with new entrants along the value chain from large-scale RES to new consumer-facing offerings. Utilities now see the change coming, and are increasingly aware of the innovation imperative that will fundamentally shape the future of the EU power sector.

3 ACCELERATED POWER-SECTOR INNOVATION COULD BE WORTH 70 BILLION EURO TO THE EU ECONOMY IN 2030



In addition to the private opportunity and imperative, innovation is a cornerstone of achieving the EU's energy system and climate policy objectives:

- Achieving emissions reductions targets while keeping costs affordable depends on continued cost reductions and performance improvements in low-carbon generation technologies.
- Further decoupling of economic growth and energy use depends on new business models to enable much broader take-up of energy efficient technologies.
- Maintaining security of supply with higher shares of renewables and decentralised generation requires new approaches to system management.
- Providing end-users with the convenience and services they demand depends on a new set of technology enablers as well as business models in meeting customer demand.

The value of an innovation breakthrough could be substantial. Initial estimates indicate that lower costs from low-carbon generation and increased energy efficiency capture could add 70 billion EUR to EU GDP in 2030, and amount corresponding to 350 euros per household. The new sources of value would be shared by a range of beneficiaries of innovation: households and companies consuming electricity, electric utilities and other companies in the electricity supply chain, and various actors throughout the wider economy. Accelerated innovation will enable cheaper energy, higher productivity, improved competitiveness, additional value for consumers, and opportunities for EU businesses. It is a precondition for putting the EU's objectives for the power and wider energy sector within affordable reach.

AFFORDABILITY OF THE POWER SECTOR TRANSFORMATION DEPENDS ON CONTINUED INNOVATION SUCCESS

The cost of the energy sector transformation is attracting increasing attention as a concern across the EU. By the start of 2012, European consumers were paying 38 billion euros per year in subsidies for RES electricity. In several countries, these payments added more than 15% to an average residential electricity bill. Support schemes that seemed affordable with smaller volumes of renewables have been difficult to maintain as the economic slowdown has continued. Several countries have cut support levels, capped total funds or eligible volumes, or in some cases put a moratorium on further support. Meanwhile, only a few countries have put in place the mechanisms required to meet the aspirations of the Energy Efficiency Directive, with ongoing discussions of how to finance the investments required. The EU clearly is still in search of a sustainable policy framework to finance the transformation of the power sector.

Recent fast technology development and increased energy efficiency has laid a foundation to build on. Reductions in the cost of several low-carbon generation technologies have fostered optimism that – with prudent policy – the impact on future electricity prices can be kept to manageable levels. Similarly, the EU has seen early signs of accelerating efficiency, with a slowing of electricity demand growth relative to growth in GDP. Take-up of new and more efficient technologies has been enabled by regulation as well as new business models.

THE BENEFITS OF A HIGH-INNOVATION SCENARIO AMOUNT TO 70 BILLION EURO IN 2030

To investigate the potential contribution from high innovation, EURELECTRIC has examined the potential value to the EU economy of breakthroughs in two main areas:

- Lower power supply costs: the impact of fast cost reductions in renewable energy supplies and system balancing costs
- Increased energy efficiency: business model innovation that achieves greater take-up of cost-effective energy efficiency technologies.

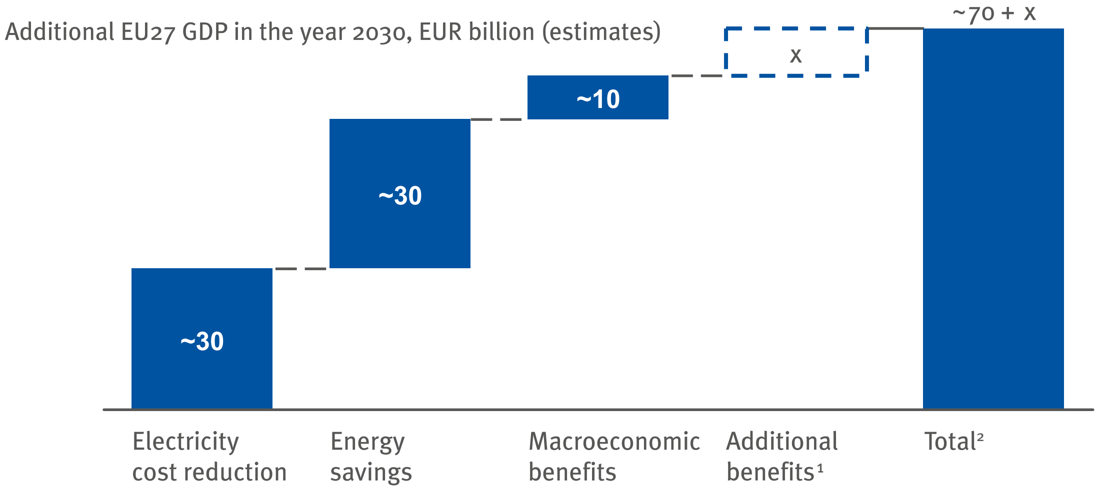
Compared with a reference case, these innovation breakthroughs could be worth 70 billion euros to the EU economy in 2030. Direct electricity cost reductions account for 30 billion of this, while energy savings in buildings account for another 30 billion. Wider macro-economic effects, including improved EU competitiveness but also the cost of implementing energy efficiency, have a net impact of 10 billion (Figure 34).

INNOVATION COULD REDUCE 2030 ELECTRICITY GENERATION COSTS BY 11%

To investigate the implications of different innovation trajectories for the cost of power generation technologies, the analysis took as a starting point the 'Diversified supply technologies' decarbonisation scenario used by the European Commission in its 2011 'Roadmap 2050'. The use of this

FIGURE 34

Accelerated innovation in the EU power sector could be worth 70 billion EUR in 2030



1 Additional innovation benefits not included in this calculation could include reduced costs of balancing the power system, improved consumer convenience and value, additional economic benefits or contributions to EU objectives through accelerated electrification of transport and heat, and clean technology and other business opportunities that could be captured by European industry in the context of an expanded global market.

2 The estimate is of additional gross domestic product, and in total corresponds to 135 EUR per capita in 2030. The benefits would be shared between households and companies consuming energy, electric utilities and other companies in the electricity supply chain, and various other actors throughout the wider economy.

Source: EURELECTRIC Innovation Action Plan Task Force analysis

scenario is not an endorsement of this specific analysis or a suggestion that it should guide policy. Rather, it serves as a reference point frequently cited in public discussion about a possible future of the EU power system that is consistent with the political objectives for the sector. For the power sector, the scenario implies a RES share of 50% by 2030. To achieve this, EU Member States would need to put in place additional capacity to generate 1,100 TWh of annual generation from onshore wind, offshore wind, solar, and biomass (Figure 35).

These large additions will require substantial investment, the size of which in turn depends on the future cost evolution of the underlying technologies. Several RES technologies have recently seen sharp cost reductions, and in the last decade the pace of change often has outstripped projections. The future potential for further cost reductions nonetheless remains difficult to gauge. It depends in part on inherent technological uncertainty. Equally importantly, future cost reductions depend on choices by the private sector as well as public policy: will the EU and the rest of the world put in place the R&D investment and business environment required for continued innovation?

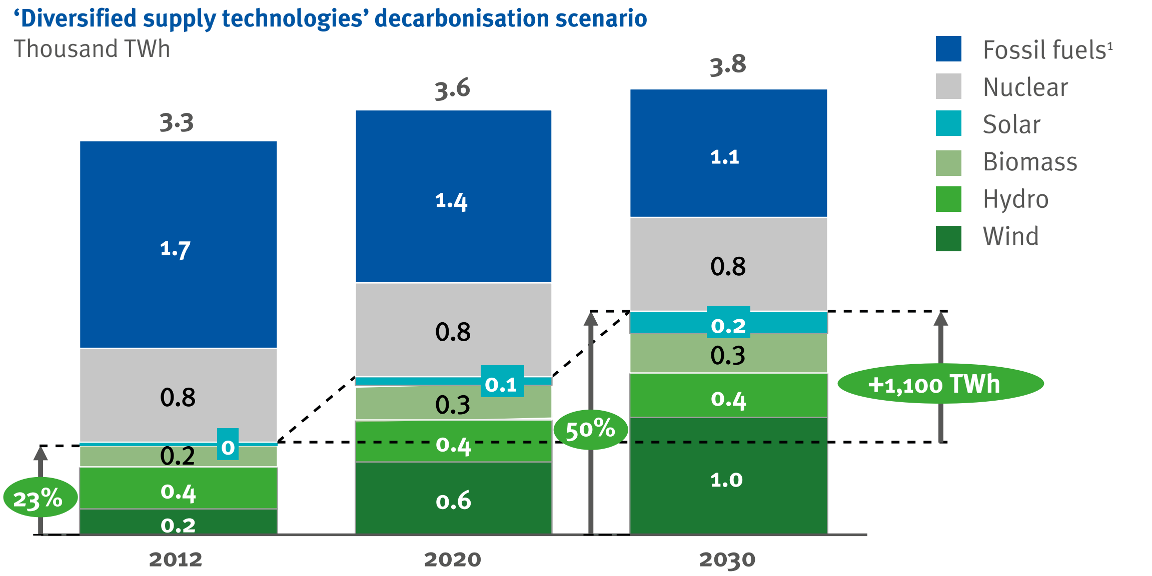
To determine the value of a high pace of innovation, we contrasted two different views on future cost reductions. As a reference case, we used the EC Roadmap analysis assumptions on future costs – i.e., the same projections that underlie the modelling of the above electricity generation mix.[2] The EC Roadmap projections already contain significant cost reductions in RES technologies. For example, the levelised cost of energy (LCOE) for solar PV is projected to drop by 63% over current levels (Figure 36). It nonetheless is significantly more conservative than some other scenarios. As a contrast, we compared the EC Roadmap with an analysis published by Google.org.[3] The Google.org study is not intended as a base case, but aims to show the full potential for innovation as expressed by a potential breakthrough innovation scenario across clean electricity generation. The resulting cost reductions across solar PV and wind technologies

2 As the EC Roadmap is now 2 or 3 years out of date, we update current technology cost levels to more recent estimates, relying on the International Energy Agency's World Energy Outlook 2012

3 See http://www.google.org/energyinnovation/

FIGURE 35

The EC Energy Roadmap 2050 implies an additional 1,100 TWh annual generation from renewable sources by 2030

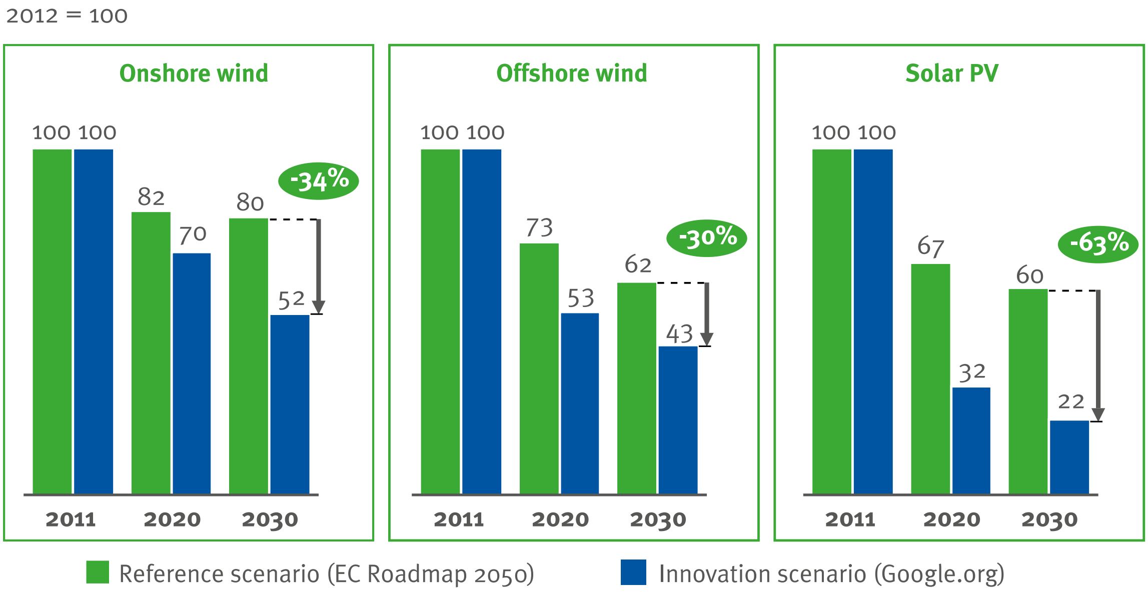


1 Fossil fuels include coal, lignite, gas, and oil

Source: EC Energy Roadmap 2050; EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 36

Scenarios for future cost reductions show significant potential impact of a higher pace of innovation



Sources: European Commission 'Roadmap 2050', Google.org 'The Impact of Clean Energy Innovation', EURELECTRIC Innovation Action Plan Taskforce analysis are significantly more aggressive than those assumed by the EC. Both scenarios assume that continued technology development takes place, but the reference case from the EC Roadmap scenarios is merely 'fast', whereas the innovation scenario from Google.org assumes 'disruptively fast' change.

With a 50% share of renewables in the energy mix, these differences have a significant impact on the overall cost of generating electricity. The reference case implies a 15% increase in the cost of generating electricity, through a combination of shifting to higher-cost RES technologies and rising fossil-fuel prices for the remaining conventional generation. By contrast, the innovation case manages to keep costs in 2030 down, with the per-unit cost of electricity increasingly only modestly over current levels. Underlying this aggregate EU-27 picture, the impact on generation cost varies by geography, depending on the prominence of the relevant RES technologies and fossil fuels in the underlying electricity mix.

