Germany's Energy Concept

Road Map for the Renewable Age

The German Federal Government’s “Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply” promises to transform energy supply - and provides a road map to a truly genuine “renewable age.”

In doing so, it will further consolidate Germany’s role as a major energy exchange partner in Europe. Officially launched in fall 2010, Germany’s "Energy Concept" is a long-term energy strategy for the period up to 2050. The aims of the plan are ambitious in their sweep but simple in their intent: the securing of a reliable, economically viable and environmentally sound energy supply to make Germany one of the most energy-efficient and green economies in the world. The pressing challenge of sustainable energy provision is one born of long-term global trends and harsh energy truths.

Transforming this energy vision into a renewable energy age reality is one of the greatest challenges of the 21st century, with global demand for energy expected to lead to a dramatic increase in energy prices in the medium to long term. As a result, dependence on energy imports will also increase significantly. This in turn will lead to increased greenhouse gas emissions - the current energy mix accounting for 80 percent of all emissions at present.

The defining activity areas of the Energy Concept set out the establishment of renewable energies as a cornerstone of future energy supply; energy efficiency; the creation of an efficient grid infrastructure for electricity and integration of renewable energy sources; energy upgrades for buildings and energy efficient new buildings; and the country’s mobility challenge (one million electric vehicles on the road by 2020 and six million by 2030). As such, the Energy Concept represents a market-driven, technology-neutral framework transforming energy supply.

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Creating a Renewable Energy-based Supply Structure

Central to Germany’s Energy Concept is the need to transform the existing centralized, load-optimized system to a decentralized, intelligent load and supply-oriented energy supply structure.

Renewable energy sources are privileged within the legislative framework of the Renewable Energy Act (2000) and the Combined Heat and Power Act (2000). Reliability of supply, fair pricing and protection of the environment are the three pillars underpinning the Renewable Energy Act. Power grid owners are obliged to access energy from suppliers producing from renewable sources and to purchase at specified minimum rates.
Storage Operators and Services in Energy Grids

<table>
<thead>
<tr>
<th>Power Storage</th>
<th>Daily Storage</th>
<th>Long-term Storage</th>
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- Own Consumption
- Island System/Off Grid

Decentralized Storage
- Balancing Energy Grid stabilization
- Peak load sharing
- Balancing Energy Peak load shaving
- Prevention of Distribution Grid Expansion
- Price Arbitrage
- Island System/Off Grid Backup/UPS

Centralized Storage
- Balancing Energy Grid stabilization
- Offset Daily Variations
- Prevention of Distribution Grid Expansion
- Offset Seasonal Variations
- Island System/Off Grid

Source: Clustered

Storage operations and services in energy grids | © GTAI

Electricity Supply - The Importance of Renewable Energy Resources
The shape and nature of future electricity supply is a matter of major global importance. Germany has been quick to take the lead in addressing the challenges of long-term sustainable energy supply, with the country’s Energy Concept representing a market-driven, technology-neutral framework which will transform energy supply.

Energy storage technologies which effectively manage energy surpluses - and renewable energy surpluses in particular - are accordingly a major priority on the global energy agenda. Alone in Germany, the share of renewable energy and natural gas resources used in electricity generation has increased significantly over the past decade. Wind-produced energy already outperforms nuclear power in terms of installed capacity.
Energy Source Share in Gross Electricity Generation (2011)

- **Wind Power**: 8%
- **Nuclear Power**: 18%
- **Hydro-electricity, Biomass & other RE**: 12%
- **Oil, Pumped Storage**: 3%
- **Natural Gas**: 14%
- **Lignite**: 26%
- **Hard Coal**: 19%

Total: 612 TWh

Source: BMU 2011, BDEW 2012

Energy source share in gross electricity generation (2011) | © GTAI

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The German electricity market is Europe’s largest, with annual power consumption of around 530 TWh and a generation capacity of 184 GW.

Transmission system operators (TSOs) keep control power available to maintain stable and reliable supply. Demand for control energy is created when the sum of power generated varies from the actual load (due to unforeseeable weather fluctuations in the case of renewable energies).

Primary control, secondary control, and tertiary control reserve are procured by the respective TSOs within a non-discriminatory control power market (www.regelleistung.net) in accordance with the requirements of the Federal Cartel Office.

Procurement takes place in a competitive tender bidding basis within the German control power market in which a significant number of suppliers participate. Smaller suppliers are also able to participate in calls for tender by a pooling process. Almost 90 percent of all power generating plants capable of providing control energy are eligible for participation at the TSOs.

