THE FUTURE OF ENERGY

An independent report for Oracle Utilities

14–10–2011

FUTURE POLL

ORACLE UTILITIES

POWER
INTERRUPTIONS
CURRENTLY COST
EU BUSINESSES
€150BN
A YEAR
GLOBAL ELECTRICITY
DEMAND WILL INCREASE
115% BY 2050
BY THEN
THE EUROPEAN
RENEWABLE
ENERGY
SECTOR
WILL EMPLOY
6 MILLION
PEOPLE

FUTURE POLL

This document

As part of our continuing commitment to sustainability, this document is designed to be easily read and shared in a digital format. If a print version is required, the recommended setting is to print double-sided in a landscape format, bound on the short, left-hand side.

About us

Future Poll is the research division of The Future Laboratory, one of Europe's foremost consumer research, trends, insight, forecasting, and brand innovation consultancies. Via its online network, LS:N Global, it speaks to 300 clients in 14 lifestyle sectors on a daily, weekly and monthly basis.

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Introduction

Demand for energy continues to rise unabated. Yet it does so against huge challenges: the long-term environmental sustainability of fossil fuels, vulnerabilities in the energy supply chain and volatility in energy markets. Left unchecked, these could have serious social, economic and environmental impacts worldwide.

An energy revolution to rival the roll-out of electrification in the 20th Century is required.

1 Overview

The scale of the energy challenge means action must be taken now to secure our future energy needs in a sustainable fashion.The solution lies in the decarbonisation of our industry and society. To achieve this we need to develop Smart Grids capable of integrating clean technologies - such as wind and solar energy - and also be able to efficiently align power supply and demand.

The projected increase in global electricity demand by 2050, created in part by the industrialisation of emerging economies

By 2050 the energy landscape will be transformed into a two-way power infrastructure where embedded intelligence enables real time coordination and dynamic decision making. Intermittent renewable energy and storage will be ubiquitous, consumerisation of smart energy will be part of our daily lives and clean electricity will power our cars, residences and economies in a reliable and affordable way.

Data will be as important as energy itself in the power grid of the future and the successful interpretation of these data will be of central importance in safeguarding our energy security. Only the convergence of data, energy, and ICT into active components in the grid, in the plant and office, in the home and appliances, in the car and transport will enable the energy transformation.

This report highlights the issues that must be addressed over the next four decades and the trends that will combine to make the smart grid and smart energy a reality. It also emphasises the commercial investment, consumer engagement and political leadership that will be essential if the carbon emissions targets of 2050 are to be met. Our study also draws attention to technological advances such as electric vehicles that will act as a vital catalyst for change in moving towards this future of smart energy.

THE SMART GRID

Putting intelligence into infrastructure

The smart grid brings two-way digital technology to the energy network, creating an intelligent system better able to balance power supply and demand. Full deployment will result in a more robust and resilient infrastructure, one that suffers fewer outages and possesses the necessary flexibility to accommodate renewable generation, electric vehicles and other low carbon technologies. Customers will also be able to make more informed decisions about their energy use and its associated costs. Successful deployment of the smart grid could save €52bn annually in the EU alone, both by reducing losses from electricity distribution and by enabling greater energy efficiency.

ENERGY SECURITY IN A TURBULENT WORLD

In June 2011, the 28 members of the International Energy Agency made 60m barrels of oil available to the market to counter the impact of the conflict in Libya. The event served to highlight the increasing fragility of oil and gas supplies from politically unstable regions. Yet energy security is increasingly concerned by more than combating supply disruption and price volatility. The rapid industrialisation of emerging economies will add to a projected 115% increase in global electricity demand by 2050. With the European Union currently importing half of its energy requirements, a desire for greater energy independence has joined environmental concerns as the major drivers of investment in renewable energy. Investment in the sector grew globally by 30% to $211bn in 2010, with China the single largest investor ($49bn) and the Middle East & Africa increasing investment the most rapidly (up 104% in 2010).

1.1 EXPERT CONTRIBUTORS

Frits Bliek, principal consultant, KEMA

Dr Andreas Breuer, senior vice president, innovation and new technologies, RWE

Jeff Erikson, senior vice president of thinktank SustainAbility

Gerard Evenden, design director and senior partner at Foster + Partners.

Bastian Fischer, vice president, industry strategy, Oracle Utilities

Steve Heinen, secretariat, International Energy Agency

Hans Martens, chief executive, European Policy Centre

Mark Ossel, vice president, Echelon Energy & Utility

Will Pearson, analyst of global energy and natural resources, Eurasia Group

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Jessica Stromback, executive director of the Smart Energy Demand Coalition (SEDC)

David Weatherall, housing strategy manager, Energy Saving Trust

Dr Gerry Wolff, UK coordinator, Desertec

2 2050: vision of a low carbon economy

The energy landscape of 2050 is already being defined. Legislators in many territories have set out the targets that must be achieved on the path to a low carbon economy.

Estimated cost of realising an 80% reduction in greenhouse gas emissions through a near zero-carbon power supply over the next 40 years
Source: European Climate Foundation

'Smart grid technology can help achieve goals without changing lifestyles, and sometimes with relatively small investments. It creates a win-win situation: we reduce the use of carbon based fuel. We reduce emissions. We stimulate growth, jobs and innovation. And we save money.'

Hans Martens, chief executive, the European Policy Centre

In 2007 the European Council committed to reduce greenhouse gas emissions by 20%, to increase the share of renewable energy by 20% and to make 20% improvements in energy efficiency by 2020. This 20:20:20 agreement represents an initial step towards the Low Carbon 2050 Strategy, which calls for an 80-95% cut of greenhouse gas emissions below 1990 levels by 2050.

The Roadmap 2050 study, initiated by the European Climate Foundation (ECF), reveals that an 80% reduction can only be realised with a near zero-carbon power supply. This transition will cost an estimated €7 trillion over the next forty years with an annual increase of €270bn in public and private investment. The Roadmap emphasises that this figure will be significantly higher if the radical transformation of the energy system is not started in earnest within the next five years.

Some national governments and utilities within the EU are already seizing the initiative. One illustration is the roll-out of smart metering, a key enabling technology of the smart grid. In Italy, smart meters have been installed in almost all households, while penetration rates across Scandinavia are over 50%. National regulators have demanded full deployment of smart meters by 2016 in France, 2018 in Spain and 2020 in the UK. In the Netherlands and Germany progress is being made and roadmaps with defined actions, defined decision criteria and a preliminary timeline are being developed to determine the details of a large scale roll-out. According to Dr Andreas Breuer, senior vice president of innovation and new technologies at RWE in Germany: 'Next year a cost-benefit analysis will be completed from the perspective of our politicians and our regulator. They will decide whether Germany wants to achieve 80% on smart meters by 2020. I believe that in 2014 we will get the signal for a full roll-out of smart meters.'

The United Nations Intergovernmental Panel on Climate Change (IPCC) believes that as much as 77% of the world's energy demands could be met by renewable energy by 2050

In a number of countries, however, predominantly in Eastern Europe, smart metering has not yet become a political or social issue. Turkey is one of the fastest growing economies in the region, with GDP forecast to increase by 4.3% in 2011. Yet it is the only country in the OECD not to have set a national emissions target for 2020 and a suggested target of a 7% cut in emissions remains tentative. Like many rapidly developing economies, Turkey's most pressing challenge remains meeting increasing energy demands, expected to grow by over 6% a year over the next decade. The country does have an active strategy to reduce dependence on imported oil and gas. The government plans for renewable resources to have a 30% share of the energy market by 2023. At present wind, thermal and hydroelectric production is growing at 218%, 53% and 13% respectively.

Meanwhile, Russia plans for a 15-25% cut in the 1990 level of greenhouse gas emissions by 2020 and a 50% cut by 2050. However, there was a 40% fall in emissions between 1990 and 2009 due to Russia's economic collapse following the breakup of the Soviet Union. As a result, the planned 2020 'cut' represents a substantial increase in current emissions levels.

Hydropower generates 16% of Russia's energy needs but other renewable sources account for just 1% of energy demand – perhaps unsurprising for a country that is the world's largest oil producer. Nevertheless, official energy policy seeks to more than quadruple this share to 4.5% by 2020. Russia's Federal Grid Company (FGC UES) also plans to invest $15bn on energy storage and smart grid technology by 2012 with the aim to reduce electricity loss by 25%.

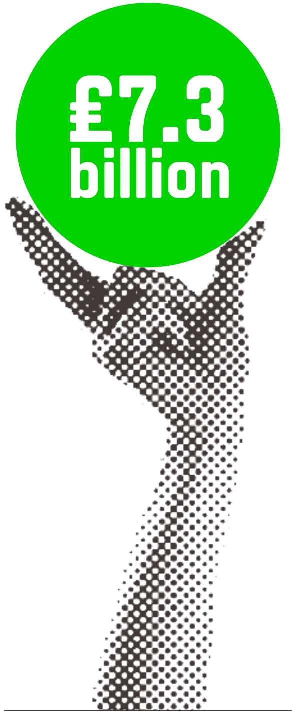
The United Nations Intergovernmental Panel on Climate Change (IPCC) believes that as much as 77% of the world's energy demands could be met by renewable energy by 2050. The panel highlights that almost half of electricity production capacity installed globally between 2008 and 2009 were renewable resources. Such investment in energy generation and in enabling smart grid technologies is essential if the 2050 vision of a low carbon economy is to be realised. The varied progress to date emphasises the critical importance of political will, corporate commitment and public engagement to make this vision a reality.