Overall, the innovation case would lead to an 11% reduction in the overall average per-unit cost of electricity for the EU-27 in 2030, relative to the reference case.[4] In absolute terms, this cost reduction is worth 30 billion in 2030.

INNOVATION COULD UNLOCK 1,000 TWh OF ENERGY SAVINGS IN 2030

Another significant source of value from innovation is the potential to overcome barriers to energy efficiency improvements. A service-based model for energy supply could help overcome many of the barriers that have held back energy efficiency to date. Meanwhile, cost reductions and performance improvements in key technologies – such as heat pumps, insulation materials, advanced air conditioning, and chromatic windows – could increase the convenience and financial attractiveness of energy efficient solutions.

For this assessment, we focus on opportunities amenable to business model innovation. We take a conservative approach, restricting the assessment of innovation impact to currently existing technologies in the following categories:

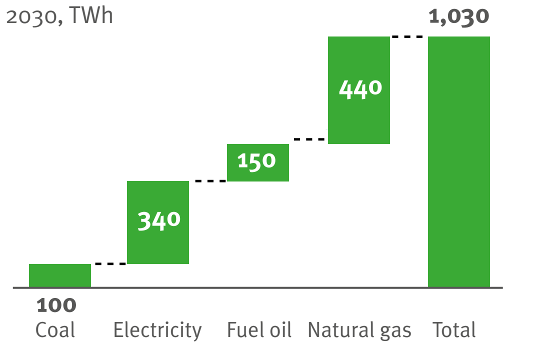
- Opportunities in the residential and commercial buildings sectors that are amenable to a service-based model of energy supply. These include several options for more efficient space and hot water heating, lighting, and appliances and electronics.
- Opportunities within some categories of industrial energy use that are amenable to a service-based business model, notably more effective control systems, energy management, and motors.

Additionally, we included only opportunities that, from a technical standpoint, already are profitable when viewed from a commercial perspective.[5] Finally, we assume that only part of the potential is captured, ranging between 40 to 70% depending on the specific lever. Even with these restrictions, the total energy savings potential is more than 1,000 TWh of energy in 2030 (Figure 37).

Achieving these improvements in efficiency would require a substantial capital investment programme, amounting to an estimated 280 billion euro over two decades. This cost is included in our modelling of costs and benefits, with measures amortised over an average of 15 years and at a cost of capital of 8 to 10%. Overall, the investment cost is outweighed by the benefits of energy savings, which are worth an estimated 64 billion euros in 2030. The benefit net of annualised capital costs is 30 billion euros in 2030.

FIGURE 37

The high-innovation case could achieve energy savings of 1,000 TWh in 2030



Notes: The savings result from capturing 40-70 percent of the energy efficiency opportunities in buildings and industry sectors potentially amenable to a service-based model of energy supply, and which are commercially viable at a 8 percent discount rate and 15-year amortisation period for capital expenditure.

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

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4 The aggregate LCOE for the EU-27 is built up from detailed analysis of the conditions for renewables across the five major EU regions, thus accounting for differences such as varying quality of wind resources and levels of insulation. The number also accounts for the gradual build-up of capacity over time, so that the 2030 number reflects the weighted average of all the 'vintages' of capacity added at different points in time up to that date. Fuel prices are taken from the IEA World Energy Outlook 2012 projections.

5 The energy efficiency assessment uses McKinsey & Company's Global Greenhouse Gas Abatement Cost Curve for estimates of the potential and cost of a range of different energy efficiency measures.

Business model innovation will be at the heart of achieving this potential, in particular in unlocking significant investment potential as well as overcoming other barriers that have impeded energy efficiency improvements to date. Regulation could support the change, but ultimately it will depend on new delivery models for energy products and services. Here, the innovation in business models and new approach to energy supply described in Chapter 2 offer the potential for a step-change in performance. Capturing energy efficiency is very much bound up with successful innovation.

WIDER MACROECONOMIC AND OTHER BENEFITS FURTHER INCREASE THE VALUE OF INNOVATION

The direct savings on electricity generating costs and energy use, as well as the cost of undertaking the investment, have knock-on effects on the wider economy. We investigated these effects using a macroeconomic model of the EU economy to represent lower electricity generating costs, energy savings, and the investment needs to achieve energy efficiency improvements.[6] A range of macroeconomic benefits emerge, with some of the more prominent including increased disposable income for households, benefits to EU companies from reduced cost of production, and increased EU competitiveness (relative to the reference case). Cumulatively, these and other effects would increase EU GDP by 10 billion euros in 2030, or around 50 euros of additional GDP per EU household.

The above assessment of benefits arguably is conservative, leaving out important categories of benefits to the EU economy. Four prominent examples include:

- **Power system costs:** innovation in grid management, storage, demand-side management, and flexible power generation could cumulatively significantly reduce the cost of handling variability in low-carbon generation sources.
- **Consumer convenience:** the availability of new services to end-users could have significant convenience and other benefits beyond the energy savings investigated above.
- **Energy security:** the value of increased energy security is not included in the above assessment, but could be an auxiliary benefit of both increased energy efficiency and the electrification of transport.
- **Wider energy price impacts.** Significantly reduced costs of RES would lead a worldwide expansion of non-fossil energy technologies, with a drop in demand for fossil fuels. This in turn would lead to falling fuel prices, reflecting the fact that significant reserves of hydrocarbons can be extracted at costs significantly lower than currently prevailing prices.

In addition, innovation across these areas will create a large market for technology and business models to promote low-carbon supply and resource productivity. The innovation performance and degree of dynamism of EU firms in turn will determine how much the EU economy gains from these trends – including through global market opportunities.

Overall, power sector innovation has a very high value. In a breakthrough scenario, it could significantly soften or even eliminate the upward pressure on electricity prices that otherwise results from the decarbonisation agenda. Similarly, innovation in business models could unlock significant energy efficiency and other downstream benefits. Initial estimates indicate a direct value of electricity cost reductions and energy efficiency improvements in an innovation breakthrough case of 60 billion euros in 2030. Wider macroeconomic benefits would add another 10 billion euros, for a total of 70 billion, or 350 euros of additional GDP per EU household in 2030. A range of other benefits might also be enabled, ranging from reduced power system costs to increased consumer convenience, energy security, and reduced fossil-fuel prices.

Capturing this value will depend not only on developments in the EU, but also on the worldwide pace of innovation. Yet the EU has an important role to play, at least commensurate with its leadership role in undertaking GHG emissions reductions. As we discuss next, putting in place an enabling EU policy framework for power and wider energy sector innovation needs to be a core priority for overall energy and climate policy.

6 The model is a dynamic general equilibrium model of the world economy, including separate modelling of five major EU regions. The model represents the linkages between different sectors in the economy, and through these represents the impact of different energy system characteristics on the prices of intermediate goods as well as final consumption. It also accounts for trade relationships, and for dynamic adjustments over time.

4 INNOVATION POLICY IS MORE THAN R&D: A LARGE NUMBER OF POLICY FACTORS AFFECT INCENTIVES FOR INNOVATION

Many constituent parts are in place for the EU to continue as a centre of power sector innovation. For example, the EU is ahead of other geographies on several enablers of innovation, and the EU has performed well in filings for clean energy patents.

However, private sector innovation will require an effective enabling policy framework. This must recognise that a large range of policies act on innovation. Far from being just a matter of R&D funding, innovation depends on functioning markets and on support throughout the innovation process.

EU POWER SECTOR INNOVATION CAN BUILD ON SIGNIFICANT STRENGTHS

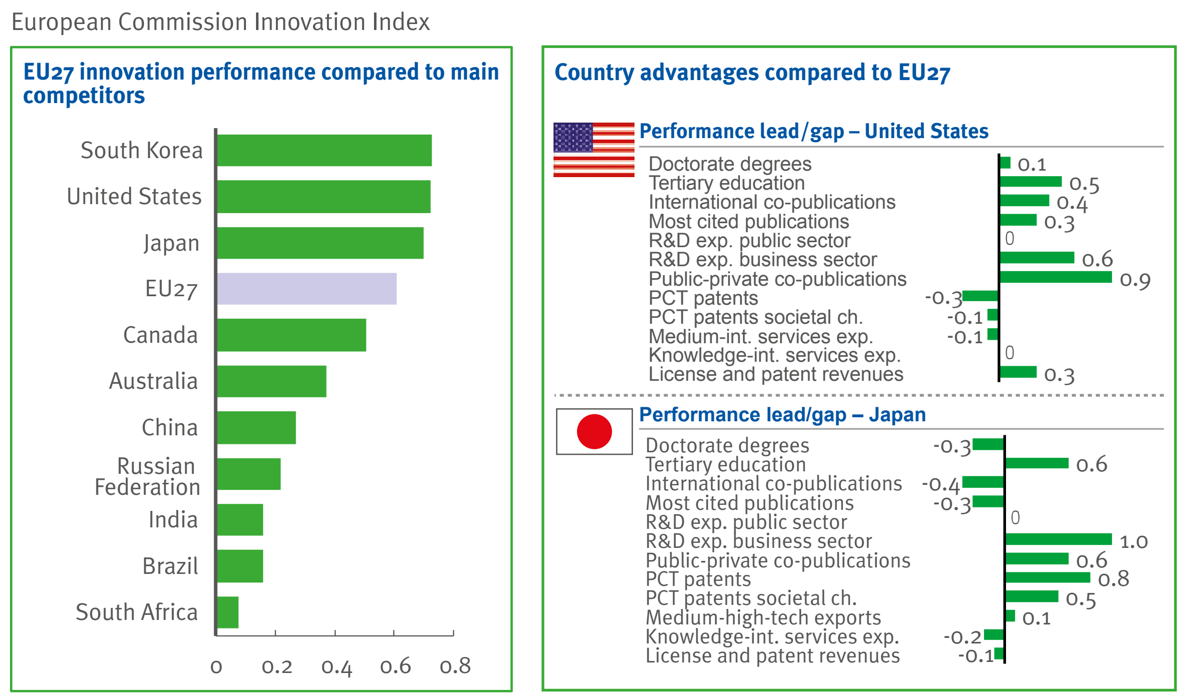
It is a long-standing concern that the EU lags behind competitors on several metrics of innovation performance. Looking across all sectors of the economy, less than 2% of EU GDP is devoted to research and development, whereas the USA spends 2.5% and Japan more than 3%. This situation is mirrored in several other indicators, including education, publications, patents, and high-tech exports (Figure 38).

Nonetheless, in the power sector, the EU has several strengths that paint a more positive picture. Several of the trends discussed in the foregoing chapters have given the EU a lead in important enablers of power sector innovation (Figure 39):

- Retail competition: the EU has gone further than any other region to open electricity supply to competition. This has the potential to provide a conducive enabling setting, especially for downstream business model innovation.
- Smart meters: the EU has a lead in smart meters. This holds promise for innovation in both grid management and new consumer offerings, especially when coupled with more extensive smart grid infrastructure.
- RES deployment: the EU has long led the way in deploying renewables. This contributes to significant cost reductions in key technologies, and the EU will also be the geography that first needs to innovate to integrate a large share of variable power production in its electricity system. With these imperatives come costs and challenges, but also the opportunity to innovate to take a lead in the next generation of solutions required.

FIGURE 38

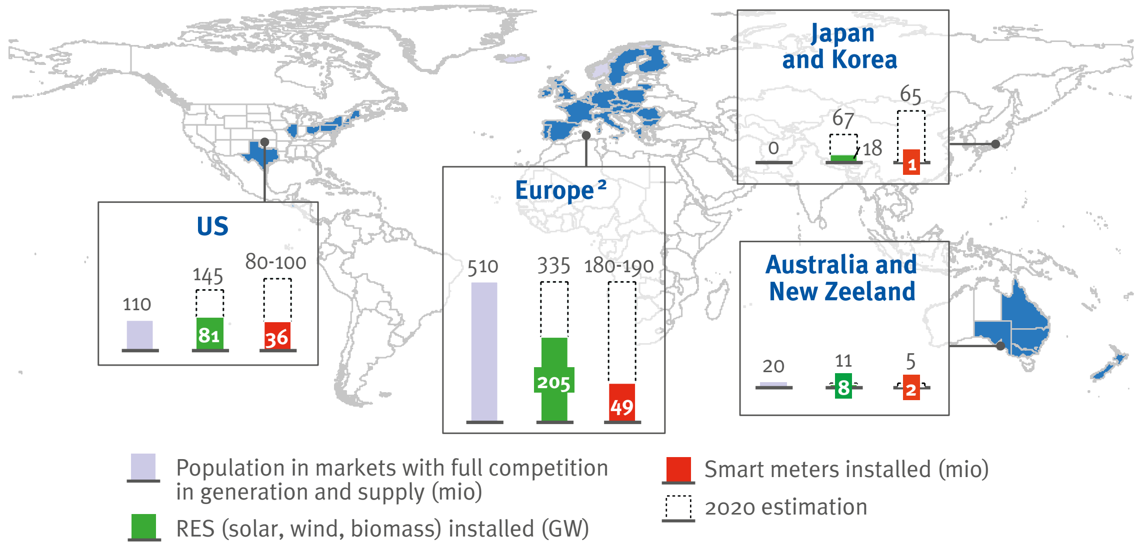
The EU lags behind other regions in innovation performance on several metrics