<table>
<thead>
<tr>
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<th>Primary control reserve (PCR)</th>
<th>Secondary control reserve (SCR)</th>
<th>Tertiary control reserve (TCR)</th>
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<tbody>
<tr>
<td>Time for activation</td>
<td>30 s</td>
<td>5 min</td>
<td>15 min</td>
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<tr>
<td>Availability</td>
<td>Up to 15 min</td>
<td>15 min to 1 hr</td>
<td>Minimum of 15 min</td>
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<td>Previously required min.</td>
<td>5 MW</td>
<td>10 MW</td>
<td>15 MW</td>
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<td>bids by regulator</td>
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<tr>
<td>Newly required min. bids</td>
<td>1 MW</td>
<td>5 MW</td>
<td>5 MW (10 MW**)</td>
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<td>by regulator*</td>
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<tr>
<td>Tendering period</td>
<td>monthly</td>
<td>daily</td>
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<tr>
<td>Tendering period (as of</td>
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<td>April 13, 2012*)</td>
<td>weekly</td>
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<tr>
<td>Focus on new technologies</td>
<td>Flexible/controllable plants,</td>
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<td></td>
<td>battery storage systems,</td>
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<td>direct marketing</td>
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Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

*Changes occurred in April 2011 for PCR ands SCR and october for TCR
**As transition bid amount before definitive reduction to 5 MW
Electricity is delivered to the end-consumer through the high and extra-high voltage grid system. Power is further distributed through lower level grids, with transformer stations used to transform electricity voltage levels. Major expansion of the high-voltage systems is required to meet Germany’s ambitious 2020 energy goals (see Network Development Plan).

**European Union Electricity Directives**

In the late 1990s, Europe adopted a number of directives created to open up EU member state domestic electricity and natural gas markets. European power markets were transformed in 1996 following the European Union (EU) Electricity Directive (subsequently replaced by successive directives in 2003 and 2009 further safeguarding principles of a level power-generation playing field, non-discriminatory transmission and distribution charges and third-party network access rights) enshrining the principles of an internal energy market and customer choice.

**Domestic Energy Market Liberalization - Energy Industry Act**

Germany’s domestic electricity market was fully liberalized in 1998 (Energy Industry Act). Prior to liberalization, a defined supply area was typically served by a single supplier (e.g. local utility) operating in near-monopolistic market conditions.

Today, the German energy market is a healthy market place with enough room for four vertically integrated suppliers – Amprion (formerly RWE), EnBW Transportnetze, TenneT TSO (formerly E.ON), and 50Hertz Transmission (formerly Vattenfall Europe) - who supply approximately half of the market, and a thriving regional and municipal supplier market with both distribution and retail assets. A single-price settlement scheme with quarter-hour settlement periods is implemented in the four control areas supplied by the four main suppliers, with the European Energy Exchange (EEX) acting as a common point of reference for domestic electricity prices.

More than one thousand market participants are active in the fully liberalized German electricity market, with new market actors – who do not own power plants or supplier networks - successfully entering the domestic electricity market.

**Federal Network Agency**

The creation of the Bundesnetzagentur ("Federal Network Agency") regulatory office for electricity, gas, telecommunications, post, and railway markets in 1998 further opened up the power market, thanks to the introduction of a raft of measures promoting competition including legal unbundling for suppliers with more than 100 thousand customers. The agency is responsible for ensuring non-discriminatory third party access to power networks and control fees charged by Germany’s TSOs.
German electricity market value chain | © GTAI

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E-Energy stands for "smart grids made in Germany." Smart grids are the key enabling technology for sustainable economic development and the long-term solution to energy and climate problems. Germany already enjoys an international reputation as a pioneering force in this field thanks to its "E-Energy: ICT-based energy system of the future" project (first initiated in 2007). The "E-Energy Network" uses predictive systems to forecast power consumption and generation levels according to weather conditions. ICT gateways at domestic and industry points-of-use and energy producer control systems receive pricing information based on these forecasts. The E-Energy Network allows a revolutionary new ICT-based "energy marketplace" to be created; one where consumers play a more active role as producers of self-generated electricity and electricity is no longer simply traded but instead transferred according to a new usage model (i.e. "allow delayed switch on," "feed into grid in event of demand peaks," and "use only in event of sunshine and/or high winds."). E-Energy is also a key element in Germany’s National Electromobility Development Plan. This is because E-Energy creates a foundation for the intelligent integration of electric vehicles into the smart power supply grids of the future. Within the new E-Energy marketplace, producers and consumers alike are rewarded for their contribution to the securing of a cost-effective and environmentally friendly source of electricity provision.