According to Hans Martens, chief executive of the European Policy Centre, smart grid technologies are essential: 'It is one of the most important measures because it can help achieve goals without changing lifestyles, and sometimes with relatively small investments. Using ICT also creates a win-win situation: we reduce the use of carbon based fuel, we reduce emissions, we stimulate growth, jobs and innovation and we save money.'

3 Energy efficiency

Encouraging and sustaining greater energy efficiency involves two key areas of activity: influencing consumer behaviour, and updating an ageing energy infrastructure.

Change coin deposit lamp by Tima Naskanen, Finland. The lamp raises environmental awareness by forcing users to place a coin into the base to turn it on and to remove the coin to turn it off



Potential savings in UK customers' fuel bills over 20 years from the roll-out of smart meters which begins in 2014

ENERGY EFFICIENCY FOR CONSUMERS: NUDGE POLICIES AND CHOICE ARCHITECTURE

Recent years have seen changes in consumer behaviour across advanced economies towards a greater awareness of environmental sustainability and a move towards leaner, more pared down lifestyles. While this is partly motivated by the global economic downturn, it also represents a more fundamental shift away from the excesses of hyper-consumption. The public's growing environmental concerns have forced companies to adopt clear sustainability strategies. The challenge however, has been to provide the appropriate cues to influence consumer behaviour.

The answer has been to develop 'nudge' policies and choice architecture to encourage greater energy efficiency. The Swedish National Society for Road Safety, for example, reduced driving speeds by 22% in a pilot project that entered motorists travelling within the speed limit into a lottery prize draw. Similar 'nudge' techniques have been used to reduce drivers' fuel consumption too, including dashboard displays that turn fuel-efficient driving into a game: a US Department of Energy study says that aggressive driving can reduce efficiency by up to 33%. The roll-out of smart metering for domestic and commercial energy consumers promises a similar step change in energy efficiency. As David Weatherall, housing strategy manager of the Energy Saving Trust, puts it, 'Without them, promoting energy efficiency has been a bit like telling people to drive slower when they don't have a speedometer in their car.'

The OECD reports that smart meter information may encourage domestic users to reduce domestic consumption by up to 20%. Bain & Co calculates that a 20% reduction in power consumption will reduce emissions by 48%. A recent trial of smart meters by Ireland's Commission for Energy Regulation in 10,000 homes and businesses found that 82% of residential customers made a change in their energy use. 'Pilot projects show that customer acceptance is key,' says Jessica Stromback, executive director of the Smart Energy Demand Coalition (SEDC). 'Once they have customer involvement, these initiatives are delivering results year after year.' The UK's Energy Saving Trust calculates that the roll-out of smart meters from 2014 could save UK customers £7.3bn in fuel bills over 20 years.

With consumer support in mind, many governments have provided a range of incentives to help reduce the energy demands placed on the grid by domestic users. Germany leads the way on domestic solar panels with a photovoltaic market of over 860,000 systems installed, generating 12,000 GWh of electricity. Ensuring a fixed price for solar electricity sold to grid operators has encouraged the sharp rise in installations.

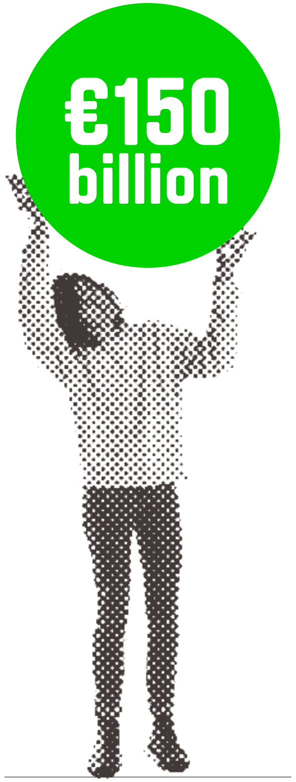
Mark Ossel of Echelon Energy & Utility, says that a particularly impressive example is a project by the SEAS-NVE energy company in Denmark: 'They have been putting a proper system in place and doing a great job with communicating with consumers through text messages, mobile apps, web portals, whatever the consumer likes. They have provided regular feedback, as well as incentives, to help change consumer behaviour. The result has shown a decrease of 17.4% in energy consumption. There are significant opportunities to have fairly instant impact on consumers.'

Legislation has also been used to promote change. The UK government has stipulated that all new homes must meet zero-carbon regulations by 2016, with improved materials to increase energy efficiency. The EU estimates that over the next decade investment in energy saving building materials and components will need to be increased by up to €200bn.

Taking a city-wide approach to energy efficiency, the Masdar project in the United Arab Emirates aims to be the world's first completely carbon neutral and zero-waste city powered entirely by solar energy. When completed in 2025, Masdar could be home to 50,000 people. 'We're now getting information on performance and the data is beginning to build. This will influence construction and urban planning around the world,' says Gerard Evenden, design director and senior partner at Foster + Partners. 'The buildings themselves have to perform better passively if we are going to be able to reduce energy consumption to a level that can be sustainably supplied with renewables. We're achieving about a 50–60% energy reduction.'

VEOLIA WATER: A SMART GRID FOR WATER

The water industry provides some precedents for smart energy. In March 2011, Veolia Water announced the creation of a new company specialising in remote environmental data and water meter reading services. M2o city, a joint venture with mobile telecommunications operator Orange, improves the gathering and management of data related to water usage, and has significant implications for the reduction of waste. Individual customers are invoiced for exact water usage and receive automatic alerts in case of any abnormal consumption. Companies and real estate managers are able to keep a check on year-round usage across a number of properties. The real time monitoring of the water network also enables the detection of serious or persistent leaks, and the detection of backflows. To develop the m2o city, Veolia has implemented Oracle Utilities Meter Data Management, which will enable it to manage the vast amounts of data involved, and provides Veolia with the potential to expand operations beyond water in the future.
In the more immediate term, m2o city has already helped improve customer satisfaction levels: remote meter readings mean that customers are not disturbed by house visits, resulting in fewer complaints and billing inquiries. The project, which is initially being rolled out in France, also means that customers can actively monitor their consumption for conservation programmes.



Annual cost of power interruptions for European Union businesses

ENERGY EFFICIENCY FOR INDUSTRY: A ONCE IN A LIFETIME OPPORTUNITY

Many aspects of the energy infrastructure are several decades old. In the UK, pre-1937 electricity cut-outs are being replaced by 2013. ‘We occasionally encounter assets that date back to the beginning of the last century,’ says Paul Smith, Operations Manager of the UK’s Energy Networks Association. ‘The roll-out of smart meters and smart grid technologies represents a once in a lifetime opportunity to address many legacy issues.’ These include practices which are labour intensive, inefficient and inconvenient for customers, suppliers and network operators alike. Smith estimates there are network operators who currently have to deal with 20,000 network issues a week. ‘There are insufficient resources to manage this situation in the long-term,’ he says.

‘The new wealth of data gives utilities a granular insight into usage patterns, into the status of the distribution network and allows better planning and optimisation of their supply chain, pre-empting network disorders and maximising network availabilities and minimising network restoration times,’ says Bastian Fischer, vice president of industry strategy at Oracle Utilities. Better management is essential as the pressures on the power infrastructure increase. The US Energy Information Administration anticipates total world consumption of energy to increase by 49% from 2007 to 2035. The combination of a rapidly growing population and rich regional oil reserves mean the market for energy in the Middle East is expected to increase by 82% over the same period.

To provide reliable energy supplies to meet this rising demand will continue to be of critical importance, especially as economies move to an even greater dependence on digital technology. Power interruptions currently cost European Union businesses an estimated €150bn a year. Meeting peak demand presents the greatest challenge, particularly in rapidly growing economies where the power infrastructure may simply be unable to cope. The authorities in Shanghai extended their power rationing this summer with 24,000 factories and 3,000 shopping malls and office blocks subject to mandatory power cuts.

In the coming decades, the use of advanced demand-side management tools to encourage load-shifting away from periods of peak demand will be vital. Meeting peak demand often requires the most expensive, inefficient and polluting generating capacity to be deployed. Across the EU, between 5% and 8% of installed capacity is only used to meet the highest 1% of demand. The roll-out of smart grid technologies over the coming decades will mitigate this through the use of automated load control programmes, both for domestic and commercial customers. Although some tools have been available for decades, the smart grid provides the scalability to make demand-side management cost-effective.

The PowerMatching City project in Groningen, Netherlands, consists of 25 households and aims to develop a smart grid market model using coordination mechanisms. ‘A concern for distribution companies is that they will run out of capacity, for example when everyone starts charging their electric vehicle at night,’ says Frits Bliek principal consultant at KEMA. ‘Automation using smart appliances will help manage demand without inconveniencing the customer. For example, a smart washing machine can be instructed to switch on at times when energy demand and prices are lower.’

PECAN STREET PROJECT: COLLABORATING ON SMART ENERGY

Essential to developing smart energy infrastructure is cooperation between government, private enterprise and technological research. In Austin, Texas, the Pecan Street Project is a collaborative research project that has developed into a real world case study. Founded by the City of Austin, Austin Energy, The University of Texas, the Austin Technology Incubator, the Greater Austin Chamber of Commerce and the Environmental Defense Fund, it also enlisted the participation of nearly a dozen private companies to explore the technical, economic and policy implications of an energy system that relies on better energy efficiency, locally generated renewable energy and a new economic model for electric utilities.

