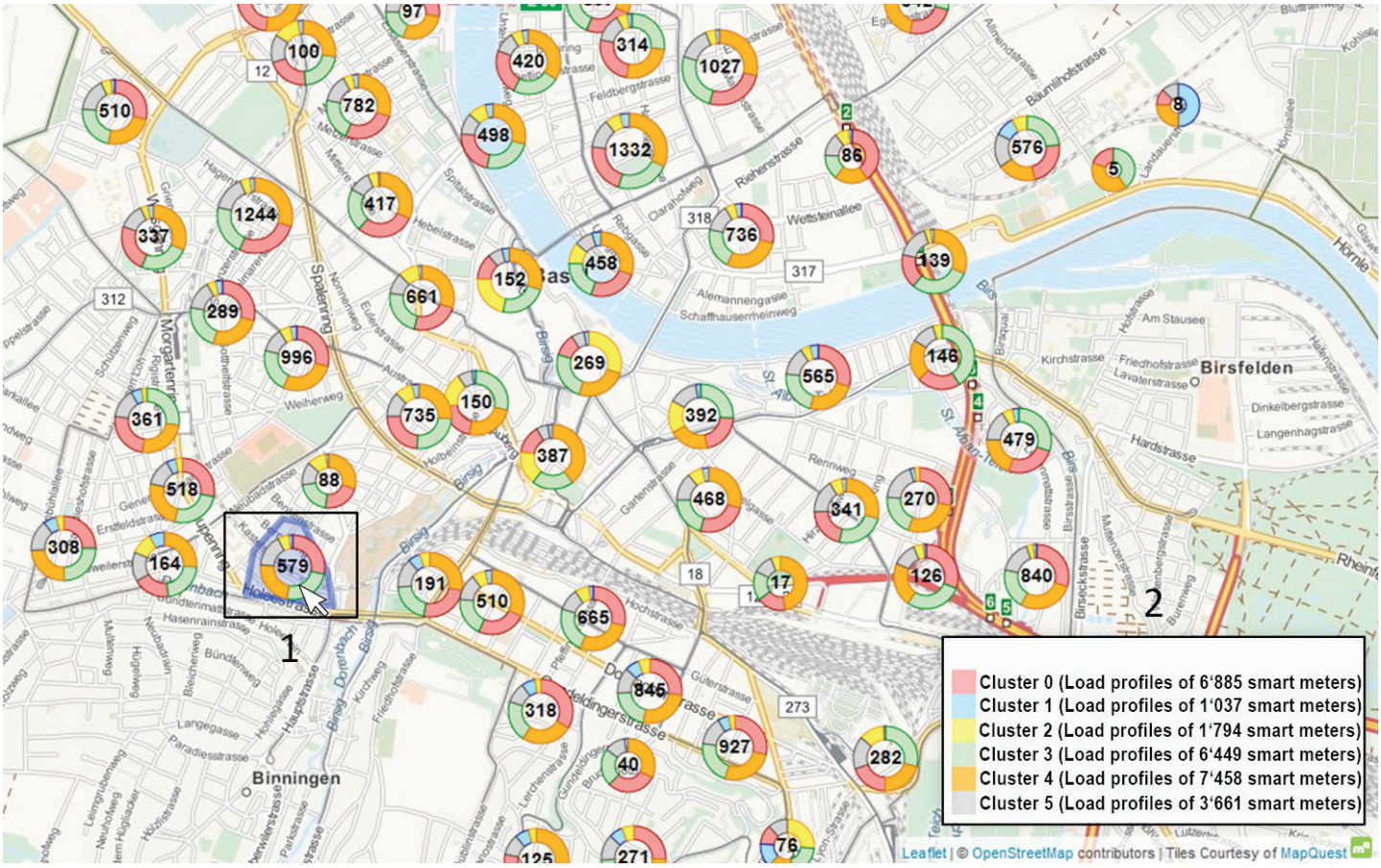
ELECTRICITY FLOW ON TRACK

In the past, power stations were satisfied if their distribution networks reached all customers and copper cable satisfied performance requirements. Today electricity suppliers want to know exactly what is going on in their extensive networks, especially to be able to integrate renewable energy safely. To understand this, one needs measurement infrastructure - and one needs simulations that can replicate the network and flow of electricity. The ETH spin-off Adaptricity specializes in the development of electricity distribution network simulation tools.