Source: European Commission Innovation Scoreboard 2013

FIGURE 39

Europe leads in market liberalisation, renewables and smart meter installations[1]



1 All figures are estimates as of end of 2012
2 Scope of countries with full competition corresponds roughly to EU27 (excludes Estonia, Latvia, Malta, Cyprus and includes Norway, Switzerland and Iceland)

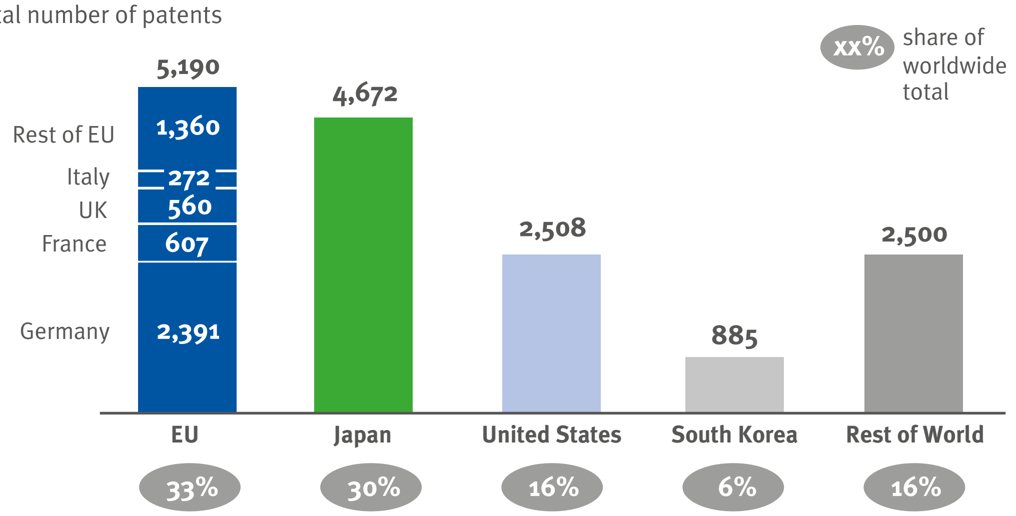
Sources: Energy Velocity, Global Insights, EEI, eMeter, press search, various government sources, Platts, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 40

With one-third of the global total, the EU accounted for more clean energy patents than any other region in recent years

Clean energy technology[1] patents by geography, 1988-2007

Total number of patents



1 Technologies included are solar PV, solar thermal, wind, geothermal, hydro and marine, biofuels, carbon capture, carbon storage, and IGCC

Source: European Patent Office; EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 41

A wide range of policies act on innovation in the power sector

		Description
R&D and demonstration funding	Direct R&D grants	Grant direct funding for research, in the EU typically focussed on basic research through universities
	R&D risk-sharing and loans	Provide rebated finance for major R&D projects
	R&D tax credits	Provide tax credits for various categories of R&D costs
	Demonstration funding	Make available financial support to validate technologies not yet commercially viable and disseminate findings
Support for commerciali-sation and deployment	Public VC function	Provide public seed / start-up finance and related commercialisation support for SMEs
	Product-to-market support	Push technologies into market by financially supporting production
	Patents	Enable value capture of innovation investment in commercially (near-)viable products
	Prizes	Proposed as alternative mechanism to reward innovation, but limited current use
	End-use support[1]	Create demand pull for products and services, both through market stimulation and risk mitigation
	Public procurement	Use public procurement (e.g, quotas for "innovative products") to create market pull
Enabling market framework	Infrastructure	Provide the public infrastructure required for innovation (grid, labs, data access, etc.)
	Competition	Create competition as one of the most powerful incentives for innovation
	Regulation and incentives	Set the regulatory conditions to reward the provision of innovative services or products
	Legal framework	Ensure relevant legislation favour innovation process (laws on IP, bankruptcy, insolvency, start-ups, etc.)
Collaboration and learning	Education and training	Create fundamental talent pool (e.g., university education, slow-acting) or entrepreneurial skills (e.g., business training, faster-acting)
	Coordination and publication	Create forums for coordination of research, validation and dissemination of R&D results, public databases of findings, etc.
	Technical standards	Improve market scale by setting joint direction of innovation.
	Networks and outreach	Support networks for innovation including international collaboration, industry-academic collaborations; industry extension services; centres of excellence; public information campaigns; etc.

1 Includes subsidies, mandates, tax credits, and rebates for end-users of innovative products

Source: EURELECTRIC Innovation Action Plan Taskforce analysis

These and other favourable enablers have translated into successes on various indicators of innovation performance. As an illustration, the EU accounted for one-third of the patents worldwide across a range of clean energy technologies in the decade leading up to 2007. This put the EU ahead of all other geographies, including Japan and the United States (Figure 40).

These snapshots illustrate an opportunity for the EU. If it can sustain a dynamic private sector and the right policy environment, the EU has the potential to remain a significant hub for power sector innovation.

INNOVATION INCENTIVES SPAN A WIDE RANGE OF APPLICATIONS

Policy acting on innovation in the power sector goes beyond traditional innovation policy domain of research, development and demonstration (RD&D) support. Four categories of policy are all highly significant to enable innovation (Figure 41):

- R&D and demonstration funding: RD&D provides the overall 'push' for innovation, but it is only a first step in implementing an effective innovation policy, and this is particularly true in the power sector.
- Support for commercialisation and deployment: equally important policy impetus for innovation comes through support for bringing innovations to market. This creates the conditions to enable privately funded RD&D. It also enables innovation beyond the point of demonstration – through commercialisation technologies and opportunities for new business models.
- An enabling market framework: in power in particular, a business environment conducive to innovation also depends on the broad set of policies and regulations that define the overall enabling market framework – effective competition, innovation-friendly regulation, and supporting infrastructure.
- Innovation networks: finally, policy can facilitate the innovation process by facilitating links between researchers, industry, and finance, as well as across sectors and geographies.

The current EU-level innovation policy landscape contains a large number of policy initiatives spanning all of these categories. Figure 42 shows a high-level policy map, discussed in more detail below.

Effective R&D and demonstration funding presents particular challenges in the power sector

Long-term innovation in the power sector is highly dependent on public R&D support. As in other sectors, the case for public funding rests on the principle that there are societal benefits of R&D that private firms cannot be expected to take into account when making their R&D investment decisions. In the power sector, this effect is further amplified by the strong role that societal objectives have in defining the future evolution of the sector – notably targets to reduce emissions and concerns with ensuring the security of energy supplies. Correspondingly, the need for public R&D support also is greater than in many other sectors.

The power sector also poses particular challenges to ensuring that R&D policy is directed effectively and efficiently. Many features and potential pitfalls are shared with other sectors – notably, the risk that public investment 'crowds out' private efforts, or that the absence of market scrutiny means dead ends are followed for too long. However, in the power sector, the challenge is multiplied by a number of additional factors. Technology rivalry is complicated by the existence of multiple technologies at very different maturities and with very rapidly evolving cost and performance. Long lead times (potentially decades) to reach mass markets and uncertainty about eventual performance mean there is high value in finding out more about the potential of particular technologies and solutions. At the same time, the potential for wasted effort and misdirected funds also is large when the potential benefits are far in the future. Also, the ongoing significant change in business models wrought by policy as well as consumer expectations and enabling technologies means the business case for particular innovation investments is in constant flux.

A range of policies are used to support R&D, the most familiar of which is probably direct public grants. In the EU, these typically are directed at universities and research

FIGURE 42

Overview of current EU-level power sector innovation policy levers

		Main EU-level examples
R&D and demonstration funding	Direct R&D grants	• FP7 & Horizon 2020, Structural funds, Intelligent Energy Europe, Euratom, CIP
	R&D risk-sharing and loans	• EIB Risk Sharing Finance Facility (RSSF)
	R&D tax credits	• Implemented at Member State level (typically not energy-specific)
	Demonstration funding	• Ad-hoc / one-off programmes including NER 300, European Energy Programme for Recovery • More systematic support through FP7, European Industrial Initiatives (SET plan)
Support for commerciali-sation and deployment	Public VC function	• Intelligent Energy Europe start-up / SME support, EIT VC functions in InnoEnergy
	Product-to-market support	• No significant use in EU energy policy, but cf US biofuels support programmes
	Patents	• Standard patent provisions; no special provisions for energy sector
	Prizes	• (No significant use in EU energy policy)
	End-use support[1]	• Policies to create market demand, including implementations of RES directive, EU ETS, EE directive
	Public procurement	• Selected Member State initiatives (e.g., Spain 3% quota for innovative products)
Enabling market framework	Infrastructure	• E.g., connecting Europe Facility (TEN, EIB, Structural Funds, Cohesion funds)
	Competition	• Third Internal Energy Market Package
	Regulation and incentives	• Market design, undertaken at Member State level
	Legal framework	• EU coordination of various applicable legislation (bankruptcy, IP, etc.)
Collaboration and learning	Education and training	• Fit European Research Area, various Member States
	Coordination and publication	• SET Plan and Energy Technology Platforms, European Industrial Initiatives, Zero Emissions Platform
	Technical standards	• Range of specific initiatives, including product energy efficiency standards, grid standards, etc.
	Networks and outreach	• European Research Area, EIT, technology-specific collaborations

1 Includes subsidies, mandates, tax credits, and rebates for end-users of innovative products

Sources: European Commission; EURELECTRIC Innovation Action Plan Taskforce analysis institutes, often focussing on areas where the lack of near-term prospects for commercial application means there are insufficient private-sector incentives. However, policies can also support private R&D. A prominent mechanism is tax breaks for various categories of costs incurred in the pursuit of R&D. There are also policies attempting to act on the risk (rather than cost) component of R&D, by offering rebated finance or other risk mitigation mechanisms.

In addition, support for demonstration projects has a particularly important role in the power sector. The gap between small-scale pilot performance and real-world deployment is greater than in many other sectors, making demonstration a critical bottleneck in the overall innovation process. Moreover, demonstration is highly risky for individual private companies to undertake – in view of long amortisation periods for assets, large capex for individual projects, and long development cycles for key technologies. Although typically carried out by commercial companies, the case for public support rests on the same principle as support for R&D, i.e., that the demonstration activity results in benefits (knowledge about the validity of initial R&D findings in real-world applications) that benefit society at large, whereas the private benefits may not outweigh the risks and costs incurred by companies.

> *“Policy needs to take into account that Innovation in the electricity sector implies a demonstration phase after research and before roll-out”*
>
> *– EU utility executive*

Concretely, RD&D funding is dominated at the EU level by the EU Framework Programme (FP) for Research and Technological Development. The current FP7 dedicated 2.3 billion euros to energy, as well as 2.7 billion euros to nuclear R&D. EU-level funding has more than doubled from FP5 to FP7, and under current proposals is set to grow further under Horizon 2020 to a total of 6 billion euros for the period 2014 to 2020.[7] In the last several years, FP7 has also been complemented with adhoc programmes that support deployment and demonstration activities, including the 4 billion euro European Energy Programme for Recovery, and the 'NER300' programme to support demonstration projects for CCS and RES solutions. Finally, the EU has instituted the Risk Sharing Finance Facility, administered by the European Investment Bank, which offers low-cost finance to reduce the risk of R&D activities.

Capturing the full innovation potential in the power sector requires effective support for commercialisation and deployment

In many sectors, the chief or even sole innovation policy complement to RD&D support is intellectual property rights, notably patents. The increase in profitability resulting from an effective temporary monopoly on an innovation creates sufficient financial inducement to 'pull' innovation activity in the private sector. Ultimately, the private RD&D process is financed and enabled by the prospects of profits earned in the market.

In the power sector, however, the value of patents in a market setting is not sufficient to induce private-sector innovation. The objective of decarbonisation eventually will require deployment at scale of technologies and business models that currently are immature or even unavailable. Patents do not provide incentives for innovation in situations where the market for the patented product is too small or unprofitable to warrant private investment in RD&D and commercialisation. In such cases, commercialisation and market deployment will attract private resources only if the requisite market setting is actively 'created'.

> *“Demand-led innovation is particularly important, with public sector procurement a promising instrument”*
>
> *– National EU policymaker*

Experience has shown that a functioning market setting for commercialisation and deployment is an indispensable component of successful power sector innovation, in three main ways.

First, it provides incentives for private investment in R&D as well as demonstration.

Second, it enables industrialisation and 'learning-by-doing', as end-users, engineers, and managers get hands-on experience with technologies and business models. By

7 This incorporates components for energy under the Competitiveness and Innovation Framework Programme (CIP) as well as the EU contribution to the European Institute of Innovation and Technology (EIT)

contrast, R&D support does not reach these crucial actors in the innovation and product supply chain.

Third, demand-side pull integrates the innovation cycle, allowing producers and innovators to discover the real-world set of issues encountered by end-users. This in turn helps determine what should be the subject of the next wave of (applied) R&D activity.

For these reasons, many of the most significant power sector innovation successes of the last two decades have been not about bringing lab 'breakthroughs'to market. Instead, power sector innovation has largely been about continuous learning through deployment. The set of processes is complex and cannot be easily anticipated by centralised policy. Demand-side support, when implemented well, can enable firms to undertake the numerous small steps of innovation that ultimately enable commercially viable products, processes, and business models.

Examples of mechanisms to create the necessary 'enabling market setting' include product-to-market support, subsidised production, and the allocation of public procurement projects to products that would not win on current commercial criteria alone. There also are much more specific types of intervention, such as public financial or other support for small and medium enterprises (SMEs), or publicly funded facitilities similar to private venture capital.