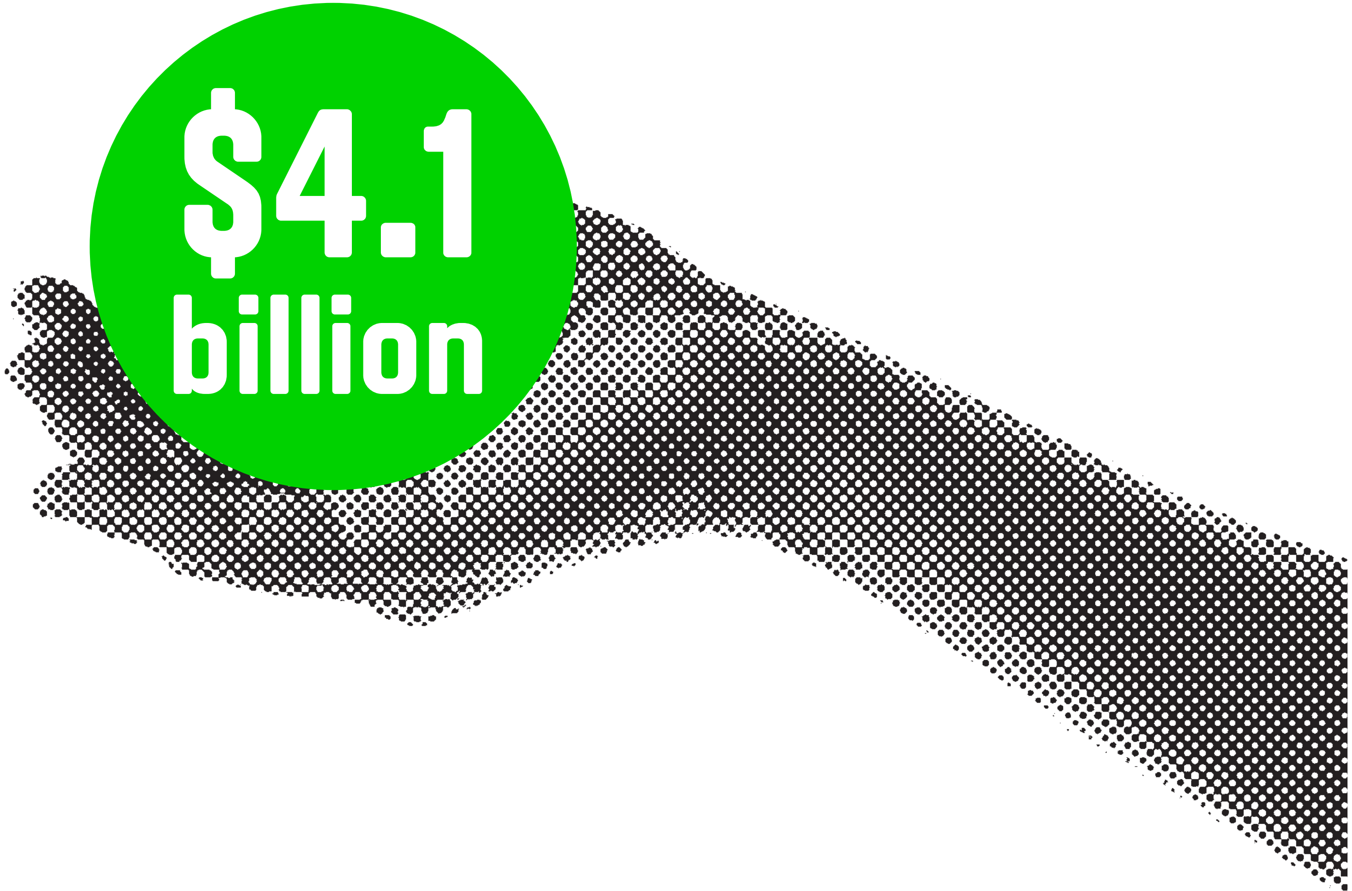
In early 2010, smart grid monitoring systems were installed in the first 100 homes in Austin’s Mueller community. Austin Energy has now built a Customer Information System (CIS) using software from Oracle.

The CIS is integrated with a smart grid infrastructure and provides multiple pricing models and pricing features, as well as Demand Side Management, allowing households to wield greater control over their own energy usage and bills.

It is hoped that demonstration project will help establish industry standards for smart grids in the United States.

4 Data Intelligence

The development of the smart grid will produce a dramatic increase in the quantities of data available to utilities: Lux Research estimates a 900% increase in data volume over the next decade.



Estimated value of the smart grid analytics market by 2015, a rise from $356m
Source: Pike Research

'Guaranteeing privacy is important for customer confidence and is essential in encouraging consumers to benefit and participate in smart energy.'

Bastian Fischer, vice president, industry strategy, Oracle Utilities

DATA ANALYTICS: BRINGING KNOWLEDGE TO POWER

The ability to turn terabytes of data into intelligent business decisions will become central to utilities' efficiency and competitiveness. 'Every one of these energy decisions has not only a financial implication but also a physical implication on the energy network and energy supply,' says Bastian Fischer at Oracle Utilities. The need to extract the value contained within smart grid data is already encouraging utilities to invest heavily in data management services and data analytics. Last year Pike Research estimated that the smart grid analytics market would grow from $356m to over $4.1bn by 2015.

Smart information systems able to respond in near real time will enable dynamic pricing, which will have a pronounced influence on energy use. Providing consumers with time-differentiated electricity prices creates a clear incentive for them to modify their behaviour. The US Federal Energy Regulatory Commission's (FERC) assessment of over 70 pilot projects suggests dynamic pricing could reduce peak demand by an average of 20%. 'The current grid might require more peaking power plants to compensate for the increasing share of variable renewable energies. The smart grid can facilitate the integration of variable renewables by increasing the flexibility of the electricity system,' says Steve Heinen at the International Energy Agency (IEA). 'Smart Grid technologies can optimise asset utilisation and reduce peak demand. The deployment of demand response and controlled smart charging of electric vehicles for example, could reduce projected peak demand in 2050 by 12–26 % in OECD countries.'

The ready availability of consumer data and dynamic energy rates will encourage the development of new business models, fostering competition and altering the competitive landscape.

- Energy aggregators will pool customers with similar demand profiles in order to optimise this demand according to cost or emissions criteria.
- Energy advisors will provide similar optimisation services to domestic and small commercial customers, either individually or in groups, according to their cost and risk profiles.
- For regulators, promoting competition by ensuring the open access to both the grid and energy data will remain a central challenge over the next decade.

CONSUMER ENGAGEMENT AND DATA SECURITY – THE NEW VULNERABILITIES

Despite strong investment in smart grid technologies, many utilities are not matching their commitment with similar investments in consumer awareness and education. The Oracle Smart Grid Rollout report found that 18% of EMEA utilities surveyed do not have a smart meter customer communication plan in place. In the short-term this failure to act will blunt the effectiveness of such enabling technologies. 'The consumer is not sure of the technology and that must be addressed before the deployment of smart meters can be successful,' says Monika Stajnarova, an economist at the European Consumers' Organisation (BEUC). 'Consumers must be engaged with smart meters if their energy behaviour is to be changed.'

With the EU aiming for 80% of users to have smart meters by 2020 this process of customer education will begin in earnest in the near future. The BEUC believes that companies should ensure end-to-end privacy and security but notes that common standards are not yet in place. The level of detail available on consumers' energy usage could potentially allow similar insight into their lifestyles. To forestall accusations of unwanted intrusion it is essential that the smart grid provide data transparency in gaining the necessary consumer support. Bastian Fischer says, 'Guaranteeing privacy is important for customer confidence and is essential in encouraging them to participate in smart energy.'

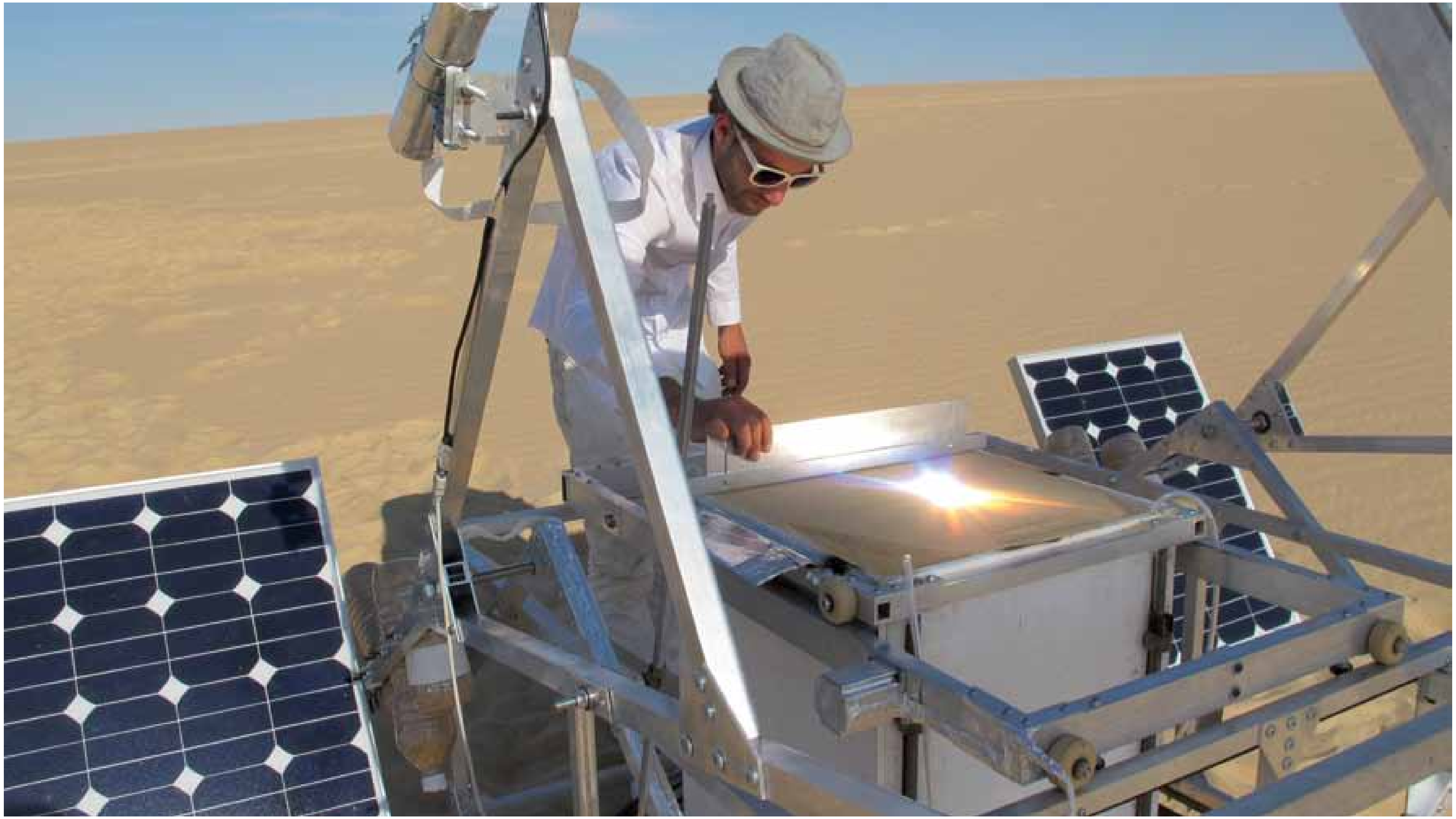
Such confidence is also closely linked to the wider public perception of the security of the smart grid. Whilst intelligent energy systems will provide greater network resilience, they also introduce new vulnerabilities. The threat of cyber terrorism and energy theft are real enough. The UK Cabinet Office estimates that cyber crime already cost the UK economy alone some £27bn in 2010. 'We cannot afford to have this impact on the energy networks,' says Fischer, 'because we cannot just shut down our energy infrastructure. The protection of ICT platforms and integrity of all active smart grid components is a prerequisite.'

