Smart grid network concepts

The vision of future electricity networks

At a glance

Smart grids are the basis for developing future transmission and distribution networks as highly flexible, reliable and sustainable systems. Siemens Power Technologies International (Siemens PTI) develops optimal network structures and smart grid concepts considering:

- integration of renewable energy sources
- application of innovative technologies, e.g. energy storage devices, power electronics, electric vehicles (EVs), etc.
- use of communication technologies to improve observability and controllability of the networks
- development of intelligent applications, protection and automation concepts
- high security of supply and overall appropriate network performance
- design of new network structures, e.g. microgrids, DC networks, overlay transmission grids

The challenge

Electrical distribution networks will change more rapidly in the near future than ever before. Environmental awareness in the public drives changes in electrical generation towards the increased utilization of renewable energy sources. Additionally, network development and operation have to consider the existing regulatory frameworks.

Due to developments in energy generation and consumption, today's standard network structures are not sufficient to provide state-of-the-art security of supply under increasing cost pressure. New requirements for the future distribution networks will derive. The networks have to be transformed into more intelligent grids to ensure technically appropriate and economically efficient operational performance.

Smart grids benefit from a large number of new technologies, such as power electronics, communication, energy storage, smart metering, electromobility, etc. Their possibilities can be taken advantage of in operating future distribution networks and in forming a smart grid.

Our solution

The drivers for changes in supply systems (see Figure 1) – together with new concepts for network equipment, planning and operation – motivate the transition of today's networks into smart grids. Increasing the power system's capabilities for communication, control and automation are key prerequisites for meeting the upcoming requirements.

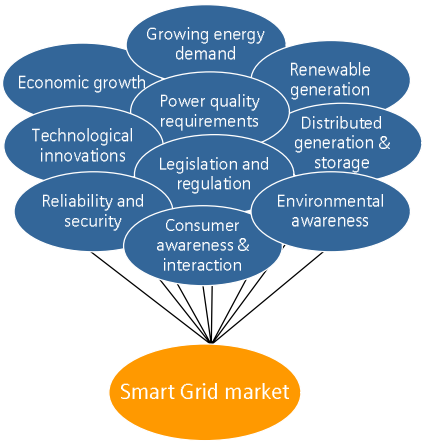

Figure 1: Main smart grid drivers

Siemens PTI has long-term experience in planning and operation of various networks and offers high-quality consultancy services and tools based on proven knowledge and expertise. Siemens PTI provides dedicated design of smart grid structures (Figure 2) and detailed analysis of their system performance, which will become important tasks for network operators in the future.

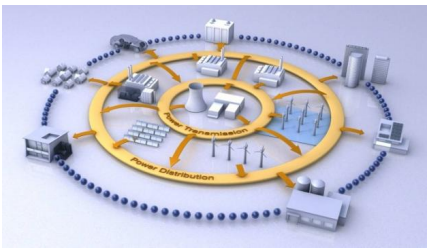

Figure 2: The vision of the smart grid

- assessment of the expected requirements and selection of suitable key performance indicators (KPIs)
- definition of detailed targets that should be addressed and the respective performance that is required
- specifications of components and their standard ratings

With the focus on the system as a whole, Siemens PTI ensures that the developed network concept and system architecture meets all technical as well as economical and environmental requirements – while addressing electricity networks and other systems like gas, heating, water, etc.

Thus smart grid design creates an integrated solution with a physical layer of network components as the basis and adds communication and the most important application layers, as shown in Figure 3.

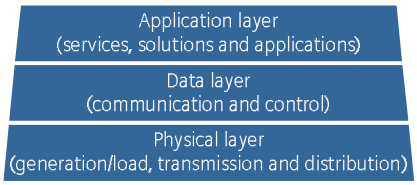

Figure 3: Layers of a smart grid

It is important not only to create an optimal structure for the electrical network, but to also develop a solution taking into account state-of-the-art electrical components like renewable generation, intelligent protection system, information and communication technologies (ICT), energy management systems and energy automation, demand site management and smart metering, and further innovations in intelligent household appliances, smart building technologies, electrical public transport, water and waste treatment.

To analyze the future grids, new methods and power system planning and simulation tools were developed based on the PSS® Product Suite. The following calculation methods are used in smart grid studies to ensure a feasible, integrated solution:

- probabilistic power flow and reliability calculations
- harmonic analysis considering power electronics, EVs, photovoltaic (PV) generation, etc.
- dynamic behavior during normal operation and in island mode
- protection simulations to ensure safety and security of supply

The transition from today's system into the future smart grid is supported by the elaboration of phased modification plans. In several projects, adequate roadmaps have been developed to transform the current network step-by-step into an optimal and intelligent network concept. Also, urban development projects created exemplary models for new developments and sustainable living.

Application Example

As an example for a future urban grid, the vision of Masdar City is to build a new development for 100,000 inhabitants and commuters on a desert near the city of Abu Dhabi, which uses 100-percent renewable energy and is CO_2 neutral. The key objectives are sustainability and the integration of the most innovative technologies regarding energy generation, distribution and consumption.

To achieve CO_2 neutrality on an area of about 3 km by 3 km, renewable energy sources are used. For example, most buildings are equipped with PV generation. Additionally, the possibility of reducing consumption by increasing efficiency and by load management will be applied. In this way, the total peak load compared to the typical values in this area can be reduced by the factor of three. To achieve this, most recent technologies and equipment have to be merged into one system.

Initial plans for the electrical network were designed based on standard guidelines for distribution systems – not suitable to account for Masdar's special needs. Therefore, Siemens PTI developed and proposed a focused and innovative network concept for Masdar City, which considers the unique possibilities of the complete system.

A major challenge was not only to create an optimal structure for the electrical network, but also to achieve the main targets of Masdar:

- CO_2 neutral energy supply and ensuring high sustainability levels
- integration of renewable energy sources
- design of an energy management system
- integration of electromobility

Published by
Siemens AG 2016

Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact
power-technologies.energy@siemens.com