For the EU power sector, demand is created primarily through support for the end-use of technologies. The more important categories include product mandates and standards for energy efficiency or other attributes; taxes or charges on pollution; subsidies or mandates for deployment; and direct regulation to deploy grid or other technologies. Correspondingly, the main EU-level policies intended to create 'demand pull' support for innovation are the three pillars of overall climate and energy policy: the EU ETS, the Renewables Directive, and the Energy Efficiency Directive. These all make some contribution towards creating market volume certainty for technologies that otherwise would not be commercially viable, thus providing some opportunity for prospective innovators. Yet, as we discuss below, innovation is but one of many objectives pursued, and the role of innovation in these instruments far from clearly articulated.

A final broad category of demand pull is created through the regulatory regime for distribution and transmissions grids. National regulatory initiatives to adopt smart meters and other distribution grid features have been instrumental in creating an enabling environment for key aspects of innovation in both smart grids and in the technological basis for new consumer offerings.

Innovation requires an effective enabling framework of strong competition, innovation-friendly regulation, and supporting infrastructure

The third major category of policy arises from the recognition that innovation requires a broad set of additional enablers to be effective. This includes stimulating functioning competition to provide incentives to explore and deploy new business models, products, or processes. It also includes public infrastructure, and a legal and regulatory system conducive to entrepreneurship.

> *“Innovation is driven by market forces. Good innovation policy is ultimately a policy that creates competition”*
>
> *– EU energy innovation expert*

In the power sector, an additional policy layer is added by the fact that some activity is regulated, or markets are designed by regulators. Although liberalisation has reduced the extent of regulation, many aspects of the power system remain under regulatory influence. Regulation can be a significant roadblock to innovation by circumscribing the range of feasible business models, or by reducing or altogether removing incentives for R&D or for new product offerings or processes. This was vividly illustrated by interviews with utilities and policymakers in the United States and other geographies, who cited regulatory inflexibility as one of the most significant obstacles to continued innovation, particularly in new business models to supply end-users. Conversely, the Japanese experience is but one example among many of how innovation takes place chiefly where competition is allowed to flourish: in the Japanese case, between gas and electricity suppliers. Although rarely thought of as an innovation policy, regulation certainly can be one of the policy areas with significant scope for reform to improve innovation performance.

Regulation also shapes innovation in electricity grids. Some Member States have introduced specific innovation incentives for grid companies. For example, the UK allows grid companies to raise prices by up to 0.5% of revenue to recoup R&D expenditure, while combining this with limits on pass-through to maintain some risk-sharing. Furthermore, the UK has introduced a specific fund to finance experimentation with new technology as well as with operating and commercial arrangements. An alternative mechanism is in place in Italy, in which a higher weighted-average cost of capital is set for the regulated distribution asset base of selected demonstration projects.

Networks to enable collaboration are important enablers throughout the innovation process

A final major policy category consists of a number cross-cutting initiatives that policymakers can put in place to enable the networks through which innovation takes place. One is ensuring that the necessary talent pool is available through education and training. Coordinating research and ensuring adequate resources for collaborations also can be powerful promoters of innovation, as can coordination of technical standards and measures to ensure access to data and findings that enable further innovation.

“People are key, innovation is about developing a generation of entrepreneurs/ business people with an innovation mindset”

– EU innovation expert

The main vehicle for coordinating EU energy policy is the Strategic Energy Policy Plan (SET Plan). This is complemented by other initiatives, including the European Energy Research Alliance, the European Technology Platforms, and the InnoEnergy Knowledge and Innovation community.

Although these collaboration mechanisms offer opportunities for coordination, the large majority of EU research is undertaken outside the framework of these initiatives. National Member State R&D programmes typically are run mostly independently.

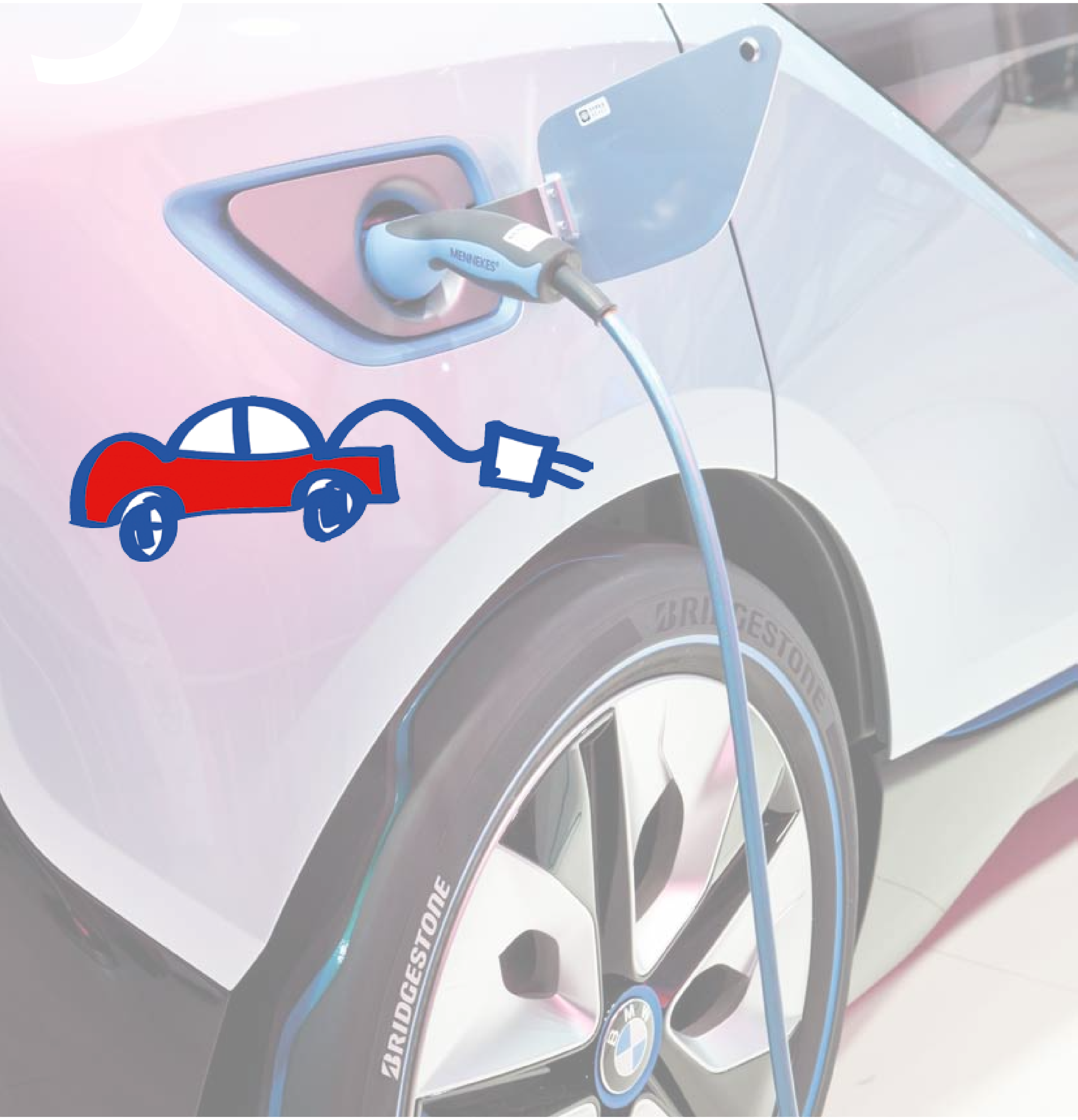
“The right human capital is essential for innovation. We need a new generation with the right skills and knowledge”

– EU national policymaker

In sum, innovation in the power sector depends on a full set of enablers: a vibrant private sector incentivised by competition and entrepreneurship, functioning RD&D that is effectively linked to the rest of the innovation process, an ‘enabling market setting’ to underpin the business case for deployment, and a set of wider enablers, including strong competition, effective regulation, and supporting infrastructure.

The experience in the wider energy sector bears this out strongly. A recent spectacular illustration is the breakthrough in US unconventional gas, where a private sector with significant investment capacity and risk appetite was supported by public policy initiatives.

5 CURRENT EU INNOVATION POLICY – MISSING THE MARK?



Where does current EU policy stand in its ability to encourage innovation? The answer is mixed, and EURELECTRIC has identified a number of areas where current policy does not realise its full potential to promote innovation. Recent increases in funding have been a welcome reversal of a tendency to deprioritise RD&D investment in the power sector. Yet much can be done to better align this investment with strategic objectives and to improve its effectiveness. On the demand side, the EU has made significant interventions in the market to stimulate the entry of new technologies and to some extent business models. However, implementation is dominated by top-down targets that often treat innovation objectives as an afterthought. In addition, a greater role for competition could be a significant enabler of innovation in the EU.

EU PUBLIC ENERGY RD&D INVESTMENT: A CLEAR PRIORITY

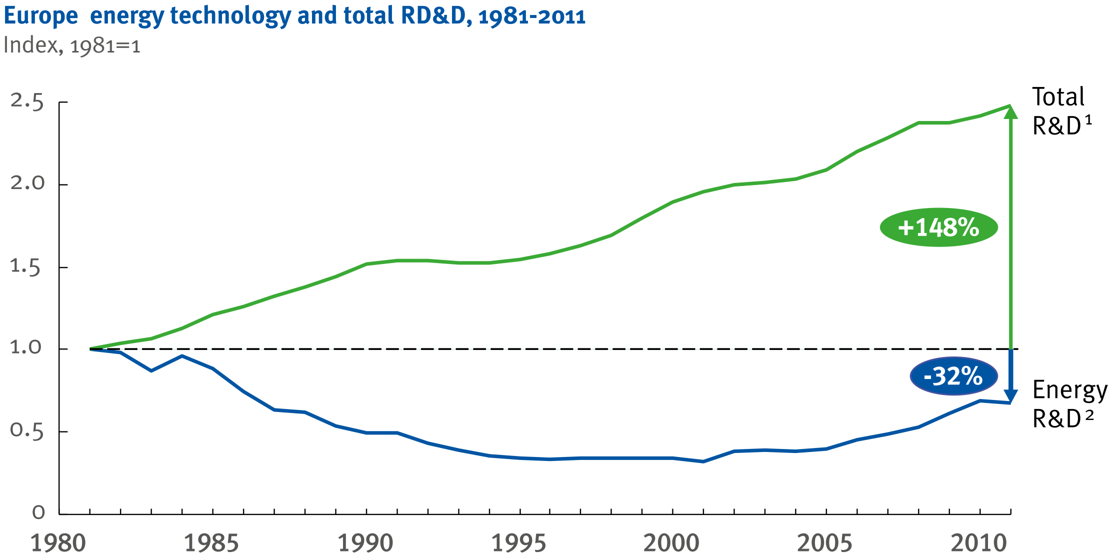
Research, development, and demonstration are cornerstones for continued long-term innovation in the power sector. Many of the benefits relate to long-term strategic policy objectives for the energy system, rather than to near- or medium-term business opportunities that could make investment profitable for private businesses. Public funding therefore is a necessity to achieve societal objectives.

Yet public RD&D investment is often at risk of becoming a low priority. Its benefits are uncertain and often far in the future. Many of the benefits are shared internationally rather appropriated by the country providing the R&D funding. Unlike industrial investment support policy or subsidies for particular technologies, RD&D has few natural advocates. For these and other reasons, there is a significant risk of systematic public under-investment.

This risk of deprioritisation has been evident in the power sector in the last three decades. Since the early 1980s, EU public funding for energy sector R&D has fallen by a third in absolute terms, even as total public R&D more than doubled (Figure 43). If the EU had maintained the share that energy had in overall R&D funding support in the early 1980s, it would spend more than three times more on energy RD&D today. This pattern is repeated in the United States, Japan, and the OECD as a whole. Not only the EU, but the world as a whole has a significant energy RD&D deficit to close.

FIGURE 43

EU public energy R&D investment has declined and, despite recent growth, lags far behind total growth in R&D



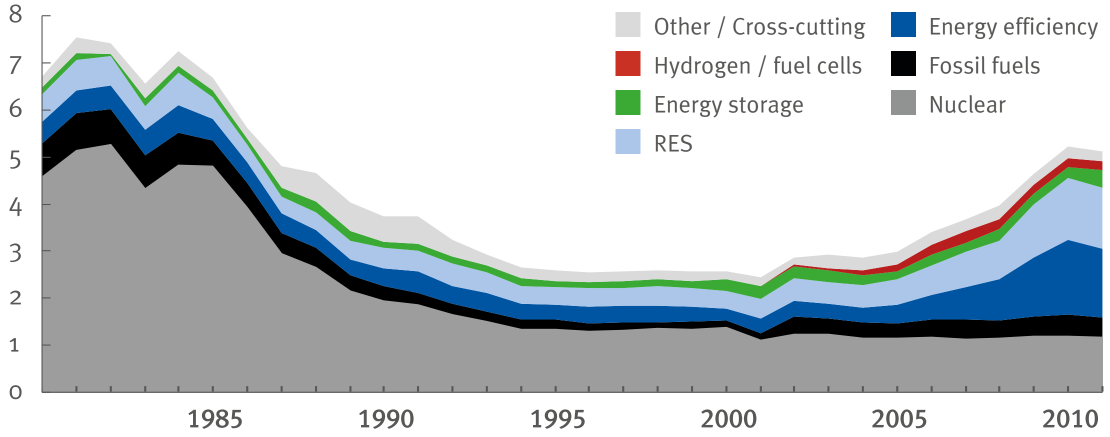
1 EU 27; missing individual data points 1981-1999 interpolated based on 2000 shares of R&D expenditure.
2 EU IEA member countries; energy technologies include nuclear, fossil fuels, energy efficiency, renewables, energy storage, hydrogen / fuel cells, and other cross-cutting energy categories

Sources: Energy Technology RD&D 2012 edition © OECD/IEA 2012, Eurostat, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 44

Recent EU RD&D funding growth has emphasised renewables and energy efficiency

IEA Europe public RD&D funding for energy technologies, 1980-2011[1]
USD billions (PPP); 2011 prices



1 Data covers EU IEA member countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden, and United Kingdom, as well as EU-level funding

Source: Energy Technology RD&D 2012 edition © OECD/IEA 2012; EURELECTRIC Innovation Action Plan Taskforce analysis

Recently, the EU has taken steps to close the gap. There has been recent growth in energy RD&D funding, which in the last decade has grown at 6% per year, or twice as fast as total RD&D funding. Continuing this trend, funding levels will catch up with the absolute levels seen in the 1980s towards the end of this decade. Yet this current funding growth will need to be sustained for another two decades to restore energy RD&D to the priority (as a share of GDP) that it commanded towards the end of the 1970s oil crises.