The potential for criminal disruption or exploitation of a highly interconnected energy smart grid is already galvanising an effort to coordinate security standards. Jessica Stromback of the SEDC points to public confidence in online banking and is optimistic about public acceptance. 'As long as the issue is given the proper respect and built into regulatory structures I don't think this will be a long-term barrier,' she says. David Weatherall of the UK's Energy Saving Trust agrees: 'If we get the education and awareness phase right I think people will be willing to let their information be used in a flexible and empowering way so that we can help them save energy.'

In Germany this has proved a major factor in the implementation of smart energy policy: 'The government is currently developing a protection profile for smart meters. Once this has been established, we will be able to begin installing smart meters in every new building and any existing buildings with consumption higher than 6000 kWh per year,' says Dr Andreas Breuer at RWE. According to Mark Ossel at Echelon Energy & Utility, it is a problem that can be overcome: 'People need to distinguish between the data needed to manage the grid and personal data. These days the technology is there for data to be safe, as in financial systems. It is a matter of methods and procedures, particularly with the human interface, which is the bigger risk rather than the technology.'

5 Generation and storage

The smart grid will enable distributed generation of power and this will increase the penetration of renewables – such as solar and wind – at the same time as delivering improved efficiency and reliability. But the challenge is in managing these sources' variable outputs.



Solar Sinter by Markus Kayser. This sand- and solar-powered 3D printer uses a Fresnel lens to focus a beam of sunlight hot enough to melt silica sand, which is then used as ink to print glass objects

RENEWABLE ENERGY GENERATION – MEETING THE TWIN DESIRE FOR ENVIRONMENTAL RESPONSIBILITY AND ENERGY INDEPENDENCE

The EU's 2050 Low Carbon Strategy targets require the almost complete decarbonisation of the power sector, which currently accounts for 37% of all CO2 emissions. The share of low carbon technologies in the electricity generation sector is estimated to increase from 45% today to approximately 60% in 2020, 80% in 2030 and nearly 100% in 2050. Carbon capture and nuclear power offer a partial solution but significant use of renewables is essential, particularly in markets such as Germany, which plans to phase out its nuclear plants by 2022. The EU target of a 20% share for renewables by 2020 is just the start.

Today 80% of global energy comes from fossil fuels, but the WWF argues that obtaining 100% of our energy needs from renewables by 2050 is an achievable target. Renewables consultancy, Ecofys, says this scenario would include a 15% cut in energy demand over the next four decades and estimates a worldwide annual saving of nearly €4 trillion compared to a 'business as usual' scenario. Its calculations highlight both the potential and the difficulties presented by renewable energy. For example, an additional 1.1m wind turbines could meet 25% of the world's electricity needs by 2050. Today, wind power accounts for only 2% of global electricity demand, although in Denmark it is responsible for 20%.

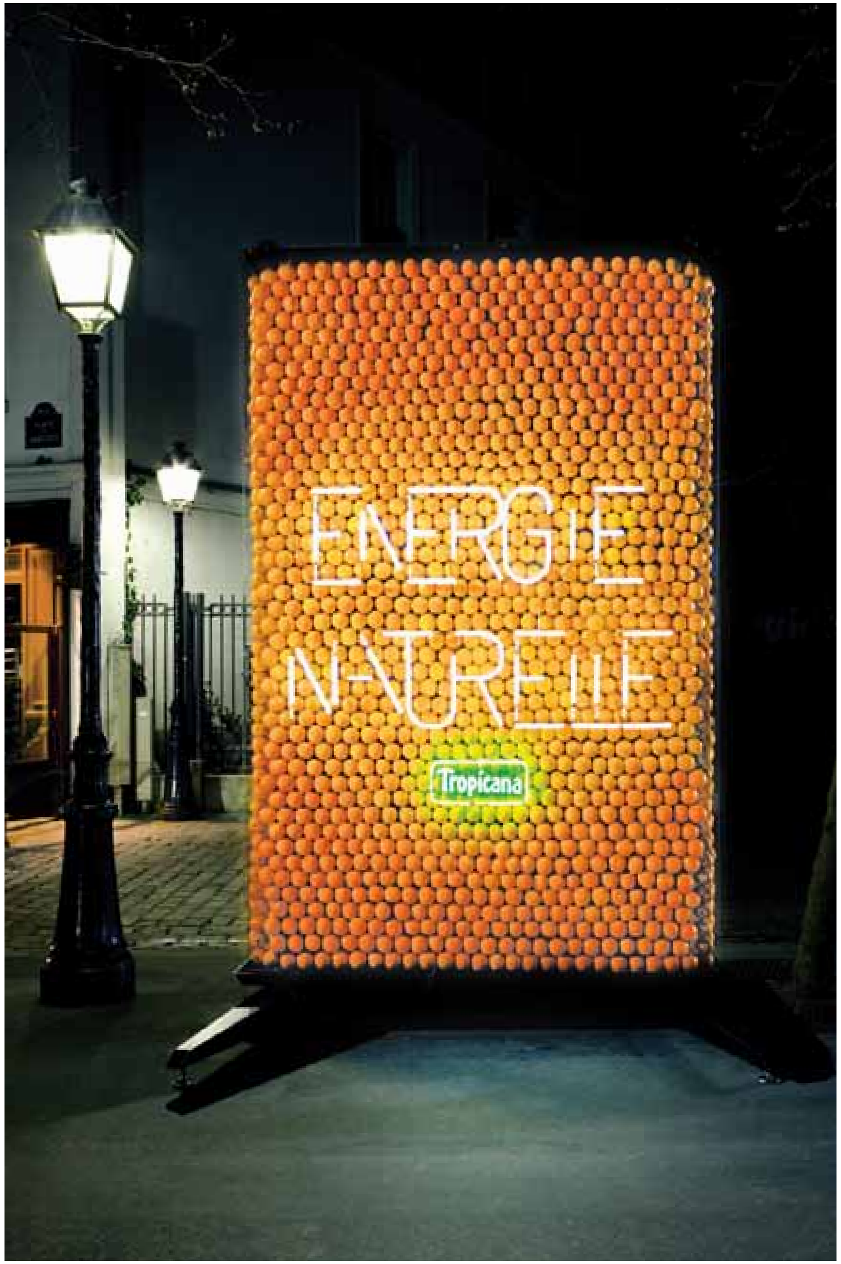
The motivation for such decarbonisation is not simply to reduce greenhouse gas emissions but also to ensure energy independence and security. The European Commission estimated that energy imports in 2008 cost the EU €350bn, or €700 per citizen. Countries such as Turkey are eager to reduce their dependence on imported oil and gas, often sourced from increasingly expensive and volatile international markets. The country imports over 90% of its oil and 95% of its natural gas, while only 4% of electricity produced comes from renewables.

The European Renewable Energy Council (EREC) calculates that by 2050, wind and photovoltaic energy will contribute approximately 30% each towards EU electricity consumption. Geothermal is anticipated to provide an additional 12%, with an additional 10% from biomass sources. Half of the EU's energy demands is for heating and cooling, and biomass will account for 45% of this specific area of demand by 2050. Solar thermal and geothermal sources are expected to expand rapidly from 2030 onwards to meet the remaining 55% of demand. The EREC believes the number of people employed in the renewable energy sector in Europe could increase from 500,000 today to over 6m in 2050.