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In Germany, smart grid activities are promoted within the "E-Energy: ICT-based energy system of the future" funding initiative of the Federal Ministry of Economic Affairs and Energy (BMWi) in partnership with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The initiative exists to develop new schemes for digital networking and intelligent electricity supply control to provide smart electricity production, grid, storage and consumption solutions while simultaneously advancing the integration of renewable energies into the supply chain.

Since December 2008, six competition-winning model region consortiums have been conducting and developing smart energy R&D projects as part of the country’s wider “Germany: Green IT Pioneer Action Plan” to promote the research, development and use of resource-efficient ICT products and services. Sixty million euros in R&D funding has been made available to the six technology model projects by the BMWi within the framework of a partnership with the BMU. The partner regions are contributing a further EUR 80 million to the activities.

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Six model regions were identified as winners of the national beacon "E-Energy: ICT-based energy system of the future" project. For the first time, exemplary "energy internet" projects will be set up across the country. The four-year project acts as a test-bed for the creation of a genuinely smart power system in which all actors and processes are intelligently linked.

From the beacon into the regions: The six pilot regions (on the left) and the other finalists (on the right) in the E-Energy technology competition are developing solutions for the ICT-based energy system of the future.

Germany’s E-Energy Model Projects
eTelligence

The eTelligence project in and around the northern port of Cuxhaven is testing an idea for a smart grid in a rural area with a high share of renewable power generation from sources such as wind power. A consortium led by power company EWE AG is developing a marketplace for energy that balances out fluctuations in wind energy generation and brings together producers, energy users and network operators.

Even private households can sell electricity by using plug-and-play appliances that operate automatically in the market. Cuxhaven is a fishing port and the new power system being tested takes advantage of its many cold storage houses. Their energy needs are balanced out with the requirements of the town’s swimming pools, for example, in a way that enhances efficiency and ensures a steady power supply from wind, biogas, solar and combined heat and power plants.

E-DeMa

In the western Rhine-Ruhr area, the E-DeMa project is testing a smart grid in a region that has both rural and urban areas and therefore poses particular technological challenges for efficient power generation. E-DeMa wants to turn the electricity consumer into a “prosumer” - a client who both produces and consumes power.

The consortium includes RWE Energy AG and Siemens AG and is developing an intelligent power consumption control system which ensures the real-time collection and provision of consumption data. The project also aims to optimize network operation management in decentralized distribution networks. It will allow consumers to regulate their energy consumption from their living rooms based on real-time information on when peak periods are over and the price of power is at its lowest.

MeRegio

The third model region is located in the state of Baden-Württemberg. The vision of the MeRegio project is to create a minimum emission region. In the MeRegio model house, the dishwasher switches itself on when power is cheap, and electricity is generated through solar panels on the roof or a combined heat and power (CHP) plant in the basement.

The household appliances are interlinked via communication technology and connected to a smart system platform. Smart mobility also comes into play. The electric vehicle is parked in the garage and its battery is charged when the mini-CHP produces more electricity than the grid can take. If necessary, the electricity from the battery can also be fed into the grid.

Since November 2009 some 100 private households have joined the project to help build up the smart grid system, electronically providing information on their everyday energy usage to the local network operator to help develop a low-emission, maximum efficiency power grid.

Model City of Mannheim

The Model City Mannheim project is testing a smart grid system that is suitable for a conurbation and which makes heavy use of decentralized renewable power sources. The cities of Mannheim and Dresden are taking
part in a large-scale trial using new methods to improve energy efficiency, grid quality, and the integration of renewable and decentralized sources of energy into the urban distribution network.

Electricity is offered to customers close to the point of generation and immediately when the power is generated. This avoids having to transport power (a process in which power is lost), and includes the use of decentralized energy storage units. So-called "prosumers" can adjust their power consumption and power generation in line with variable pricing structures. And real-time information and energy management help the customer contribute to even greater energy efficiency.

**RegModHarz**

RegModHarz (short for "regenerative model region of Harz"), is developing a "virtual power station" grouping renewable power generators, consumers and energy storage facilities. By coordinating production, storage and consumption, the project aims to prove that it is possible to achieve stable, reliable and consumer-oriented electrical power from a high proportion of renewable sources.

**SmartWatts**

The sixth project, SmartWatts, is located in the western city of Aachen where companies are developing an intelligent grid based on the concept of a smart kilowatt hour in which participating households can see where the electricity was produced, how it was transported, and how much the power currently costs. The aim is to develop a system in which household appliances primarily consume renewable electricity when it is available at low cost (for example, in strong wind or sunshine).