Even with recent growth, RD&D is small in comparison with other public support for technology development. Support for solar PV is an instructive example. As indicated above, Germany has by far the largest number of clean energy patents of all the EU Member States, and also has the largest and most active solar PV industry in the EU. In 2008, total public support for solar PV R&D in Germany was 60 million euros. For comparison, one study found that, at that time, Germany committed as much as 4,200 million euros per year to feed-in tariffs for solar PV, while investment support for solar-PV-related manufacturing plants amounted to 650 million EUR.[8] In other words, R&D support was just 3% of total public support for the overall solar PV innovation process. Germany is not a unique example in this respect, in the EU or internationally; the equivalent number for China, for example, is around 1%.

RD&D SUPPORT NEEDS IMPROVED TARGETING AND GREATER EMPHASIS ON DEMONSTRATION

The EU recently has improved its ability to match RD&D to overall energy system objectives. R&D investment in energy efficiency and RES started to grow in the late 1990s, as decarbonisation objectives came to the fore. These categories account for more than 80% of the increase in the funding since then (Figure 44). By contrast, much of the overall decline in energy R&D in the last three decades is due to a large drop in expenditure on nuclear fission R&D, which has not grown since the mid-1990s. The reasons here are complex, not least differing Member State priorities and attitudes towards nuclear power.

Although there is improving high-level alignment in broad technology areas, the EU faces significant challenges in putting together a coherent RD&D programme to match its strategic energy objectives. In this area, the interviews and analysis undertaken by the EURELECTRIC Task Force idenfied five broad areas for improvement:

- **Programmes need better strategic direction and a systems approach.** The establishment of the SET Plan

8 See Grau et al (2011). The FIT estimate refers to the present value of annual FiT commitments for new installations in the period 2003-2009, using a discount rate of 7%.

and other coordinating mechanisms was a significant step in the right direction. However, the approach remains fragmented into technology silos. Interviewees pointed out that many of the innovation requirements ahead depend instead on overall energy system issues, which the current SET Plan is ill-equipped to incorporate. Similarly, experts suggesd there are important regional dimensions that cannot be captured by the pan-EU technology approach.

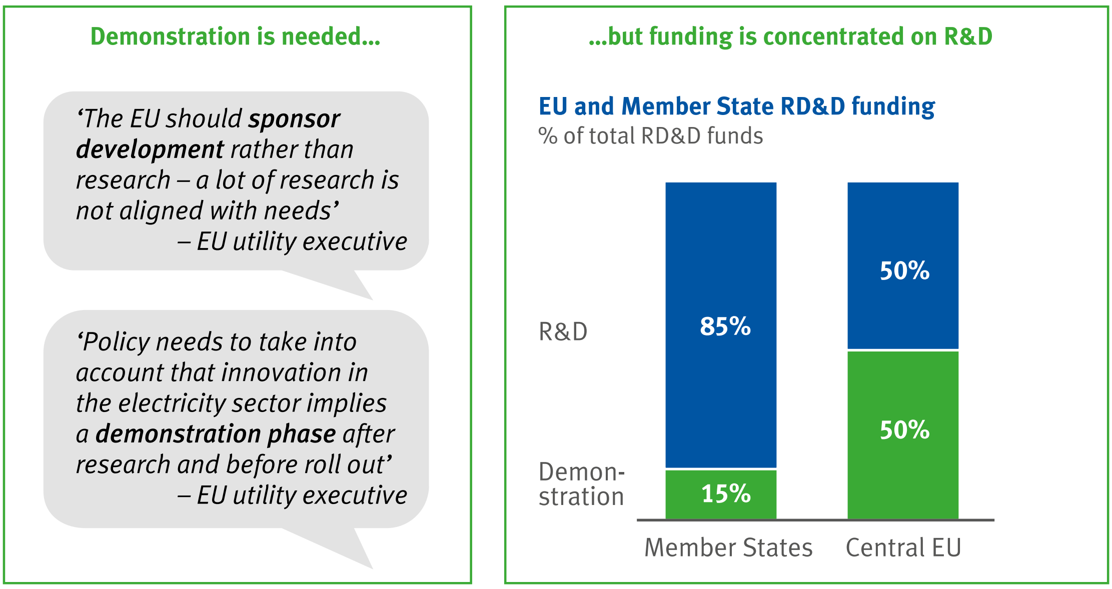
> *"We should not put in place policy that eliminates the possibility of disruptive breakthroughs"*
>
> *– EU policymaker*

- **RD&D funding is highly fragmented.** Some 80% of public energy RD&D funding is provided through Member State initiatives with only very limited coordination. (Figure 45). Even the limited mechanisms that exist for coordination, such as the Strategic Energy Technology Information System (SETIS), do not succeed in practice in tracking the information that would allow Member States to coordinate their actions. Moreover, coordination at the EU level is far from what is required: seven different DGs are involved in setting energy research priorities, leading to a significant risk of competing initiatives and lack of coordination. Moreover, the structure of the FP programme does not lend itself to supporting cross-sector initiatives, which are becoming increasingly important to the power sector.

- **Funding does not sufficiently emphasise demonstration.** Practically all private-sector interviewees noted that demonstration risked becoming a bottleneck to power-sector innovation. As noted above, the power sector has key features that make public support for demonstration particularly important. In the last five years, EU-level funding has taken significant steps towards a greater concentration of resources on demonstration, with power sector funds under FP7 split nearly half-and-half. However, at the Member State level (and thus the large majority of total funding), the share devoted to demonstration is far smaller, at 15% (Figure 46). Additionally, central EU demonstration funding is not carried out on a stable footing and effectively integrated with an overall strategy. Both the NER300 and European Energy Programme for Recovery mechanisms are ad hoc, with limited and insecure funds. The NER300, in particular, has suffered from the failure to coordinate with

FIGURE 45

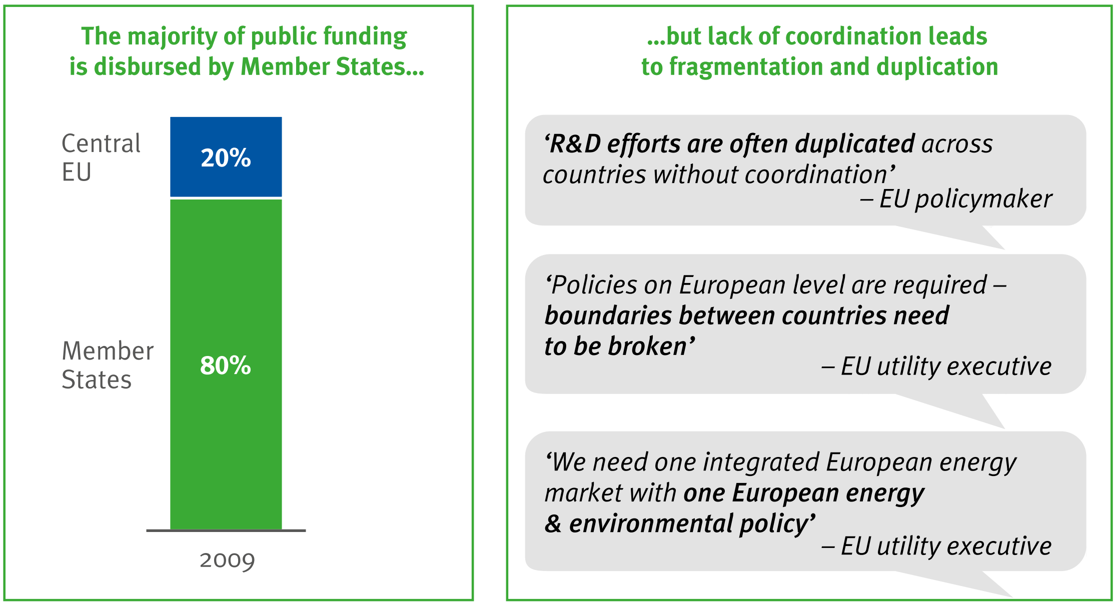
Demonstration is key to power sector innovation but risks being deprioritised



Sources: European Commission SET Plan, EURELECTRIC Innovation Action Plan Survey- December 2012, CTO and policy expert interviews, EURELECTRIC Innovation Action Plan Taskforce analysis

FIGURE 46

EU funding of power sector R&D suffers from fragmentation and lack of direction



Sources: European Commission SET Plan, EURELECTRIC Innovation Action Plan Survey- December 2012, CTO and policy expert interviews, EURELECTRIC Innovation Action Plan Taskforce analysis

policy to create a private business case for demonstration as well as from a lack of coordination between Member States and central EU programmes (see details in the box on page 61).

- **Public-private partnerships play a limited role.** Interviewees also suggested EU should consider greater use of mechanisms to incorporate industry insights to steer funding allocation, including through public-private partnerships. Overall, less than a third of EU FP funding is executed through public-private partnerships (PPPs). This is in contrast to the US, where Department of Energy R&D finance places a much greater emphasis on private contributions and risk-sharing. Recent steps in FP7, including PPP support for low-emissions vehicles and energy-efficient construction, offer a promising start to increasing the role played by PPPs in the European energy policy mix.
- **The mechanisms and programmes remain very complex.** Even large companies surveyed by the Task Force find the application procedures burdensome, and the barrier is correspondingly higher for smaller prospective entrepreneurs or efforts. The steps taken in Horizon 2020 are very welcome in this regard. The European Commission recently outlined steps towards a reduction of application times by 100 days compared with the average application time for FP7 initiatives.[9]

One lesson about the high potential of effective targeting can be learned from the US ARPA-E programme, which, despite a relatively modest budget, has made important contributions to the overall US RD&D policy only a few years after its creation (See details in the box on page 61).

CONTINUED INNOVATION REQUIRES AN EFFECTIVE MARKET SETTING TO SUPPORT THE ENTIRE INNOVATION PROCESS

The EU's power sector innovation strategy needs to recognise the limitations of public RD&D. Private funding already accounts for some 70% of total energy RD&D investment in the EU. Incentives for private-sector investment in innovation – along the entire innovation process – therefore are a precondition for success. Moreover, much critical innovation activity is undertaken by stakeholder that are not involved in

9 http://europa.eu/rapid/press-release_IP-11-1475_en.htm

The NER300 demonstration programme

The NER300 was first conceived in 2008 as a mechanism to support carbon capture and storage (CCS) projects. Yet in its first round of funding in 2012 it failed to support a single CCS initiative. The original proposals in the European Parliament envisaged the sale of 500 million EU ETS allowances (EUAs) to support CCS. By the time it was launched, the amount had been reduced to 300 million EUAs, to be split into 60% for CCS and 40% for innovative RES projects. Yet when awards were made at the end of 2012, not only had funding been further halved by a collapse in the EUA price, but all of the support went to RES projects. A multi-year effort to take the next step in CCS innovation thus had entirely failed. NER300 contains a number of lessons on pitfalls in demonstration policy:

- **Insecure funding.** Linking the demonstration support to the price of carbon credits created unnecessary uncertainty that significantly undermined the scope of the programme.
- **Fragmentation of programmes.** At the same time, EU-level support for CCS was fragmented across mechanisms. Notably, several of the short-listed CCS projects were also to be supported by the EEPR (yet another ad-hoc funding source). Instead of putting in place a concerted demonstration effort, the EU thus put in place fragmented efforts, multiplying the number of obstacles to success.
- **Insufficient coordination and Member State commitment.** The NER300 set-up made Member State support a precondition. Yet in the end, Member States did not commit the funds required, a factor that eventually undermined the entire programme. This instability of commitment and lack of coordination of Member State and EU RD&D efforts create a significant impediment across EU innovation policy, although the result is rarely as directly visible as in the case of NER300.
- **Lack of demand-pull and unrealistic expectations for private actors.** CCS is dependent on a functioning carbon price. Its collapse and the subsequent inability of EU policy to restore the EU ETS to a meaningful role in EU climate policy have generated significant uncertainty about the future potential market for CCS. In brief, demand-pull has been all but removed. This also fundamentally undermines the private-sector case for co-investment in demonstration. Especially with the collapse of Member State commitment, the policy environment failed to generate the market rewards that could have provided a case for high-risk investment by private actors.
- **Faltering commitment to demonstration of new technology.** CCS was made to compete with RES projects. Yet, from an innovation perspective, the two have entirely distinct purposes: nearly all the RES projects pertain to incremental improvements of existing technologies, whereas CCS demonstration has the much more significant challenge of achieving a worldwide first, namely large-scale demonstration. Although support for RES demonstration is welcome, the bundling of different innovation needs prevented a policy design specifically tailored to CCS. For example, several projects failed because timelines were too challenging for the much more significant technical challenge posed by CCS. This deficiency is at risk of being repeated with the (much smaller) second round of NER300 funding.
- **Limited innovation focus.** NER300 projects were compared in the first instance on their ‘cost-per-unit performance’ – i.e., their near-term performance in removing CO_2. Although seemingly objective, this is an example of how policy easily is led to consider near-term energy impacts ahead of innovation contribution. Near-term benefits are arguably less important for demonstration than are the future technology prospect or potential contribution by the technology towards overall energy objectives.