By 2050, wind and photovoltaic energy will contribute approximately 30% each towards EU electricity consumption
Source: European Renewable Energy Council

Even oil rich regions will see significant growth in renewables over the next four decades. Biomass and wind power in Russia and solar energy in the Middle East have huge development potential. Will Pearson, global energy and natural resources analyst at the Eurasia Group, believes renewables' overall share of these energy markets will remain small in the medium term. 'This is particularly true of Russia as it has abundant coal and natural gas, which can be used domestically, combined with strong government support for nuclear energy,' he says. 'In the Middle East there is a drive to preserve hydrocarbons for export, but again the share of renewables is likely to remain pretty minimal overall.'

'The momentum is going to increase over the next 40 years but we're not going to see as much progress in the early years as we will in the later years,' says Jeff Erikson, senior vice president of thinktank SustainAbility. 'Distributed generation will become more pronounced. It's going to become much more of a mosaic of energy sources.' The proper government policies could accelerate this process but Erikson believes the move towards a low carbon energy future will happen only when there is price parity between different sources of energy. Will Pearson agrees, saying 'the unconventional gas boom creates further uncertainty for renewables because it will reduce the cost of natural gas, delaying the price parity of renewables and extending their dependence on subsidy programmes.'



Natural Energy advertising hoarding by DDB Paris for Tropicana, France. The advertising agency harnessed the power of 2,500 oranges to create a 100% orange-powered billboard

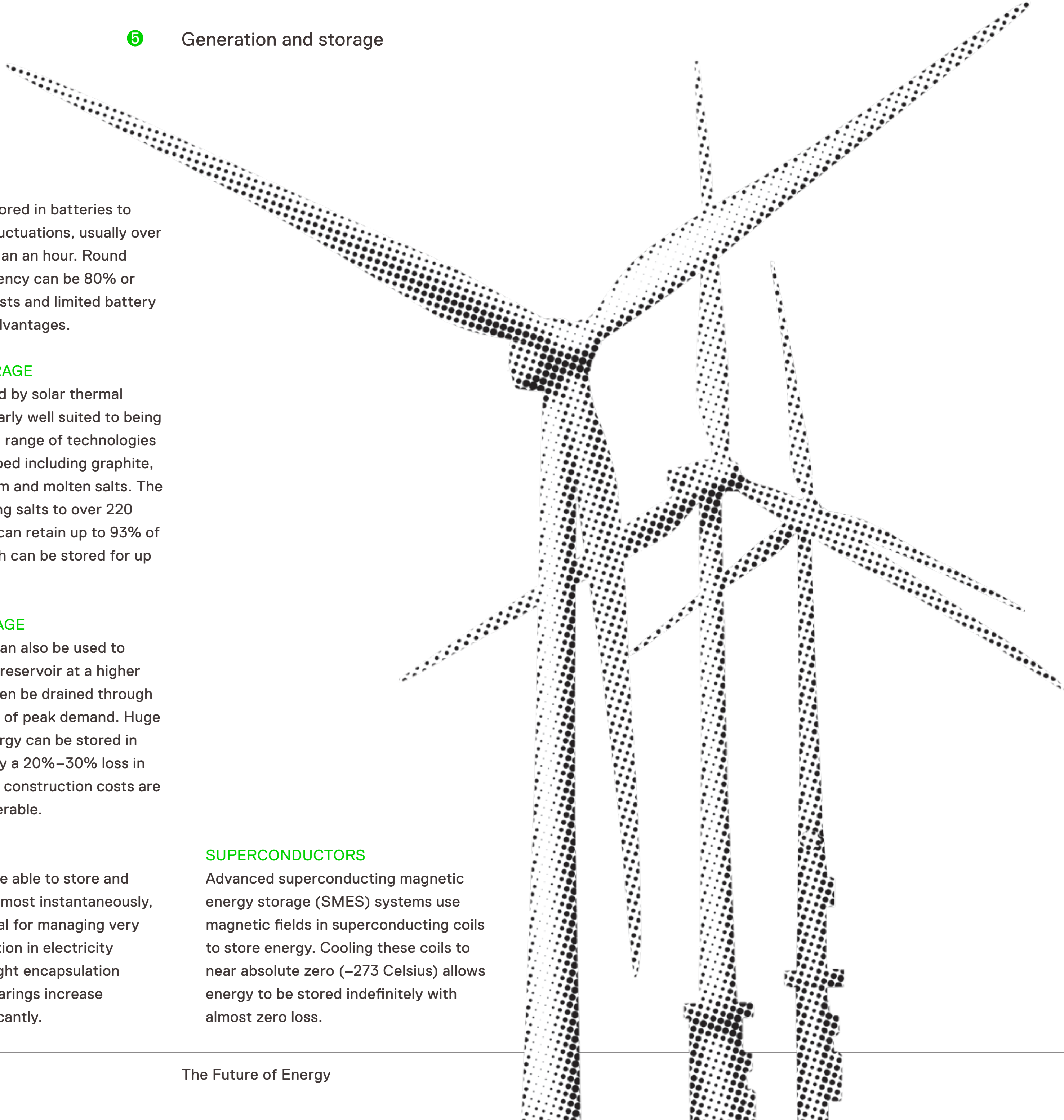
Estimated number of people in Europe employed in the renewable energy sector in 2050, up from 500,000 today Source: European Renewable Energy Council

STORAGE – THE KEY TO MAINTAINING ALWAYS-ON POWER

Smart grid technologies will be essential to maximising the full benefits of renewables, not only because renewable sources are often distributed across many locations, rather than concentrated in central power plants, but also because many have variable and unpredictable outputs. Greater interconnection, such as switching to daylight solar in the South and night time wind in the North will increase a network's ability to accommodate variable renewables, but infrastructure limitations remain.

The IEA highlights Denmark for its ability to accommodate 63% renewables, partly thanks to its connections with other Nordic markets. This figure falls to 48% for the Nordic market in general, 31% for the British Isles and 27% for Iberia. The ability to balance supply and demand has always been required of energy networks but the variability of renewables means that storing energy is essential to maintaining the provision of always-on power. Currently both storage technology and infrastructure are a weak link in the route towards a low carbon economy.

Pumped hydro storage allows water to be pumped to a higher altitude at times of low demand, storing huge amounts of energy that can be released when required. This process has a modest energy loss of about 25% but its feasibility depends on suitable geography. Superconductors can store electricity within a magnetic coil at extremely low temperatures without any energy loss. Alternatively cheap electricity can be stored in compressed air used to drive turbines when demand increases. Approximately 40% of energy is lost in the process.



BATTERIES

Energy can be stored in batteries to manage power fluctuations, usually over periods of less than an hour. Round trip energy efficiency can be 80% or more but high costs and limited battery lifespan are disadvantages.

THERMAL STORAGE

Energy generated by solar thermal plants is particularly well suited to being stored as heat. A range of technologies has been developed including graphite, pressurised steam and molten salts. The process of heating salts to over 220 degrees Celsius can retain up to 93% of the energy, which can be stored for up to a week.

PUMPED STORAGE

Surplus energy can also be used to pump water to a reservoir at a higher altitude which then be drained through turbines at times of peak demand. Huge quantities of energy can be stored in this way with only a 20%–30% loss in the process. The construction costs are however, considerable.

FLYWHEEL

These devices are able to store and release energy almost instantaneously, making them ideal for managing very short-term variation in electricity generation. Airtight encapsulation and magnetic bearings increase efficiency significantly.

SUPERCONDUCTORS

Advanced superconducting magnetic energy storage (SMES) systems use magnetic fields in superconducting coils to store energy. Cooling these coils to near absolute zero (–273 Celsius) allows energy to be stored indefinitely with almost zero loss.

ELECTRIC VEHICLES

Not only can smart grid technology charge electric vehicles (EV) when energy is cheap, it could also draw energy from car batteries at times of peak demand, adding an additional storage option. An EV battery could meet the power needs of the average family for five days but batteries are expensive and repeated recharging reduces their lifespan.

CAPACITORS

Able to store and release sizeable quantities of electricity in a matter of seconds, capacitors are an inexpensive and reliable solution to frequency regulation.

HYDROGEN

Using renewable energy to extract hydrogen from water or natural gas is a comparatively wasteful process in which up to half the energy is lost. However, the hydrogen can be stored in compressed gas or liquid states and its energy density makes it a huge potential for specific applications such as fuel for vehicles.

COMPRESSED AIR

Air can be compressed by surplus electricity and stored in tanks or in sealed caves. When it is released it can be used to power turbines. 40% of the energy is lost in the process but this storage technology is relatively cheap.

The development of storage technology and infrastructure will also address the need to store energy for a matter of minutes or seconds in order to optimise turbine energy production and manage a stable power supply. Batteries are currently efficient but expensive and typically used for periods of less than 30 minutes. Capacitors and flywheels are well suited for regulating the second-by-second frequency of highly variable renewables such as wind.

The use of hydrogen as an energy store will be significant in the decades ahead, particularly for specific power uses. The gas can be extracted from water or natural gas and, although 50% of the energy is lost in the process, hydrogen is suitable as a high grade fuel for high energy density applications such as transport – including aviation. Starting in 2013, the Audi e-gas project aims to turn hydrogen into synthetic methane using renewable energy from North Sea wind farms. Audi's A3 TCNG can run on this e-gas and could potentially offer carbon neutral motoring.

PEAK LOAD SHIFTING

Just as important for the balancing of the grid is peak load shifting. This means reduction of electricity energy demand during a utility's peak generation period, and is particularly useful where there is a high ratio of volatile or intermittent renewable energy supply. This can happen very precisely, in discrete geographical areas by, for example, controlling switchable loads such as heat pumps. It can also be done on a large scale by interrupting the work of a few large industrial sites, such as aluminium production. This strategy is well established: it was piloted on an urban scale by Beijing during the 1990s, driven in part by an over-burdened coal industry. Industrial manufacturers and the government worked to introduce price differentials for peak and off-peak energy, replaced inefficient machinery and interrupted production during peak times. The net result of these measures was a reduction in the peak demand of 50 MW in 1997 and an additional 50 MW in 1998: there was an increase of 150 GWh in energy consumption during the off-peak period.