Smart Meters installed in the city of Basel enables Adaptricity with its software solution to organize data into clusters on the basis of similar load profiles (in this example, six clusters, each represented by a color), which can be formed according to various criteria. In the neighborhoods in the city of Basel, these six different load profile types are starkly represented (for example, the rectangle 1 around the Ring graphic denotes the Neubad-Quartier). If the Basel utility IWB knows what load profile type has the strongest presence in what quarters, it helps optimize the distribution network. Graphic: Adaptricity / processing B. Vogel

A technical report about the results of a SFOE flagship project and a research project in the field of grids, which were financially supported by the Swiss Federal Office of Energy. The report has been published in the technical magazine Bulletin SEV/VSE (issue September 2016).

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

Smart meters, as they today are often installed in homes and businesses, typically measure power consumption at 15-minute intervals and forward the measured values to the local power company. Power companies use this data from 'smart' electricity meters to generate electricity bills. Utility companies can also optimize the operation of their distribution networks using this data. Next to Arbon (TG), Basel belongs to one of the few regions today that are already equipped with a large area of smart meters. Erik Rummer, media spokesman of the Basel energy provider IWB, sees advantages for customers and power utilities: "We must call customers who still have an old electricity meter once a year to read the meter and send the meter values to us. Customers with a smart meter are spared this effort," says Rummer, adding: "We as utility providers make smart meters so that we can get a better view of the future network situation."

Network Analysis with Smart Meter Data

Smart meters promise electricity customers and utility companies added value. How exactly the use of smart meters provides benefits, however, has to date been only vaguely apparent. Today, many utility companies evaluate how they could use smart meter data for the operation of the electricity distribution network. As part of a joint pilot project with the Zurich company IWB, Adaptricity analyzed records to learn more about the exact load curve in electricity distribution networks. To protect customer privacy, the data was blinded so that it could not be associated with any specific customer. The pilot thus meets the requirements of data protection and does not allow conclusions about the behavior of individual customers to be made. The project is more concerned with getting detailed information about the workload of the distribution network. "Based on smart meter data, we want to provide analyses of the distribution network," says Dr. Stephan Koch, the 35 year-old co-founder of Adaptricity, a spin-off of ETH Zurich.

Adaptricity has developed machine learning algorithms that can organize the records of smart meters according to such features as similar characteristics of electricity consumption ('load profiles'). In a second step, the requirements for the distribution network (for example, technical requirements of a transformer station) are derived from a group of load profiles (for example, from a neighborhood). Utility companies hope the results will deliver insights that would be of interest for the operation of the distribution network, because the utility provider could better understand the amount of electricity required at specific times and locations in the network.

The founding team of Adaptricity (f.l.t.r.): Stephan Koch, Andreas Ulbig and Francesco Ferrucci. Photo: Adaptricity

By comparing these data with other publicly available databases, such as the building database of the Swiss Federal Office of Statistics, can the up to now only partial available data sets from smart meters be extrapolated to the whole city area. Based on such analyses, for example comparision with previous data, the energy supplier can create more precise and targeted consumption forecasts for the following day. "Predictions for the consumption along the entire distribution network have indeed long been possible," says Stephan Koch, "but thanks to our simulation, such predictions are now possible at the level of the transformer station, so for an area of about 100 households." This forecast accuracy opens up interesting new options for electricity suppliers, Koch is convinced. Network operations, expansion and maintenance can be planned more accurately as well as the procurement of electrical energy in the electricity market, says Koch.

Holding Distribution Networks in Balance

Stephan Koch studied Control Engineering in Stuttgart. For his doctoral thesis, he moved to the laboratory for Electrical Energy Transmission and High Voltage Technology at ETH Zurich. There he developed along with his two colleagues Dr. Andreas Ulbig and Dr. Francesco Ferrucci, the simulation software. The three researchers founded the spin-off Adaptricity in early 2014. The company now consists of a team of 15 software developers and sales professionals (mostly part-time). In the near future, Adaptricity will provide distribution network operators comprehensive IT-based decision support for network planning and management. In addition, the products shall help network operators to demonstrate the need for expansion measures toward regulatory organizations. Commercial success for Adaptricity is yet around the corner. Currently, the company is financed by cooperation projects with ETH Zurich and other research partners. In order

to succeed in the market, management has recently transformed the company into a stock company and is currently looking for an investor to finance its growth.