Case study: the US ARPA-E programme shows the impact of effective RD&D targeting

The US Advanced Research Projects Agency – Energy was established to focus on high-risk, high-reward research in the energy field. It had several key features that set it apart from more traditional R&D programmes:

- **Established following detailed whitespace analysis.** The idea for ARPA-E was generated from a systematic review by the US National Academies of hundreds of potential mechanisms to promote scientific and technological leadership.
- **Focussed on additionality to existing industry research.** ARPA-E was conceived to ‘support creative “out-of-the-box” transformational generic energy research that industry by itself cannot or will not support and in which risk may be high but success would provide dramatic benefits for the nation’.
- **Employing a new and lean organisational approach.** From its inception, ARPA-E was modelled on the Defense Advanced Research Projects Agency (DARPA). It was designed not to carry out research, but to support efforts by universities, start-ups, established firms, and others. Like DARPA, the organisation was set up to enable long-term support.
- **Supporting a critical gap in the energy innovation chain.** The ARPA-E model resembles a venture capital approach, bridging the gap between basic energy research and development and commercialisation. It focuses on revolutionary, high-impact scientific advances and seeks to translate these into technological innovations.

ARPA-E has quickly gained recognition across the research community and industry as a highly effective programme. This stems both from its effective implementation, success in bridging and filling an important gap in existing policy, and in its capacity for playing to existing strengths through effective targeting. For these reasons, its influence has been far greater than suggested by its relatively modest budget of 400 million dollars.

FIGURE 47

Public support for power innovation needs to go beyond R&D

Selected comments from utility executive survey

Source: Eurelectric, Innovation Action Plan Survey, Dec 7, 2012 – Final; CTO and policy expert interviews

public R&D programmes – beyond the point of R&D (Figure 47). Policy needs to create the business case for innovation through an effective ‘enabling market setting’, consisting of sufficient end-user demand for innovative solutions, effective competition between rival approaches, enabling infrastructure, and regulatory room for manoeuvre.

In creating a suitably enabling market setting, the EURELECTRIC Task Force sees a case in principle for an ‘ETS plus’ approach. By this, we mean: demand-side innovation policies that complement and build on the EU ETS rather than work against it or around it. There are instances where the combination of a decarbonisation target and carbon pricing alone cannot provide the demand-pull required for a deployment large enough to support continued innovation, if for no other reason than because the price levels required for some immature technologies would be prohibitively high. At the same time, such policies should be formulated to achieve innovation objectives, leaving the achievement of near-term energy system aims to the EU ETS.

The starting point for creating the necessary enabling business/market setting must be to distinguish between innovation objectives and other objectives. Current deployment and near-term energy-system aims call for mechanisms (such as the EU ETS) that preserve competition, promote cost-effectiveness through technology and business model neutrality, and offer stability to market participants.

By contrast, innovation objectives may require policies that do one or more of the following:

- Emphasise the value of discovering more about the future potential of currently immature technologies and business models
- Base the extent of support on a transparent analysis of the extent of market deployment required for continued innovation of immature technologies or business models
- Link continued support to ongoing performance improvements to avoid continuing down dead ends – e.g., by defining strong reductions (‘degression’) in support from the outset.

Such ‘ETS plus’ policy also needs to recognise the significant risk that demand-pull policies will have adverse and unintended consequences. Support for particular technologies easily descends into mere top-down ‘picking winners’. It risks eliminating the very competition between solutions that is needed to preserve long-term innovation momentum. Without market discipline, there is a significant risk that unpromising solutions are supported without critical appraisal of their real innovation potential. Moreover, the scope for policy interactions means that complementary measures can undermine the EU ETS price signal when deployed at such scale that they materially affect near-term emissions. Therefore, when deciding to intervene to create specific markets to support innovation, policymakers must carefully weigh these disadvantages of complementary demand-pull policies.

CURRENT EU ENERGY POLICY NEEDS SHARPER INNOVATION FOCUS

Current EU policy stacks up unevenly against the above principles for demand-side innovation policy. On the one hand, it is clear that the EU has been a global leader over the past decade in creating deployment opportunities for some immature renewables, as well as some energy efficiency and other technologies. This has enabled significant innovation across the power system, and perhaps particularly in renewables-based generation. On the other hand, this progress has been achieved at a high cost in terms of both expense and market distortion. Also, EU policy in this area does not maintain an effective innovation focus. There is no shortage of intervention, driven ultimately by top-down targets. In actual implementation, however, innovation objectives are constantly in danger of being deprioritised in favour of other, near-term concerns.

The EURELECTIC Task Force identified several features of the current demand-side EU power-sector innovation policy regime that undermine its effectiveness:

- **The lack of a stable CO_2 price undermines the market for low-carbon technologies.** The inability of the EU to match its decarbonisation targets with a stable CO_2 price is the most significant weakness in current EU demand-pull policy efforts. EURELECTRIC has elaborated elsewhere that it considers this highly damaging to the cost-effectiveness of efforts to reduce emissions in the near and medium terms.[10] Moreover, the adverse impact is not only a matter of near-term cost-effectiveness. The absence of a long-term, stable price signal also jeopardises key aspects of the innovation processes that ultimately need to contribute to achieving long-term cost-effectiveness. The ETS has several institutional and market advantages over other policies. It has pan-European reach and scale, and is effectively harmonised across the EU. It also is able to encourage competition between low-carbon solutions, and offers built-in mechanisms for cost-effectiveness. The current doubtful status of the ETS undermines other attempts at creating market conditions that will enable low-carbon innovation.
- **Top-down targets encourage mass-deployment rather than deployment for innovation.** The root cause of the problems to date is that the current EU policy mix stems from a top-down volume target for desired outcomes, notably through the RES Directive and the Energy Efficiency Directive. This is then overlaid with national priorities and strategies for achieving the targets. This approach is ill-suited to the principles of innovation. It sets up incentives for mass deployment (to achieve near-term energy system impacts) rather than innovation deployment (to achieve future cost reductions and performance improvements). As a result, a large share of demand stimulation still is directed towards highly mature technologies, where innovation benefits are rapidly diminishing (or, alternatively, within reach of deployment through a less market-distorting policy mechanism).
- **Innovation impact often is diluted by other concerns.** Policymakers often cite other categories of much more near-term potential benefits as motivations for demand-pull policies in the power sector – such as jobs created, near-term energy security benefits, immediate emissions reductions, or productivity increases. There seems to be insufficient consciousness of the need to design demand-pull for innovation impact, or of the conceptual distinction of mass-deployment for near-term energy objectives and (potentially, much more limited) deployment to underpin innovation. The RES Directive is perhaps the clearest example. It was introduced with aims including 'promoting technological development and innovation' and 'supporting the demonstration and commercialisation' of RES technologies. However, it also emphasises a range of other motivations for RES targets, including near-term benefits such as local jobs, energy security, and greenhouse gas emissions reductions. In practice, national targets for RES are defined simply as aggregate shares of energy use, without any provisions to ensure – or to measure – the contribution towards innovation.
- **The emphasis on near-term deployment has driven high cost increases.** The norm in demand-side policy has been very significant early deployment at high cost, even when costs were falling fast. The cost to consumers to achieve innovation has been correspondingly high. An innovation-driven approach would instead dictate targeted deployment to maintain the pace of cost reduction, saving large-scale deployment for later phases once costs have fallen.

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10 See 'European energy at a decisive crossroads', 2011, http://www.eurelectric.org/download/download.aspx?DocumentFileID=66722

- **Over-commitment has led to policy instability.** The high costs associated with mass deployment have meant support regimes have only limited legitimacy. In many cases, they have been discontinued or modified to remove further support as public budgets contract or consumer bills increase. By contrast, innovation would have been better served by a more limited and stable regime that put a premium on certainty.
- **Lack of coordination of demand-side policy with RD&D has reduced effectiveness.** The lack of clarity about innovation objectives also has resulted in poor coordination of demand-pull with supply-side push policies through RD&D programmes. The example of CCS demonstration discussed above is perhaps the clearest failure of integration, but the more general problem is that the two are designed in isolation rather than with a holistic view on the requirements of the overall innovation process.
- **Lack of competition has undermined important drivers of innovation.** Some trade-off will always be necessary between supporting currently pre-commercial technologies and ensuring competition between rival solutions to meet energy system goals. However, current policy errs too much on the side of 'picking winners' to the detriment of fostering innovation through competition. Innovation policy should use technology-neutral metrics where possible, such as performance standards and high-level, cost-degression targets or objectives.
- **The global perspective has been missing.** The EU has rarely coordinated its efforts effectively with other geographies. From an innovation perspective, it is the global market size that most matters for continued learning-by-doing and maintenance of RD&D incentives. The EU has a contribution to make in this context, much like its contributions to overall global emissions reductions. That said, the value of the EU's efforts will, of course, also depend on the steps taken in other geographies.

EU MARKETS AND REGULATION NEED TO ELIMINATE ADDITIONAL OBSTACLES TO INNOVATION

The general thrust towards introducing competition in the EU power system arguably is one of the EU's most important innovation assets. In contrast to most other geographies, all EU wholesale and retail power markets are in various stages of advancing towards retail competition, with much greater freedom for generators and suppliers to tailor investments and offerings to what consumers demand. Nonetheless, the EU needs to continue to strengthen its commitment to competition between rival technologies and business models. At the most basic level, the large majority of new generation capacity in the EU is now being added on the back of technology-specific support schemes, with much weaker competition between technologies. There is clearly a need for balance between objectives, and the long-run benefits of competition for innovation should not be too quickly sacrificed.

The importance of competition: the example of gas vs. electricity competition and innovation in Japan

In Japan, electricity and gas utilities have long been in competition for shares of energy demand, including cooking, water heating, space heating and cooling, and other household appliances. Electric utilities have been promoting 'all-electric' homes, whereas gas utilities have been promoting not only gas-based cooking and heating, but also gas-based air conditioning and small-scale gas-fired co-generation to produce electricity.

This type of inter-energy competition has been a strong contributing factor in boosting technology innovation. On the electricity side, it has added to the Japanese lead in heat pump innovation, including the commercialisation of CO_2-refrigerant heat pump water heaters. The concept of 'all-electric homes' has also spurred performance improvements in induction hob technology. On the gas side, micro-CHP technology is under development as gas companies seek new customer loads, while Japanese companies also developed the modern form of gas-fired air conditioning as an alternative to electric chillers.

Innovation also has been complemented by government policy, including for CO_2-refrigerant heat pump water heaters from the 2000s, and for gas-fired air conditioning from the 1980s. It also has been underpinned by electricity system incentives, such as time-of-use tariffs for business users, which have supported technologies to shift electric loads from peak hours.

A certain neglect of innovation can be seen in current discussions about reforming markets for ancillary services. To take but one example, many ongoing national discussions about introducing capacity markets are predicated on designs that would effectively hard-wire a preferred solution to system balancing (peaking capacity). However, unless future innovation potential is taken into account, this approach to market design risks barring the way for potential alternative solutions – such as different levels of flexibility in new gas plant, various scales of energy storage, or demand response mediated by smart grid solutions. Market design needs to account not just for efficient choice between currently available solutions, but also create incentives for developing alternatives.

As noted, the EU has gone further than other regions or countries in exposing the power sector to competition, in particular in retail. Yet the process is far from complete: 19 out of 27 Member States still regulate household retail prices. Licensing conditions and other regulation also limit the type of offerings (e.g., time-of-use tariffs, dynamic pricing, peak pricing) – and thus feasible business models – that energy retailers can provide to their customers. As another example, not all Member States allow customers to take up the option of generating their own electricity.

Innovation also is currently only weakly supported in wholly regulated parts of the system. An important reason is that many of the benefits of innovative solutions are hard to quantify, and therefore may not be adequately accounted for in regulatory reviews. Moreover, R&D expenditure by grid companies has fallen to very low levels, indicating insufficient incentives for innovation.

Finally, interviewees told the EURELECTRIC Task Force that the EU has an insufficient level of policy certainty to enable important innovation based on big data. Key areas where more certainty is required include data security, data privacy, cross-border applications (cloud), and cyber security. Interviewees expressed a desire for policies that establish a flexible set of regulations that enable technology development while creating minimum standards of privacy, critical infrastructure security, and interoperability.

