Decentralized electrification

Fact sheet for innovation fields

- The nations of the world agreed on an ambitious global environmental agreement at the UN Climate Change Conference in Paris. To limit global warming to less than 2 degrees Celsius, net greenhouse-gas emissions around the world are to be reduced to zero by the end of the century. The aim is to cut the use of fossil fuels to the greatest extent possible. As far as generation of electricity goes, "green" power produced by renewable energies will be the most important tool used in this process, particularly in light of the increased use of electricity that will be seen in many sectors, above all individual mobility (electromobility).
- These new global conditions will create challenges and opportunities for Siemens: Traditional business fields must be bolstered and new markets tapped. To do this, Siemens has developed an energy-transition strategy called "Energiewende 2.0." The name underscores the fact that the restructuring of the German electricity sector can represent only an initial step. Furthermore, there is not just "the" one energy transition occurring in Germany. Rather, many individual energy transformations will have to take place around the world if the climate goal is to be reached.
- The **decentralized electrification innovation field** involves fundamental structural change in the areas of electricity generation, supply and distribution. These changes will be performed by a large number of market players, ranging from major corporations and grid operators to regional alliances and private micro units, that will take the place of a few large central units. More and more renewable energy will be produced centrally and on a decentralized basis, a development that will continuously drive down the price of such power. At the same time, digital applications and services will affect all levels of the electrical system on a step-by-step basis. "Smart" converters working with advanced power electronics and digital technologies will increasingly be added to passive grid components such as switches and transformers.
- The hot spots of the decentralized electrification innovation field are located in the United States, South Korea and Germany. Approximately 200 start-ups funded by venture capital are currently working in this area.
- To optimize the entire system, Siemens experts are exploring future energy systems as part of a research project called "Energy System Development Plan" (ESDP). In this comprehensive study, experts are simulating how an increased level of renewable energies will impact not only power generation and transmission, but also distribution and the market as a whole over the long term.
- The trend involving electrified and multimodal grids is unmistakable: In the future, the number of power electronic converters used in the energy supply system will rise steeply. Converters will play an increasingly important role in such areas as grid storage, photovoltaic systems and pumps. Because individual energy systems for electricity, heating and air-conditioning, gas, and mobility are increasingly evolving into multimodal systems, researchers are hunting for ways that will enable different energy sources to interact in these systems. A key role will be played by small and medium-sized power plants that will be operated on a decentralized basis.

- Siemens is also focusing on the development of new chemical storage solutions that will help ensure supply stability in the future. As power generation becomes more volatile as a result of renewable sources and as the percentage of these sources in overall power usage rises, solutions able to facilitate local storage of electrical power and assure system stability will become increasingly important.
- In the future, Siemens will focus not only on research in this area, but also on partnerships with start-ups as a way of finding even more disruptive ideas and of being able to react more quickly. The following application areas will be particular focal points of Siemens' new start-up unit:
  - Energy-trading platforms and services for producers and consumers
  - Swarm platforms used to store and distribute renewable energy and their associated services
  - Energy-efficiency services
  - Innovative battery and storage solutions such as redox flow and electrical and thermal storage
  - Power-to-gas technologies
  - Software solutions used to manage smart grids

Setting the stage for improved energy efficiency and flexible demand

- Creating technologies that improve energy efficiency and support flexible energy demand are the order of the day. In many industrial countries, electricity rates only move in one direction: up. As a result, industry is looking for ways to save energy. It is relatively easy to ferret out inefficiencies and/or avoid expensive peak loads using demand monitoring systems and automatic usage controls. Siemens' technology has, on occasion, dramatically lowered companies' use of power – from the makers of garden tools to supermarket chains and breweries. But there is much more potential waiting to be tapped. By 2020, the use of primary energy to make products and deliver services is expected to fall further, and energy productivity is expected to double in comparison to 1990 levels in Germany. Private users of electricity are also trying to control costs. Apps that help them find the low rates and track down heavy users of electricity – all of these technologies are currently being used and offer tremendous potential for new applications. New approaches are particularly needed in places with high electricity rates, including islands that have very small grids or no grid supply system at all.

Battery solutions for "green" power

- Innovative battery solutions have the most promising opportunities. They are a key component of the energy transition because they help spread "green power" in many different ways. First, batteries help ensure that sufficient stored power is available in a grid to offset production and load fluctuations. In addition, companies and homeowners can install batteries that, when combined with integrated management software, make it possible to completely or partially rely on power that they produce themselves. And, finally, batteries bring "green power" to places that have no sockets, such as electric cars – systems that interact with the power grid when these batteries are charged. Siemens researchers are focusing on improving battery technology, linking batteries to smart grids and automatically managing this complex network.
- New storage technologies are needed, just as are technologies to quickly charge batteries, as well as mobile battery solutions.
- Many new application scenarios are possible. Batteries will be key players in the spread of electromobility. They will also be increasingly used in ships, which will more frequently be powered by electric or hybrid drive systems. Siemens' partnership with the start-up Caterva illustrates how private consumers, energy-supply companies and other companies can form new alliances with the aim of working together for the benefit of all. Such players virtually combine batteries in home solar systems by

using radio technology and software to create a battery swarm that has enough capacity to bolster the power reserve of regional grids.

Power-to-gas and power-to-value options

- If renewable energies are to supply 80 percent of demand, energy systems will need to store massive amounts of electrical power to ensure grid stability. Much research still needs to be conducted in this area. Siemens scientists are already working to develop power-to-gas systems in which electrolysis is used to produce hydrogen from water. The energy required for this process is provided by excess renewable power produced by photovoltaic and wind power units. The hydrogen can then be used directly for other purposes or converted into methane with the help of carbon dioxide. In March 2015, Siemens and its partners put the world's largest electrolysis facility into operation at the Energy Park in Mainz, Germany.
- Many different types of storage systems are conceivable when power-to-gas is used as a core technology: combinations with photovoltaic, wind-power or biogas systems, with integrated hydrogen production as fuel for cars, and with combined heat and power plants that also can burn hydrogen.
- In a project called CO2toValue, Siemens researchers are working on chemical storage systems that have a number of strengths. Such systems are particularly well-suited for storing huge amounts of energy over long periods of time. They also use renewably produced power to convert carbon dioxide (CO_2) into valuable resources. Chemical bonds, so-called catalysts, charge inert CO_2 with energy-filled electrons. Through the selection of the catalyst and a change of current density or the concentration of dissolved salt in water, a number of end products can be produced, including carbon monoxide, ethylenes or alcohols, which are very valuable to industry. CO_2 can thus become an attractive resource. Siemens scientists have already successfully demonstrated this approach in the lab.