The Zurich start-up company is the byproduct of a changing energy market. The expansion of decentralized power generation, with photovoltaic (PV) systems for example, presents the operators of distribution networks with new challenges. They must ensure that the decentralized input does not bring the networks out of equilibrium. The strenthening – or the expansion - of the network is only one option. Network congestion can be avoided by temporary downward regulation of solar power or wind power plants on the production side. On the part of consumers, electricity consumption can be postponed (Demand Side Management or Demand Response). The construction of decentralized power batteries or adaptations of the network infrastructure (variable local network transformer, reactive power control for example) can remedy the situation. "Even if the regulator currently accepts all options as an alternative to grid expansion, it is foreseeable that a well thought out combination of different SmartGrid technologies has significant cost advantages. The best solution for each distribution area must be decided separately. Our software helps network planners to make the right choice and if necessary to keep the network expansion as lean as possible," says Koch.

SmartGrid Takes a Reality Test

Adaptricity is testing an application of simulation software in the municipality Riedholz near Solothurn. In early 2016, 40 houses and apartments there in the supply area of AEK Energie AG were fitted with equipment to control heat pumps, electric boilers and charging stations so that the electricity distribution is always optimally utilized. The devices are based on the GridSense technology made by Alpiq AG –one of several SmartGrid technologies that are currently being tested in Switzerland in pilot projects (see journal article 'Augen im Stromnetz' under www.bfe.admin.ch/CT/strom). The project under the name SoloGrid was awarded flagship project status by the SFOE. Landis + Gyr contributed the measurement infrastructure to the 18-month project. The SFOE and the Canton of Solothurn provided financial support.

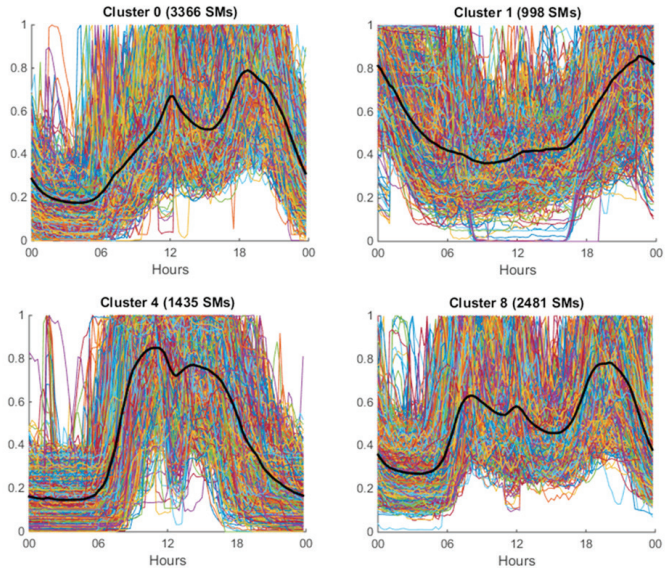
SoloGrid validates the GridSense technology for various operating situations of the distribution network and simulates a nationwide rollout of decentralized control units over large

One of 40 detached houses in Solothurn Riedholz that is part of a pilot project. Being tested is how loads of the distribution network can be optimized thanks to ‹smart› control of electrical devices. Photo: Alpiq InTec

distribution areas. Also, future scenarios will be modeled with a greater proportion of feed-in from decentralized power plants. "The project offers an interesting starting position because between the transformer station and the residential area is a relatively large distance of several hundred meters. This makes the network more vulnerable to stress problems by PV on the roofs of houses, as compared to when the distributed electricity generation is connected close to the transformer," says Koch. After a pilot application in Biel-Benken (BL) in an EBM-network with four houses, Solo Grid is the first major test run of the GridSense technology.