6 FIVE ACTIONS TO IMPROVE EU ENABLING OF POWER SECTOR INNOVATION

An important goal of European energy policy is to facilitate a *cost-efficient* transition to low-carbon power generation, not least in times of economic downturn. Innovation is indispensable to achieving this goal. The European Commission acknowledged this in its Green Paper on the 2030 climate and energy policy framework, stating it will have to *"recognise the evolution of technologies over time and promote research and innovation."*[11] EURELECTRIC fully supports this recognition.

Yet innovation never flourishes in isolation. It depends on an enabling setting: both a business environment that spurs and rewards private-sector innovation, and a public policy framework for investing in innovation where the business case needs initial support.

EURELECTRIC advocates five main actions to enhance EU innovation policy and better enable the power sector to capture the innovation opportunity.

To begin mapping what is required to enable successful change, the EURELECTRIC Innovation Task Force has critically assessed EU innovation policy and developed the following five recommendations for an improved policy framework to enable private sector engagement (Figure 48).

The description of each recommended action provides a rationale, guiding principles, and examples of the enhancements proposed.

1. ADOPT A SYSTEMS APPROACH

Power system complexity will increase as the value chain continues shifting from a linear supply-demand model to a new *systems* paradigm, a model with more feedback loops between elements. To enable successful innovation, policy must also reflect this shift to more closely intertwined elements. As examples, technological innovation has made

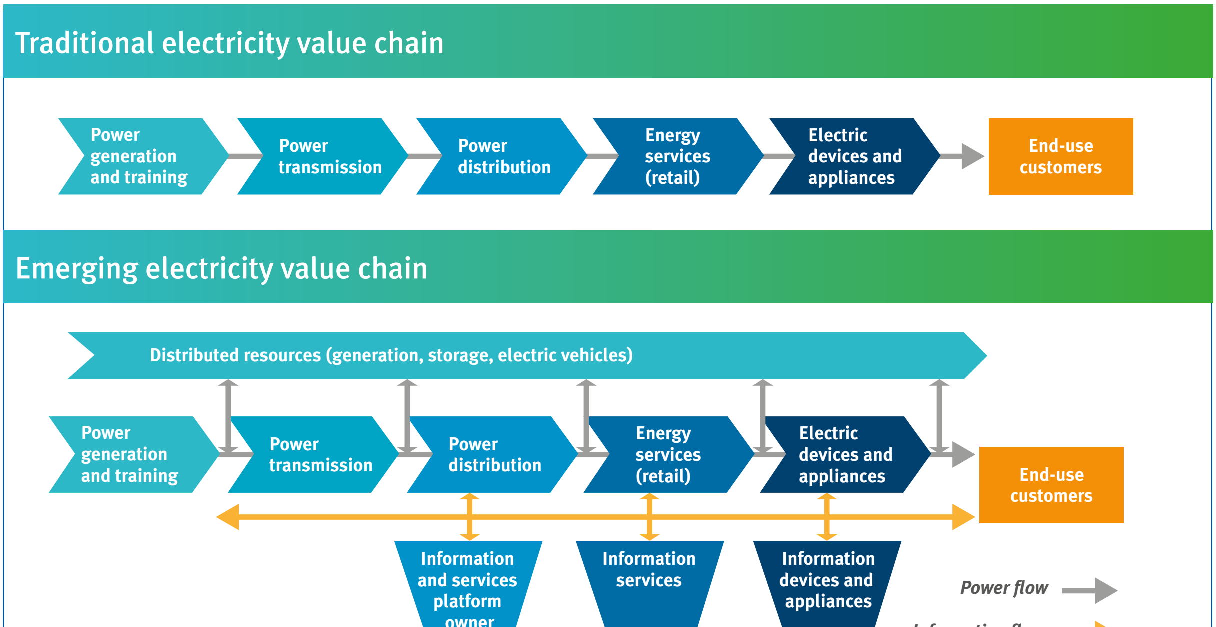
FIGURE 48

Five actions to improve EU enabling of power sector innovation

1	**Adopt a systems approach.** Innovation policy must become a tool of energy policy, avoiding focus on individual technologies in favour of an expanded and integrated perspective encompassing interconnected impacts on the overall power system.
2	**Nurture public-private dynamics.** The public and private sectors have to work hand in hand to reinvent the power system. Policymakers should harvest the low-hanging fruit: innovation through a competitive, business-friendly, and risk-rewarding market framework.
3	**Prioritise demonstration and commercialisation.** Demonstration and early deployment are indispensable parts of the power sector innovation chain. Further support mechanisms are needed to complement R&D support.
4	**Unlock downstream innovation.** Policy should move quickly to put in place the enablers of a 'new downstream' set of services and offerings: a competitive and fully liberalised market, innovation-friendly regulation, and enabling smart grid infrastructure.
5	**Create supportive governance for the innovation union.** Innovation would benefit greatly from better coordination and governance of both EU-level and Member State support mechanisms, starting with improved joint programming and pooling of resources.

11 European Commission, Green Paper "A 2030 framework for climate and energy policies", March 2013

FIGURE 49



Source: IBM Institute for Business Value

it possible for power consumers to become producers ('prosumers'), one-way electricity and information flows become bi-directional, decentralisation challenges and complements the old centralised architecture, and closer real-time management becomes feasible as well as necessary to handle more variable generation. The diagramme above[12] illustrates the shifts from the traditional electricity value chain to the emerging one (Figure 49).

Similarly, the power supply is increasingly linked to other forms of energy where energy service needs (heat, lighting, mobility) are increasingly served by multiple rival products and services. The power sector is also more closely linked to other sectors—notably transport and information and communications technologies (ICT).

This development requires a systems approach to innovation policy, in contrast to the current approach of supporting innovation in individual technologies in isolation. Continued development of individual generation technologies clearly is necessary, but must be synchronised with other needs across technologies and business models, and along the entire power value chain. Examples include lower-cost storage, smart grid applications for distribution grid balancing, business model innovation for demand-side management, regulatory innovation to compensate for the value of flexibility, etc.

12 IBM, "Switching perspectives. Creating new business models for a changing world of energy", 2010

Guiding principles

To better enable utilities to act as powerhouses of innovation, EU policies for innovation and energy need to adhere to the following guiding principles:

- **Make innovation policy a tool of energy policy.** Innovation is far more than just R&D, and depends strongly on overall energy policy. The two policy agendas therefore must be seamlessly integrated. The long-term potential of innovation must not be set aside in favour of near-term targets or aims.
- **Take a broad view of innovation.** Innovation is more than technology development. The power sector transformation will require innovation in products, processes, and business models, throughout the electricity value chain. A comprehensive innovation policy needs to pay heed to all of these aspects of innovation.
- **Maintain a systems perspective.** The current tendency to focus on single issues and isolated technologies must be consciously and rapidly replaced by an expanded and integrated perspective to encompass interconnected system impacts.
- **Account for cross-sector interaction.** The systems perspective must also extend to supplier and customer industries, as the energy sector is increasingly intertwined with other sectors such as the ICT, automotive, construction, etc.

ACTION NEEDED NOW	
CURRENT CRITICAL POINTS	**RECOMMENDATIONS**
Silo approach: The Horizon 2020 Proposal from the European Commission's DG Energy of 2011 still contains elements of the silo approach to energy innovation, for example, separate budgets for ICT, transport, climate, and energy. Underlying this, the current SET Plan is structured along individual technology platforms.	**Maintain a systems perspective:** • **Create interfaces between sectors and issues;** simplify positions within Horizon 2020 to deliver on the system solution. • **Reform the SET Plan** to account for systems issues and regional dynamics, rather than just developments in individual technologies.
Initial steps towards a systems approach: The Smart Cities and Communities European Innovation Partnership is a welcome initiative to take better account of systems issues. Launched in 2012, Smart Cities aims to pool resources in cross-sector demonstration projects in urban areas, spanning energy, transport and information and communication technologies (ICT). According to the Commission, this initiative '*will enable innovative, integrated and efficient technologies to roll out and enter the market more easily, while placing cities at the centre of innovation*'. The funding will be awarded through yearly calls for proposals: €365 million for 2013.	**Maintain a systems perspective and report on results:** • Funding awards; product and process innovations and their systems linkages, between technologies, energy types (where applicable), and supplier and customer industries; describe mechanisms, if any, for preserving competition between rival solutions.

Promising private sector initiatives

Implement a systems approach: different energy types and cross-sector applications at scale. Fortum's advanced biofuel project in Joensuu, Finland illustrates the types of systems innovations that will become increasingly important. Fortum plans to integrate a combined heat and power (CHP) plant, and existing high-efficiency technology, with a bio-oil production facility to reduce use of fuel oil for heating purposes – providing carbon-free heat through an existing district heating network. This also has potential to create synergies with the transport sector by producing bio-oil suitable as vehicle fuels. The project already links different industrial sectors by re-using waste heat and waste fuel from industrial facilities in the CHP plant.

Implement a systems approach: sustainable city solutions. E.ON works with other parties in a project to develop Hyllie as a sustainable city district in Malmö, Sweden's third-largest city. The project includes fully-integrated infrastructure for electricity, heating, and cooling. By 2020, E.ON will supply 100 percent renewable or recycled energy, incorporating a significant proportion of distributed energy generation. The smart energy infrastructure in Hyllie will communicate with innovative technologies in buildings to deliver higher energy efficiency, reduced losses, better management of peak load and a more reliable electricity supply. The ambition extends to developing the technology needed to enable demand response, setting up communications between all levels in the value chain from producer to consumer.

2. NURTURE PUBLIC-PRIVATE DYNAMICS

The public and private sectors have to work hand in hand to reinvent the power system successfully, given the EU's renewable energy targets, the need to explore currently immature technologies, and the protracted economic slowdown. Policymakers should harvest the low-hanging fruit: innovation through a competitive, business-friendly, and risk-rewarding market framework. The approach should build on the EU Emissions Trading Scheme (ETS) rather than work around it or against it.

Policy also needs to make early innovation a priority and core tool of the energy transition. Current approaches pursue mass deployment, 'picking winners' at high cost, even as technology costs are falling. By contrast, an innovation-centred policy approach would support only the level of deployment needed to ensure continued innovation in immature technologies, and rely on market-based mechanisms (notably, ETS pricing signals) to drive mass deployment of near-commercial technology.

Not just "small change"

In 2011, European consumers paid 38 billion euro in subsidies to support electricity generation from renewable energy sources, adding more than 15% to the residential electricity bill in several countries. High costs have led to policy instability, as support schemes that seemed affordable with smaller volumes of renewables have proved controversial as the recession has persisted. Yet despite the scale of current RES deployment, a detailed innovation agenda still needs to be articulated. The de facto norm has been very significant early deployment with a high price-tag, but without dynamic adjustments to reflect decreasing costs, and without an assessment of the extent and type of deployment needed to achieve long-term innovation objectives.

Guiding principles

- **Restore the EU ETS as a technology-neutral and long-term engine for the market for low-carbon solutions.** The ETS is the one climate policy mechanism that has reached pan-European scale, and is effectively harmonised across the EU. It also is able to encourage competition between low-carbon solutions once they have matured in the innovation process, and offers built-in mechanisms for cost-effectiveness. The only alternative to the ETS is to pursue country-by-country solutions, which would have the bad effect of undermining European energy policy and sacrificing scale.
- **Tailor demand-side policies to innovation discovery and market adaptation as opposed to mass deployment.** RES policies should be reformulated in the run-up to 2020 to achieve innovation objectives. They should emphasise the value of discovering more about the future potential of currently immature technologies and business models.
- **Preserve competition between rival solutions.** Given finite budgets, innovation policy often tends towards 'picking winners', and needs strong corrective mechanisms to preserve competition between different approaches, as well as between stakeholders and projects.
- **Explore promising additional mechanisms to create a market setting for innovation.** For example, consider using public procurement as a tool for market deployment of both technology and business model innovations.
- **Make public-private collaboration and risk-sharing a core part of the EU approach.** The EU should consider mechanisms for applying industry insights to decisions on funding allocation. The EU can learn from international experience here, such as US Department of Energy programmes.
- **Make R&D more market-oriented and output-based**, building on the promising model of Knowledge and Innovation Communities (KIC) and specifically the KIC InnoEnergy.
- **Invest in the future**. The size of public budgets devoted to innovation should reflect the scale of the system transformation challenge. Building on the already high RD&D outlay by the private sector and continued increase in energy R&D funding in Horizon 2020, Europe should now focus on restoring the continent's competitiveness, using innovation, infrastructure, education, and regulation as its building blocks.

ACTION NEEDED NOW	
CURRENT CRITICAL POINTS	**RECOMMENDATIONS**
Uncoordinated policy instruments have led to regulatory inefficiency and investment uncertainty.	**Restore a functioning EU ETS and tailor demand-side policies to innovation discovery:** • **Urgently agree on a 2030 GHG target;** the back-loading proposal and a revision of the annual linear reduction factor to 2.3 %.
Some new instruments and approaches, for example, the format for RD&D support, was successfully demonstrated by the launch of the EIB Risk Sharing Finance Facility. The Commission deserves recognition for creating these new instruments.	**Explore promising additional mechanisms:** • **Consolidate instruments** and increase volumes. • **Consider awarding an EU Prize** as an effective, competitive and open mechanism to reward innovation breakthroughs.
No consolidated approach to public-private collaboration with too many EU instruments / frameworks for Public Private Partnerships (PPP): Knowledge and Innovation Communities (KICs), Joint-Technology Initiatives (JTIs), Joint-Programming Initiative (JPIs), European Innovation Partnerships (EIPs), etc.	**Make public-private collaboration and risk-sharing a core part of the EU approach:** • **Simplify and rationalise EU instruments** governing public-private partnerships into a single framework.
State aid guidelines vaguely formulated, inconsistently applied. They discriminate between near-commercial technologies and R&D needs, blocking technology development. The European Commission has been very generous with subsidies to all power generation technologies, yet it has put in place inflexible guidelines on R&D state aid.	**Make R&D more market-oriented and output-based:** • **Include an innovation dimension in the ongoing state aid modernisation** to allow for more flexibility and dynamism on how to best stimulate innovation across the whole value chain.
Public spending on RD&D in energy is growing, but from a very low base.	**Invest in the future:** • **Maintain the momentum of public energy-related RD&D spending.**

3. PRIORITISE DEMONSTRATION AND COMMERCIALISATION

Demonstration and early deployment are indispensable parts of the power sector innovation chain. Not only does demonstration enable real-world validation of emerging R&D findings, but when integrated within an effective overall innovation policy, it also is a crucial step towards commercialisation and subsequent widespread deployment.