The projects are attracting interest outside Germany. In July 2010, representatives of the SmartWatts project signed a memorandum of understanding with LG Electronics in Seoul. LG Electronics will contribute servers and other hardware to integrate any brand of household appliance into the smart grid via the open EEBus system developed by SmartWatts to enable power companies and customers to exchange power usage information.

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6th Energy Research Programme

The programme sets out the key focal points of German energy funding policy for the period 2011 to 2014. Energy R&D funding in the region of EUR 3.4 billion will be made available, with particular emphasis placed on two areas of major strategic importance: energy efficiency and renewable energies. Foremost among the research focal points are energy storage solutions and grid technology, as well as the integration of renewable energy into the power supply.
A significant renewable energy surplus is widely forecast for 2020; rising from an estimated 3.5-8 TWh for the period 2025-2030 to 40 TWh for the period 2040-2050.

Renewable energy sources like wind and solar provide a number of answers to the sustainable energy questions being asked in a changing energy landscape, but they also bring their own questions: What energy storage solutions exist for the stockpiling of surplus renewable energy? How can surplus renewable energy - which currently goes unused - be best stored for future use? And more importantly, which energy storage technology has sufficient capacity to store excess renewable energy in the long term?

In May 2011, Germany announced plans to formally phase out nuclear energy by 2022. But it’s not only nuclear power plants which are being decommissioned; old and inefficient conventional power plants are also being swapped out for more efficient and flexible power.

This trend is further underpinned by Germany’s decision to achieve 25 percent electricity production from combined heat and power (CHP) sources by 2020. The use of gas for heat and electricity production will play an extremely important role in achieving this CHP target. The German gas industry has already made a commitment to replace 10 percent of commercial gas volume with renewable gas by 2030, with hydrogen - or methane after methanation - from wind electrolysis being one of the substitute sources.
**Energy Storage Model Projects and Promotion**

A number of support activities to promote energy storage technology development exist in Germany. These are aligned according to energy storage technology and area of application.

For example, a number of initiatives, partnerships and organizations to promote hydrogen and fuel cell technology solutions have been set up within the framework of the National Hydrogen and Fuel Cell Technology Innovation Programme.

**Clean Energy Partnership**

Consisting of a consortium of industry partners, the CEP is Europe’s largest demonstration project for hydrogen mobility. The German Federal Government has made EUR 200 million R&D funding available, complemented by a further EUR 500 million for the demonstration of hydrogen and fuel cell technologies in traffic and transport, stationary supply, and special market scenarios. Industry has made a commitment to match government funding, meaning that EUR 1.4 billion will have been invested in hydrogen and fuel cell technology by 2016.

**National Hydrogen and Fuel Cell Technology Innovation Programme**

The National Hydrogen and Fuel Cell Technology Innovation Programme provides a common framework for a number of hydrogen and fuel cell research projects conducted by academic institutions and industry. Funding of EUR 700 million makes this the biggest R&D and implementation initiative of its kind in Europe. The German Federal Government has set aside a total budget of EUR 1 billion for hydrogen and fuel cell technology research, development and demonstration projects. The public-private partnership (PPP) is scheduled to run for 10 years.

**National Organization for Hydrogen and Fuel Cell Technology (NOW)**

Germany is Europe’s leading nation in the field of hydrogen and fuel cell technology. In 2008, the National Organization for Hydrogen and Fuel Cell Technology (NOW) was set up to promote the development and commercialization of internationally competitive hydrogen and fuel cell technology products.

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The Federal Ministries of Economics and Technology, for the Environment, Nature Conservation and Nuclear Safety, and of Education and Research have launched a joint initiative to promote research and development in the field of energy storage technologies. Part of the 6th Energy Research Programme, the Energy Storage Funding Initiative will make EUR 200 million available to research projects to develop a broad range of storage technologies for electricity, heat and other forms of energy. A first project selection phase has already taken place. A second selection round is scheduled for 2012.
The Federal Ministry of Economic Affairs and Energy (BMWi), the Environment, Nature Conservation and Nuclear Safety (BMU), and Education and Research (BMBF) have launched 60 energy storage initiative beacon projects.

As well as the beacon 'power-to-gas' (which brings together projects concerned with generating hydrogen or methane from surplus wind power) and "batteries in distribution grids" (coupling battery storage with decentralized renewable energy systems) projects, research project areas include energy system analysis and thermal energy storage.

Research groups at five German universities will also receive funding in order to safeguard long-term, sustainable academic and scientific know-how for the energy system of the future. The different research groups will conduct interdisciplinary research in a number of energy storage technology areas.

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