Automatic Distribution Network Planning

Load shifting over time is just one way to make electricity distribution fit for future challenges. Network planners must decide what concepts are best suited for a particular network area. But it is also possible that artificial intelligence and mathematical optimization may help make this decision easier. Towards this goal, Adaptricity is working on a project for the Commission for Technology and Innovation (CTI). The low-voltage grid of the electricity supplier of Canton of Zurich (EKZ) in Dietikon serves among other things as a study object. There researchers are examining how distribution network operators can handle the growing number of PV systems and the construction of parking garages for electric vehicles. By autumn 2016, the two-year CTI project would like to clarify what SmartGrid technologies could be employed in particular cases to avoid a network expansion. A tool to do that is an IT solution that supports optimized investment decisions in the distribution plan. In addition to CTI and Adaptricity, the com-



Each graphic shows the measured values of nearly 1,000 to some 3,000 smart meters. Thanks to the combination of smart meter data ('clustering') Adaptricity can successfully structure heterogeneous load profiles and analyze and extrapolate into the future. Graphic: Adaptricity

HOW THE ADAPTRICITY-SOFTWARE WORKS

The software DPG.sim (Distributed prosumer and Grid Simulation) of the company Adaptricity enables virtual simulation of power grids. The simulations typically refer to distribution networks that supply a single district or a small town with electricity.

Such simulations provide a tool with which the behavior of the simulated network can be understood. Different example scenarios can be worked out; it can, for example, show the effect of the supply from a photovoltaic system on each node. From the simulation can be derived how large energy storage devices (for example battery storage) must be to stabilize the grid. The simulations also create end customer models. This shows, for example, when a homeowner with a PV system must operate their heat pump in order to maximize their own consumption. The simulations are designed to integrate the data from smart meters (intelligent electricity meters).

Simulations of Adaptricity do not operate with real-time data—they rather use historical data or statistically generated data. The simulations replicate the distribution network, which supplies the individual consumers (houses, flats, businesses), but not the energy flows within a house, apartment or business. Herein, the software differs from other products such as Polysun that models the energy system of a single user, in other words the power supply and heating lines inside a house, including production and consumption equipment such as heat pumps or refrigerators. The Adaptricity software and Polysun therefore operate at different levels, but both simulations have encouraged each other (see also journal article 'Die richtige Batterie für Selbstversorger'under www.bfe.admin.ch/CT/strom). BV

pany Embotech, the technology transfer institution Inspire AG and ETH Zurich are involved in the project.

In electrcity circles, everyone is talking about the upgrade of distribution networks to SmartGrids. The next few years will show which business models will grow out of these discussions for innovative service providers like Adaptricity. Swiss distribution system operators will likely have more freedom to decide on a business model. This is because the Swiss distribution networks are robustly equipped and the development of decentralized energy will proceed less quickly than, for example, in certain regions of Germany. "Financial incentives to build a dynamic, streamlined network in Switzerland are not there because the cost (of grid expansion) normally can be tacked onto network fees. However, many network operators would like to build a slim network," says Koch. Nevertheless, Grid operators must prepare themselves because the next revision of the Electricity Supply Act (Stromversorgungsgesetz) could just bring the incentives mentioned by Koch. Also the company's buisiness model must be such that through the clever use of customer data in an increasingly digitalized network infrastructure, added value can be generated. "In this environment, Adaptricity is positioned as an innovative technology provider to accompany the electricity branch on their way to the digitalization," says Stephan Koch.

- For the **final report** for IWB project, please visit: https://www.aramis.admin.ch/Grunddaten/?ProjectID=35398
- Info on SFOE flagship project **SoloGrid**: www.sologrid.ch
- www.adaptricity.com
- **Information** on projects supported by the SFOE is given by Dr. Michael Moser (michael.moser[at]bfe.admin.ch), head of the SFOE-research program networks.
- For more **technical papers** on research, pilot, demonstration and flagship projects in networks, see www.bfe.admin.ch/CT/strom.

SFOE SUPPORTS PILOT, DEMONSTRATION AND FLAGSHIP PROJECTS

The SoloGrid project is one of the pilot, demonstration and flagship projects with which the Swiss Federal Office of Energy (SFOE) supports and drives the economical and rational use of energy and the use of renewable energy. The SFOE promotes pilot, demonstration and flagship projects with 40% of the eligible costs. Applications may be submitted any time.

- For further information:
  www.bfe.admin.ch/pilotdemonstration
  www.bfe.admin.ch/leuchtturmprogramm

Author: Dr. Benedikt Vogel, commissioned by the Swiss Federal Office of Energy (SFOE)
Version: October 2016