Despite its importance, demonstration is often at risk of neglect. Private actors often lack a business case to undertake demonstration projects, especially at scale, making public support a necessity. Recent steps to put greater emphasis on demonstration in the EU Framework Programmes are a welcome start and should be pursued. Member States should design their RD&D programmes accordingly, to ensure demonstration receives the attention it requires.

Guiding principles

- **Make demonstration and early deployment a priority.** Put support mechanisms on a secure footing. Set the aspiration to double the 15% share of national RD&D support currently allocated to demonstration, to avoid creating an innovation bottleneck.
- **Expand support for commercialisation.** Support through venture-style mechanisms could enhance the impact of EU efforts. The EU can learn from influential efforts in other countries such as the ARPA-E programme in the United States.
- **Link demonstration to an enabling market setting.** The disconnect between demonstration and market uptake undermines the innovation chain as promising technologies are squeezed out of and receive no pull into the market.

Demos at scale: Dashed hopes for CCS; high hopes for smart grids

Source: SEV/DONG Energy

The failure of carbon capture & storage is a cautionary example of Europe's hitherto inadequate approach to demonstration. It is widely agreed that CCS is beyond the R&D stage; it requires testing at scale in an integrated setting. Yet EU funding to date has gone to a number of projects to validate multiple solutions – for both capture and storage – at once, encouraging jockeying to benefit from both national and EU funding. Worse, as national programmes are not aligned with the EU scheme, they have impeded promising projects. The lack of a business case for CCS – undermined by a faltering ETS and an energy policy directed towards other technology solutions – deprived CCS of any appeal to market actors, and shifted all the risks and burdens of CCS demonstration onto utilities.

By contrast, many successful demonstrators are being deployed to test and validate technologies such as smart grids. One such example is DONG's project on the Faroe Islands, which aims to demonstrate how a remote outpost may reveal answers to the challenges presented by non-dispatchable RES. The country is set to inaugurate a new 'virtual power station' that uses an advanced IT system to balance the grid by shifting supply and demand across the islands in matter of seconds.

ACTION NEEDED NOW	
CURRENT CRITICAL POINTS	**RECOMMENDATIONS**
High-risk, high-reward innovation in energy calls for **innovative public financial mechanisms** able to bridge the gap between basic R&D and demonstration and commercialisation. Such mechanisms are currently missing in Europe.	**Expand support for commercialisation:** • **Create public venture capital on a European scale.** The EU should introduce a new instrument inspired by the US ARPA-E programme to support commercialisation through venture-style mechanisms.
Private venture capital is insufficient in Europe, and innovative SMEs are struggling to get access to such funds.	**Expand support for commercialisation:** • **Give private venture capital a European dimension.** The European venture capital market needs to be unified, and obstacles to cross-border venture capital activities eliminated. We welcome the efforts of the European Commission to move towards cross-border fundraising through the European Venture Capital Funds Regulation (EVCFR).
One-off programmes have shown their limits in the main EU demonstration programmes for technology development, the EEPR and the NER300.	**Make demonstration and early deployment a priority:** • **Put demonstration on a secure institutional footing** by making certain that demonstration gets priority over basic R&D. The approach taken with Horizon 2020 is a promising first step in this crucial direction.
Low share of spending on demonstration. Member states spend 85% of their public funding on R&D activities, and only 15% on demonstration. This split becomes 50-50 at EU level.	**Make demonstration and early deployment a priority:** • **Double the share of RD&D funding allocated to demonstration at Member State level.** Given that the ETS directive binds Member States to earmark 50% of all auction revenues for projects in energy and climate protection, Member States have a golden opportunity to use these revenues to support innovation and cut public expenditure currently financed through levies on customers' utility bills.
Too many actors are involved in EU-level technology demonstration support.	**Make demonstration and early deployment a priority:** • **Simplify funding governance.** Explore whether the European Investment Bank could become the "one-stop shop" and principal actor for demonstration support at EU level.

4. UNLOCK DOWNSTREAM INNOVATION

For utilities, downstream opportunities are an essential component in offsetting the erosion in value of traditional generation assets. These opportunities also hold significant promise for customers, and can contribute to overall decarbonisation and security of supply objectives.

Many uncertainties about how the downstream opportunity will unfold still exist. What is certain is that much of the most promising future innovation in downstream business models and new services depends on two crucial components: a vibrant retail market as well as effective smart infrastructure. Downstream is about value creation underpinned by smart grids and a service-based model of meeting energy needs. Customers will benefit from market-driven prices and their ability and interest in choosing between competing offers. In addition, smart grids will contribute to information technology and operational technology convergence and thus cost reduction, thereby increasing interaction and related data flows between customers, distributed generators, market parties, and grid operators.

Currently, however, innovation is largely stifled by unnecessary restrictions on service features (e.g., time-of-use and dynamic pricing, peak pricing) and price regulation. This reflects an antiquated attitude too often taken towards energy retail markets and is counterproductive. Downstream, specific market design choices should be wide open for innovation, with no prescriptions.

On the other hand, in order to create stronger incentives to develop smart grid solutions, a clear line does need to be drawn to distinguish which businesses should be regulated and which should be market-driven. For this infrastructure development to happen, distribution system operators (DSOs) need sufficient space for investment in technologies that can improve overall system optimisation, network availability, and efficiency.

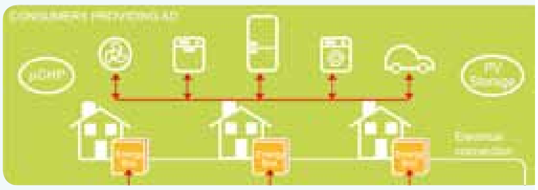
Guiding principles

- **Continue to push for effective deregulation in retail markets.** To this end, Member States need to show a sense of urgency about deregulation and stop current intervention in retail electricity pricing. Customers will then have an incentive to experiment with tariff/ price structures, new services, and product definitions. (Special measures are needed for consumers at risk/ vulnerable customers.)
- **Develop a smart market model.** This requires a framework for information exchange between all parties involved, which, in turn, will spur the development of a customer-focused demand-response market and ensure active cost-efficient network management by DSOs.
- **Incentivise innovation by DSOs.** National Regulatory Agencies should make specific provisions for DSOs to implement the most cost-effective innovative network solutions and revise the balance between risk and reward for innovative activity.
- **Explore further options for cost-reflective network pricing.** This could take the form of two-part network tariffs with power (kW) and energy (kWh) components or a network tariff with peak-price differentiation, which would contribute to demand-side participation while providing adequate revenues to DSOs.

The ADDRESS project focuses on using small consumers' possible consumption flexibility to reduce load on command through aggregation.

The project, which has received funding under the EU FP7 Programme, refers to this elasticity in consumption and generation as 'active demand'. The ADDRESS project (Active Distribution networks with full integration of Demand and Distributed energy RESourceS) has led to full-scale demonstrations of technology and concepts for aggregated active demand at three sites in Italy, France, and Spain.

It is anticipated that such load reductions could be sold to electricity market players, e.g., network companies, balancing responsible parties, and owners of non-controllable generation (e.g., wind power and PV). Small consumers' surplus production from their own generation, such as small wind units, PVs, and micro-CHPs could also be aggregated into larger amounts, allowing them to participate in market sales.



Source: ADDRESS

ACTION NEEDED NOW	
CURRENT CRITICAL POINTS	**RECOMMENDATIONS**
Data handling needs and options for smart grids have been identified in the European Commission Smart Grids Task Force.	**Develop a smart market model:** • A clear European view is needed on the division of (legal) roles and responsibilities for market and regulated players as well as an enabling regulatory framework for Big Data.
Standardisation efforts at EU level are provided for in the EC Communication on Smart Grids, which contains the baseline for these efforts. Therefore, standardisation gaps are being identified and standards are being set for smart grids under Mandate 490.	**Recognise the innovation potential of smart grids:** • **Tackle the issues of interoperability and data exchange between actors while developing Mandate 490 by 2014.** This should include smart network management, integration of DG, and active customers in a smart market.

- **Unlock the potential of flexibility provided by distributed generation (DG) and demand response (DR).** Grid connection and access rules for DG/DR should be adapted to allow grid and market operators to implement cost-effective solutions to optimize the use of the network.
- **Recognise the innovation potential of smart grids.** Cost-benefit analyses of smart grids are currently narrowly defined, looking only at current applications and benefits. If a new downstream market is to develop, however, the enabling smart infrastructure needs to be built ahead of time, providing the enabling setting for continued innovation.

5. CREATE SUPPORTIVE GOVERNANCE FOR THE INNOVATION UNION

The EU should coordinate its RD&D policies and spend scarce resources prudently, both at national and central EU level. Member States' resources are dedicated to national industrial policy needs and are often not aligned with the overall EU innovation agenda or energy strategy. The result is fragmentation and duplication of efforts. Today, 4,200 research institutes in Europe deal in one way or another with energy research, a world record.[13]

While full centralisation is neither practicable nor necessarily desirable, it does offer more scope for joint programming and resource pooling. The success of the Airbus serves as a best-practice example of joint innovation that is beyond the scope of individual Member States. By contrast, energy initiatives (such as the North Sea Countries Offshore Grid Initiative; see below) often stumble on the inability to join up national efforts.

Guiding principles

- **Improve EU innovation structures.** Create clear responsibilities and coordination between the European Commission's Directorates-General (DGs) and programmes.

The North Sea Countries Offshore Grid Initiative (NSCOGI) aims to develop a major RES technology on a regional scale. It was set up within the Pentalateral Forum, has done meaningful research, and plays an instrumental role in gathering all the parties involved around the same table. A straightforward comparison by ENTSO-E shows that the European and integrated offshore approach in the North Sea adds more value than the inefficient and more expensive national approach in the same region. Despite the evidence for a European value add, the risk is high that the chosen approach will be national.

The solution lies in installing an efficient governance mechanism, and EURELECTRIC strongly supports this approach.

13 Source: CSIC, Ranking Web of World Research Centers

- **Prioritise better coordination of Member States' innovation programmes**. EURELECTRIC urges Member States to grant a more active coordination role to the European Commission. This would improve resource pooling and maximize joint-programming opportunities.
- **Sponsor joint Member States' projects and build on established foundations**, e.g., the European Energy Research Area and the Strategic Energy Technology Plan. Leveraging the role of the European Commission as a facilitator, Europe should ensure coordination of their centres of excellence around themes central to the energy transition. Public-public partnerships among Member States exist in the current Framework Programme, but they could be used to a much greater extent.

ACTION NEEDED NOW

CURRENT CRITICAL POINTS	RECOMMENDATIONS
Seven DGs in charge of innovation within the European Commission is not sustainable. Despite growing awareness of change within the European Commission, a smart governance of innovation across the EU is needed to overcome the prevailing silo approach. In particular, a new solution is needed to overcome the split of responsibilities between the European Commission's DG Energy (demonstration) and DG Research and Innovation (fundamental research).	**Improve EU innovation structures:** • **The European Innovation Union needs more effective governance.** Conducting an international benchmarking exercise is a proven method and could serve to improve the European Commission's innovation governance. Europe can learn from other continents (e.g., the Japanese METI). • A 'one-stop shop' for innovation policy in the EU, covering the full innovation value chain could also contribute to the solution.
The Strategic Energy Technology Information System (SETIS) has been set up to ensure an open-access information system on energy technologies and develop a coordinated approach and capacities for innovation, throughout Member States, international organisations, and energy sectors.	**Sponsor joint Member States' projects and build on established foundations :** • **The SETIS system (as part of the SET Plan) should be reviewed and turned into a more effective instrument.** The Commission should incentivise energy innovation cooperation among Member States by topping up funds and explore alternative ways to move the cooperation from promise to practice (ERA plus).
Intergovernmental mechanisms are suboptimal for cost-efficient development of the North Sea grid	**Prioritise better coordination of Member States' innovation programmes:** • **EURELECTRIC recommends using the NSCOGI as a pilot-project** for an innovative EU energy policy. Reporting to the Electricity Coordination Group, this initiative would take the North Sea Grid from promise to practice, while avoiding inefficiencies associated with national-only solutions.

For the power industry, innovation will be the critical enabler that unlocks new sources of value in the decades to come. More than ever, a thriving industry will depend on finding new ways to improve products and to serve increasingly engaged customers. For policymakers, innovation will be the key to achieving decarbonisation and energy security objectives at acceptable cost. It should always be a 'top of mind' goal and inspiration when establishing the wide range of policies that affect the power sector and its customers.

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