'The largest and most recent example is in Japan,' says Bastian Fischer, 'where they were dealing with the massive reconfiguration of the Japanese energy network after the shutdown of several nuclear power plants, the start up of several conventional plants alongside imposed load shifting and energy conservation. Although the trigger for this was a natural disaster followed by a nuclear accident, it is a situation which provides many lessons and insights.'

6 Low carbon transport

On the back of promises to spur infrastructure investment, encourage new services and promote consumer understanding of energy use, electrictransportation is regarded as a crucial application of the smart grid.

Nissan Leaf by Nissan, an all-electric car that produces no exhaust pollution or greenhouse gas emissions

Global sales of electric vehicles by 2050
Source: International Energy Agency

The EU transport sector is 98% dependent on oil for its energy supplies. European greenhouse gas emissions from transport rose by 26% between 1990 and 2007 in contrast to a decline in emissions from non-transport sectors. The decarbonisation of transport is an important component of the future of energy and the European Commission's Transport 2050 strategy calls for a cut in carbon emissions of 60% by 2050. To achieve this target over the next four decades we will see the removal of conventionally fuelled cars for urban transport, a 40% use of low carbon fuels in aviation and a 50% shift in medium-distance freight and passenger traffic away from roads towards rail and shipping.

Biofuels will be one of the factors that will make this transport growth sustainable, particularly before 2020, the time by which the Renewable Energy Directive requires at least a 10% share for renewable energy in transport. But beyond 2020 the role of renewable electric vehicles becomes more pronounced. Peter Voser, chief executive officer of Royal Dutch Shell, recently said that plug-in electric vehicles would represent 40% of the global car market by 2050. The IEA suggests global sales targets of electric vehicles will be 7m in 2020, 30m in 2030 and 100m by 2050.

Global auto manufacturers are already looking beyond hybrids towards fully electric cars. Nissan, manufacturers of the all-electric Leaf, aims to sell 1.5m electric cars by the end of 2016. It will face competition from models such as the Audi e-tron, the Chevrolet Volt and the Tesla Model S. By the beginning of 2011 there were 30 electric vehicle models in various markets, with an additional 40 expected to be introduced during the course of the year. Uptake will be promoted by government policies, too. The German government is allocating €1bn for research and development. It hopes to have 1m electric cars on the country's roads by 2020.

The rapid adoption of electric vehicles will have a dramatic impact on the smart grid by spurring infrastructure investment, encouraging new services and promoting public awareness and engagement with their energy use. Large cities will adopt the technology first, driven by a need to improve air quality and by consumers who predominantly require their car for short journeys. The MOBI.E project in Portugal recently saw the installation of 1,350 public charging stations across 25 municipalities. Management consultancy McKinsey says plug-in hybrid cars and battery-only electric vehicles will account for 16% of new car sales in New York, 9% in Paris and 5% in Shanghai by 2015.

Mark Ossel says that an important factor will be the uneven distribution of the technology: 'Some may say that in 2020, only 5% or 10% of cars may be electrical. But the reality will be that in certain areas of the city, there might be 15% of people with a second car as an electrical car. This will mean a greater energy demand in specific areas of a city, placing a greater urgency on the implementation of a smart energy system.'

'The charging infrastructure required by electric vehicles is a big issue and will help to move the whole discussion of smart energy forward,' says Frits Bliek principal consultant with energy consultancy KEMA. Utilities and grid companies will be forced to invest in smart grid technologies in order to accommodate the power demands of millions of electric vehicles. 'I'm convinced that electric vehicles are one of the primary catalysts moving us towards a low carbon future,' says Jeff Erikson of think tank SustainAbility.

Smart metering will be required not only to collect, aggregate and communicate consumption and event data records to a sophisticated CRM, billing and fulfilment platform – but also to an advanced and distributed network management system aimed at optimising the balance of supply and demand in the low voltage distribution network. It will have to do this while maximising the potential of renewable energy. The smart charging of electric vehicles, the optimised use of heating, ventilation and air conditioning (HVAC) and other smart appliances will enable switching demand from peak time, such as in the early evening, to times of low demand – after midnight. In the future electric vehicles will become an intelligent and efficient means of decentralised electricity storage, mitigating the network congestion on low voltage and ultimately allowing individuals to sell back to the grid in order to help further manage supply and demand.

Perhaps most importantly of all is that the rapid adoption of electric vehicles will prompt public awareness and engagement of the issue of energy usage.

ELECTRIC VEHICLES IN PORTUGAL: BUILDING THE INFRASTRUCTURE

In Portugal, the MOBI-E pilot project – an integrated platform for the deliverance of electric mobility – is being rolled out across 25 municipalities and the country's main highways. As part of this government-led project, Inteli, a privately owned non-profit association, is installing 1,300 slow charging stations and 50 fast charging stations. Oracle is working with Inteli to provide the ICT infrastructure to operate the network – this includes the implementation of Oracle Utilities Customer Care and Billing, Oracle Fusion Middleware and Oracle Database 11g. This will deliver base rating and billing, enabling monthly flat rate and time-of-day rating of electricity consumption and network usage. It will also allow charging for additional services, such as parking, roaming between electric vehicle operators and energy retailers, as well as the settlement and clearing of all transactions among the service providers.

7 Country Snapshots

Which of the smart grid technologies or renewable energy resources a country chooses to invest in – if they choose to invest in them at all – is influenced by factors ranging from geography to political expediency. These snapshots show the differing futures of key territories across Europe and the Middle East.

Masdar City concept, the world's first carbon-neutral, car-free and zero-waste city, by Foster + Partners, Abu Dhabi

Funding available from the German government reserved for research and development projects in the ICT industry, essential to developing the country's smart energy system in the future. Source: Germany Trade and Invest

GERMANY: REJECTING NUCLEAR AND FOCUSING ON RENEWABLE

A decision was made in 2002 to phase out Germany's nuclear power plants, but only last year Chancellor Angela Merkel announced plans to extend their operational lifetimes by an average of 12 years in order to help the country meet its ambitious target of a 40% cut in carbon emissions by 2020. This changed dramatically after the disaster at Japan's Fukushima Daiichi nuclear power plant. Seven of Germany's reactors were taken offline almost immediately and the government announced the last of the country's nuclear capacity would now be shut down in 2022.

The IEA highlights the challenge now facing Germany in replacing 50 TWh of low carbon nuclear electricity with wind and solar. The government has said it wants 35% of power to come from renewables by 2022, compared to 16% today, but that is unlikely to replace the lost low carbon capacity of the nuclear plants. Nevertheless, political reality means the IEA is currently revising downwards its estimate of nuclear accounting for 14% of world energy output by 2035.

The Federal Environment Agency believes that all electricity will come from renewable energy sources by 2050. Germany already enjoys a strong position as the world's second biggest producer of wind energy after the United States. The feed-in tariffs laid down in the Renewable Energy Act have also made the country a world leader in photovoltaics. The country currently produces over 17,000MW of photovoltaic energy compared to less than 4,000MW in second-place Spain. The German government is placing great emphasis upon the development of smart energy systems, and the essential ICT systems to accompany it: it has described its mission as being to create an 'internet of energy.'

As in other countries, the growth of alternative energy supplies and decentralised power generation will create increasing demand for a smart energy system. 'There are new patterns of demand across the country,' says Dr Andreas Breuer of RWE. 'In the Ruhr Valley, for example, old coal mines that have closed down, have now the location for new service companies, which places a new demand on the grid. We are already implementing a smart grid, we cannot handle the changes in energy demand and supply in any other way. It is not a revolution, it is an evolution.'

Solar power capacity installed in Spain in 2008: more than the entire solar capacity installed worldwide in 2007

IBERIA: A CENTRE FOR SOLAR ENERGY GENERATION

Spain's primary energy supply has declined by some 11% since 2007, largely because of the economic downturn, but the long-term trend will see increasing demand for electricity. In a bid to reduce the country's dependence on imported oil and gas, Spain has increased the share of nuclear power from 3% to 11% over the last 40 years. Renewables have increased from 5% to 9% over the same period, thanks in recent years to government policies that promoted solar thermal and photovoltaics. Such incentives are essential to encourage an industry with high upfront installation costs and a need to build investor confidence.

However, the experience of the Spanish solar sector illustrates how building the infrastructure fit for tomorrow's energy needs not only political support but also policy consistency. The incentives for solar energy introduced in 2004 – feed-in tariffs – proved far more effective than anticipated. A target of 400MW of solar power capacity by 2010 was comprehensively exceeded. A total of 2.6GW was installed in 2008 alone – more than the entire solar capacity installed worldwide in 2007. In the face of unsustainable costs exacerbated by recession, the government introduced retrospective cuts to subsidies, causing widespread uncertainty and disruption in the sector.

Portugal faces a similar situation. According to Miguel Stilwell d'Andrade, board member of EDP Distribuição, the key challenge facing energy suppliers in Europe is meeting the 2020 European goals. This will require 'a major change in the way we produce and consume energy. Achieving these goals will require not only the increase in electrification of the economy (for example in transportation) but also the decarbonisation of the power sources (with a higher share of renewable energy and distributed generation).' Stilwell d'Andrade sees smart grids as central to this, and EDP is conducting a pilot project, InovGrid, involving more than 30,000 clients in the district of Évora. This project is part of the MOBI.E roll-out (see Low Carbon Transport). 'We can already say that many small businesses can reduce their consumption by over 10% as a result of the information and value added provided by the project,' he says. The future of this project depends on the extension of such pilots to other municipalities in Portugal during 2012, and on the regulatory conditions. The Portuguese government has yet to decide on a national roll-out of the smart grid project.

'There are stringent Kyoto targets we have to meet. The country is looking at developing the supply side through renewables and the demand side through smart energy to get a low carbon count for Ireland.'

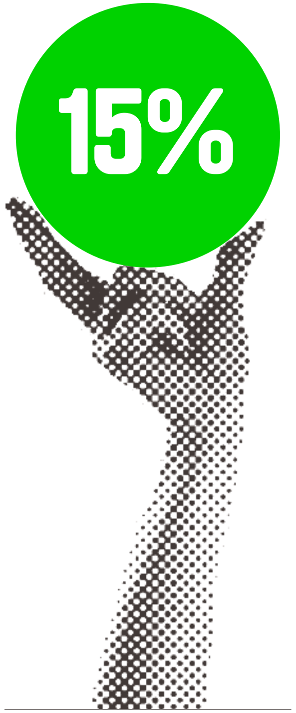
John Mullins,
chief executive,
Bord Gáis

IRELAND: A FUTURE FOR WIND POWER AND SMART ENERGY

Recent economic woes have caused problems for Ireland's renewable energy market. 'The reduced availability of bank finance has hit small energy producers. Many projects can't get funded or if they can get funded at a premium,' says John Mullins, chief executive of Bord Gáis. Nevertheless, it is more important than ever to increase renewable energy production: 'There are stringent Kyoto targets we have to meet,' says Mullins. 'None of us wants to pay fines, so the country is looking at developing the supply side through renewables and the demand side through smart energy to get a low carbon count for Ireland.'

However, at the moment renewable sources account for only 2% of primary energy supply. Ireland remains a thirsty consumer of oil. The combined share of oil (59%) and gas (23%) in the country's energy supply has almost doubled over the last 20 years. While its domestic production of energy, mainly through solid fuels (peat) and natural gas, has decreased in recent years, the production of energy through renewable sources has increased significantly: by 94% since 1990.

This increase in renewable energy supply has been due to the new wind power capacity. A €3.2bn programme of construction and development of high voltage transmission lines is already underway, which is essential to the incorporation of wind power into the power grid. This is part of the Grid25 programme instigated by Ireland's state-owned power operator, Eirgrid. There have also been extensive trials for smart energy systems, with 1800 smart meters installed across the country. These trials will be completed in October 2011, but early signs suggest a decrease of between 3%–5% in household energy consumption. 'This is purely on a reading basis,' says Mullins. 'If you have an interaction between the meter and an ICT algorithm, you could have a much higher level of demand reduction at a household level, and the cost-benefit analysis of these meters will go onwards and upwards.'



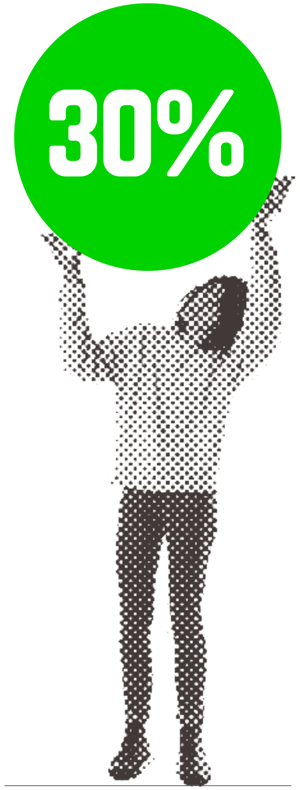
The Desertec Foundation estimates that a network of concentrated solar-thermal power plants throughout the Middle East and North Africa could provide Europe with 15% of its energy requirements

MIDDLE EAST: DIVERSIFYING AWAY FROM OIL DEPENDENCE

The rising price and growing demand for oil means depleting reserves in the Middle East are exacerbated by the region's own growing energy needs. Saudi Arabia now consumes almost 130,000 barrels per day for domestic power generation, almost double the amount of a decade ago. This costs the kingdom $6.5bn a year in lost exports. According to Ali Saleh Al-Barrak, chief executive officer of Saudi Electricity Company, there has been an increased demand for electric power at the rate of 8% per year in Saudi Arabia. 'There is high residential consumption, 55% of our energy consumed by domestic use, and consumption per capita has doubled over the last 15 years,' he says. This trend is spurring many countries in the region to invest their petrodollars in clean energy and safeguard and diversify their export revenues. This nascent revolution will grow substantially over the coming decades. In 2010 alone clean energy investment in the Middle East and Africa rose 104% to $5bn.

Egypt intends to source 20% of its energy from renewables by 2020. Jordan has adopted a 10% target and Kuwait aims for a more modest 5%. Much of the region is ideally suited to solar energy with large areas of desert and reliable weather conditions. A solar farm of 180 square kilometres, or 1% of the country's territory, could supply all of Kuwait's energy needs. Egypt built its first 140MW solar thermal plant last year and a second $700m plant will come online in 2017. There is also a growing interest in developing smart energy systems and technology: 'Unless we have a strong effort on the demand side – with population growth, demand will continue to grow,' says Ali Saleh Al-Barrak. 'We are looking for more energy preservation by giving the tools for the consumers. Over the next few years investment of $40bn in generation expansion is needed, and $24bn for expanding distribution, including some investment in making our system more intelligent and more smart.'

The Desertec Foundation calls for the establishment of a network of concentrated solar-thermal power plants throughout the Middle East and North Africa to usher in a new era of energy exports. The 40-year, €400bn proposal could provide Europe with 15% of its energy requirements. 'In desert regions, the potential of solar and wind power is colossal,' says Dr Gerry Wolff of Desertec-UK. 'A small fraction of the world's deserts could generate electricity equivalent to the world's total energy consumption – although it would be prudent to combine 'desert' power with other renewables in other parts of the world'. The cost of renewables is coming down and subsidies for traditional sources of power will be progressively withdrawn. It is likely that, within 10 years, the commercial balance will tilt increasingly in favour of renewables.



Reduction in gas and electricity use in homes and offices in the Netherlands by 2020

NETHERLANDS: SMART TECHNOLOGIES FOR DOMESTIC CONSUMERS

The Dutch government has not yet announced a mandatory national roll-out of smart meters. Despite this lack of political impetus a number of experiments led by local utilities are pioneering the development of smart grid technologies. The smart energy Collective 5000 brings together more than twenty companies to develop intelligent energy concepts.

The PowerMatching City project is a real world laboratory for smart grid technologies. In the town of Hoogkerk, 25 homes have been virtually connected together, with digital controls used to match demand and supply. The project aims to develop models that are simultaneously optimised for consumers and network operators and at the same time seamlessly coordinate hybrid heat pumps, smart appliances and electric cars. ‘Demand at the local level can be effectively balanced by giving price incentives to consumers,’ says Frits Bliek of KEMA, the company that reviewed the project. ‘At the same time energy suppliers regard the network of energy generators in people’s homes as one big power plant. They can increase or decrease production as necessary and sell surplus energy on the wider energy market.’

The Dutch government has more ambitious plans with regard to energy efficiency. By 2020 the Netherlands’ 2.4m homes and offices must use 30% less gas and electricity than today. The Meer met Minder (More with Less) Foundation believes total carbon neutrality could be achieved by 2050. The Jouw Energie Moment scheme in the city of Breda shows how this target could be reached, with 300 homes incorporating the latest energy saving technology, including solar panels, smart appliances and electric vehicle chargers. The homes are designed to give homeowners the awareness and choice of the cheapest or most sustainable energy.

Revenue from clean tech industry in Denmark
Source: WWF

NORDICS: GREEN TAXES AND PUBLIC AWARENESS

The Nordic governments are historically strong supporters of green taxation. It's a win-win approach that uses the fiscal incentive of taxation to encourage green behaviour and facilitate R&D and innovation. Finland was the first nation to enact a carbon tax in 1990, a model that Norway, Sweden and Denmark soon followed. Such measures are effective. In 1994 Denmark became the first nation to tax plastic bags, cutting their use by 66%.

The prohibition approach in Nordic countries has demonstrated that economic growth does not equate to an increase in energy consumption or CO2 emissions. Sweden increased GNP by 48% between 1990 and 2007 and decreased GHGs by 11.7%. Denmark has witnessed 30 years of economic growth without increasing energy consumption. Iceland's green tax reinvestment in geothermal means it no longer imports oil for heating.

To reach the 2015 EU requirement that all new cars in Europe must not exceed emissions of 130g/km CO2, Denmark introduced a vehicle registration tax ranging from a punitive 105% to 180% of the purchasing price. It's a cost that electric car buyers are exempt from and are instead rewarded with free parking in Copenhagen. Norway, Sweden and Finland have similar emissions-based vehicle tax schemes as part of their target of becoming carbon neutral by 2030.

This heavy taxation on traditional fuels has spurred innovation such as the planned collaboration between pork producer Stjörnugrís and energy company Metanorka, which will build Iceland's first biological waste power plant. The Nordic states are proving that an intelligent, hierarchical tax system can make significant steps towards sustainability.

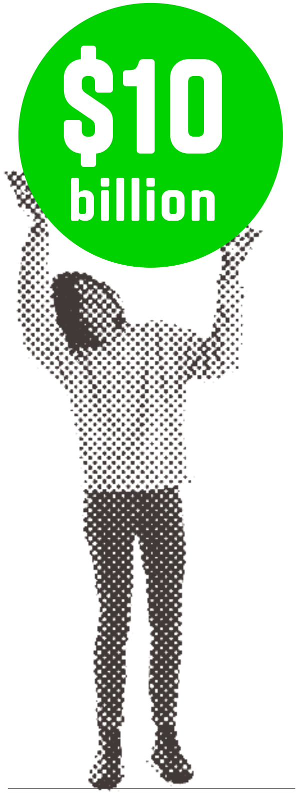
CO2 to be captured at Europe's single largest polluter, the Belchatow power plant, by 2015

POLAND: THE NEED FOR CARBON CAPTURE AND STORAGE

With its dependence on coal for 90% of its electricity and 55% of its energy supply, Poland has led the resistance to more stringent carbon targets beyond the 20% reduction by 2020. As a means of diversifying its energy sources, Warsaw will develop the extraction of shale gas over the coming decades despite environmental concerns. It's a decision faced by a number of Eastern European countries including Hungary, Bulgaria and Romania. 'Nuclear and renewables are very costly and for a country like Poland that has other resources that are less expensive,' says Will Pearson. 'There is pressure to keep energy prices low as the economy grows.'

Poland's dependence on fossil fuels will continue for many years. Coal is anticipated to still provide 60% of energy needs in 2030. As a consequence the country will become a leader in the development of carbon capture and storage technology. Europe's single largest polluter, the Belchatow power plant, will be the location of an Alstom pilot plant designed to capture 100,000 tonnes of CO2 a year by 2015. Such technologies, combined with energy efficiency fostered by the roll-out of the smart grid, will do much to help Poland meet its carbon reduction targets.

Poland has the second lowest share of renewables in electricity generation among the 28 members of the IEA. Growth will continue to be led by technologies such as biomass, which takes advantage of Poland's agricultural land and relatively low population density. An estimated 800,000 hectares of biomass will be required to meet the government's 'Biogas 2020' strategy, which commits to the generation of 2000MW of electric power by 2020, with a facility in every municipality.



Equivalent cost per year of the 12% of energy in Russia that is lost in transmission

RUSSIA: THE QUEST FOR ENERGY EFFICIENCY

Russia is responsible for 12% of the world's oil market and its energy strategy until 2030 plans to increase the exploitation of its huge oil and gas reserves. This is partly to meet its own domestic electricity needs, which are expected to increase from 1.8 to 2.2 trillion kWh over this period. But it is also aimed at meeting an insatiable demand for energy exports, particularly from emerging markets. The share of oil exports accounted for by the Far East will increase from 6% to 20% by 2030.

Despite its hydrocarbon wealth, Russia has also set a modest target to obtain 4.5% of its electricity from renewables by 2020. The country is eager to exploit its natural advantage in biomass and hydroelectric power. Specific local energy sources will also be developed over the coming decades such as geothermal in the Pacific Far East and wind power in the republic of Kalmykia in the south west, which already obtains 60% of its power from wind turbines.

However, the main focus of the energy ministry's strategy until 2020 is efficiency. Russia is the third largest consumer of energy in the world but decades of underinvestment mean that the country's grid requires substantial investment and modernisation. It is estimated that 12% of energy is lost in transmission, equivalent to $10bn a year. The government plans to invest $300bn in order to increase energy efficiency by 40% by 2020 including support for smart grid technologies.

Located close to 73% of the world's proven oil and 72% of global gas reserves, Turkey has a profound influence on the energy security of other markets

TURKEY: SECURING THE ENERGY FOR A GROWING ECONOMY

Contrasting with recession elsewhere, Turkey's economy grew at just under 9% in 2010 and even outpaced China in the first quarter of 2011. The rising living standards of its young and rapidly urbanising population will continue to contribute to what the IEA anticipates will be a doubling in energy demand over the next decade. Securing this energy supply is a key feature of Turkey's future energy plans and, as a major transit corridor, the country also has a profound influence on the energy security of other markets too. Turkey is located close to 73% of the world's proven oil and 72% of global gas reserves.

With an almost total dependence on imports for its requirements of oil (93%) and gas (97%) the country has signed long-term agreements with Russia, Iran and Azerbaijan. The pipelines across Turkey that connect the Caspian and Northern Iraq to international markets will also play a crucial role in supplying Europe's energy imports, which are expected to grow 15% by 2030. Will Pearson at the Eurasia Group believes that recent energy policy decisions could strengthen the case for infrastructure projects such as the proposed Nabucco pipeline. 'The decision to move away from nuclear [in Germany and in Italy] is going to contribute towards momentum for a southern corridor project.'

Over the coming decades Turkey will also turn to renewables to mitigate its dependence on imports. The government aims for the country to meet 30% of demand by 2023. Of Turkey's 980 wind farms, 200 came online last year and the European Wind Energy Association estimates this sector alone could ultimately meet 20% of energy demand. Substantial additional supply will come from solar, hydro and geothermal sources.

Estimated revenue from offshore wind in the UK by 2020
Source: BIS

UK: TAPPING WIND AND TIDAL POWER

The UK has committed to providing 15% of electricity from renewables by 2020 but there is considerable potential for a higher share. As much as 35% of the UK's energy requirements could come from renewable sources by 2020 according to a 2011 review commissioned by the Department of Energy and Climate Change (DECC). 'It's important to note that the annual build that we were looking at in this study was not financially constrained,' says Simon Power, technical director of the study at Arup. 'It's the art of the possible; an attempt to understand what is blocking build out of 18 different technologies. It shows what could be achieved.'

Onshore wind, particularly in Scotland, could grow as much as 500% in that period, but offshore wind has even greater deployment potential. 41GW could be generated offshore by 2030. The UK is currently the world's largest single market for offshore wind and the Department of Business, Innovation and Skills (BIS) estimates the sector will employ 70,000 workers and generate £8bn in revenue by 2020.

The UK also has the largest marine energy resources in Europe and is a world leader in other marine energy technologies, principally wave, tidal stream and tidal range generation. The Wave Hub off the north coast of Cornwall and the European Marine Energy Centre in Orkney are major proving grounds for marine energy technologies, which RenewableUK believes could have 1–2GW of installed capacity by 2020. The organisation calculates that wave and tidal power could ultimately meet 15–20% of the UK's current electricity demand.

FUTURE POLL

8 Key Take-Outs

- Widely shared objectives of energy security, reduced emissions and continued economic growth are dependent on the development of a smart grid capable of delivering energy efficiency and demand response, as well as integrating renewable and variable sources of energy.

- Electric vehicles will act as a major catalyst, encouraging the necessary investment in energy technologies and infrastructure. Recharging services will heighten public awareness of their energy consumption, too.

- The complexity and cost associated with the deployment of the smart grid means that market forces alone are insufficient to drive the necessary investment. Governments must take the lead, putting in place the appropriate policy and regulatory framework and ensuring the costs and benefits of investment are aligned.

- The development of successful large-scale pilot projects is an important element in gaining the support of smart grid developments. Such schemes are also vital in developing robust business models that are adapted to the circumstances of individual markets.

- The need for public awareness and support is vital if the necessary changes to energy use and consumption are to be achieved. Greater efforts are required to educate the public of the long-term benefits enabled by a smart energy infrastructure.

- The variable output of many renewable energy sources is likely to increase peak power demand. The smart grid is an essential means of balancing supply and demand and enabling the development of a low carbon economy.

9 Glossary

Biofuels Fuels made from organic material including wood chip and biogas from animal waste, but principally used to describe biodiesel or ethanol made from crops such as sugarcane, rapeseed or corn.

Biomass Constituting the raw material of biofuels, biomass includes managed woodland and agricultural crops. It has the benefit of removing carbon from the atmosphere as it grows but can compete for land and resources with food crops, driving up food prices.

Carbon Capture Rather than releasing CO2 into the atmosphere when burning fossil fuels, carbon capture schemes aim to store it in natural underground containers such as depleted oil and gas fields. The IEA estimates that 3,400 carbon capture and storage facilities will be required by 2050 to meet climate targets.

Carbon Neutral A process can be said to be carbon neutral through the offsetting of unavoidable carbon emissions such that emissions for the entire process are equal to zero. This process is dependent on transparent and rigorous measurement.

Cyber Crime Illegal activities undertaken for financial gain which exploit vulnerabilities in the use of the internet and other electronic systems.

Electric Vehicles Hybrid petrol-electric vehicles represent a transitional technology towards fully electric transport powered by electric or traction motors.

Load Shifting A principal demand-side management goal, load shifting seeks to transfer demand for energy away from peak usage periods to off-peak periods.

Low Carbon Technologies Technologies that cut the demand for energy, and technologies that enable the exploitation of sources of energy with no or low carbon emissions.

Megawatt The megawatt is equal to one million (106) watts.

Peak Demand The period of greatest demand on an energy system. This period is often short lived and can be mitigated by only small alterations to consumer energy usage patterns.

Renewable Energy (renewables) This refers to new renewables such as wind, solar, wave, tidal, geothermal, biomass and hydroelectric power. 16% of world energy consumption comes from traditional renewable biomass (e.g. wood).

Smart Grid Intelligent electrical grid which can predict and respond to the behaviour and actions of all electric power users connected to it – suppliers, consumers and those that do both.

Smart Meters Designed to provide customers with real time information on energy consumption, smart meters have a considerable range of specifications. The key differentiator is whether the meter has data storage and two-way communications capabilities.

Solar Energy Solar powered electrical generation includes the use of use of photovoltaic panels and solar thermal collectors to harness energy from the sun.

Wind Energy Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power

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