Smart buildings – protagonists of the smart grid

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The smart grid is the future of our power supply. Smart grids need smart buildings. Equipped with modern building automation, these buildings can be used as a counterbalance in the complex interplay between power generation and energy demand. The growing importance of user-generated energy and the different ways in which energy can be stored in buildings give consumers new optimization models. The following figure demonstrates the potential that this offers: Buildings consume 41 percent of the energy used globally – more than transportation or industry. This makes future-oriented energy concepts involving smart buildings very attractive for building operators.

Power grids of the future

More than half of the world's population lives and works in urban centers. In developed countries such as Germany, this figure is as much as three-quarters of the population. Power consumption in metropolitan areas is rising steadily. How can we make our power grids ready to meet this demand? How can we find a balance between power generation and consumption, especially since renewable energy sources are feeding more and more locally produced electricity into the grid in quantities that are hard to predict? And how can energy that is often produced remotely, such as large offshore wind farms, reach consumers?

While we could provide the necessary energy capacities by building new power plants and transport and distribution grids, this solution is not only expensive but it sometimes faces opposition from the affected residents. The smart grid concept offers a cost-efficient alternative, and can be implemented quickly. The goal is to manage existing structures intelligently and to upgrade them to meet the complex requirements. Buildings that are to have a fundamental role on the smart grid must be equipped with integrated building automation solutions that can communicate with each other and exchange information.

Smart buildings are flexible consumers

European energy providers supply electricity nearly continuously, 24/7, 365 days a year. Major blackouts are extremely rare in Europe. The smart buildings of the future will help secure the power supply on the smart grid.

Turning a conventional into a smart building requires a reliable forecast of future consumption. The consumption profile is compared with the energy availability profile, and early intervention is possible if deviations occur. The way in which building users are able to adapt their behavior to the energy available is crucial to the success of smart buildings. Unlike in the past when energy providers built costly backup reserves into the system, consumers must play an active role in any future-oriented energy concept.

Building users or operators play a central role in establishing a realistic consumption forecast since they are the only ones who are familiar with the processes in the building and know which energy-intensive processes can be reasonably delayed or moved up in time. This approach primarily focuses on thermal processes due to their inertia. One can allow a building to cool down to a certain temperature and then begin heating it again at the right time in order to maintain the comfort zone. This is implemented with the help of concrete core activation, for example, which utilizes the storage capacity of concrete. Buildings are preheated using inexpensive energy – at night, for example – in order to be prepared for the day.

Renewables generated both centrally and locally are the preferred form of energy for the smart grid. In addition, only the amount of conventional electricity actually needed is produced. In other words, consumers will balance out their power consumption according to the amount of energy available. To do this, they must know exactly when certain types of consumption occur and when they will not. Once this is clear, a smart grid can be implemented with the help of software and without significant investment. Security and comfort remain unaffected.

Estimating the best time to purchase electricity

Consumers on the smart grid will focus their attention on purchasing electricity right when a sufficient amount of energy is available. This is indicated by the price. When a lot of energy is available, the price is low – when energy is scarce, the price increases. Therefore, it may be a good idea to shift energy-intensive processes to a later time. For example, to heat an office so it reaches a comfortable temperature by 7:00 a.m., a conventional building automation system may begin heating or cooling the office one hour earlier. A “smart” solution, on the other hand, may begin heating or cooling hours ahead of time when the electricity rates are lower. On the whole, more energy would be purchased but at a better price.

The best time to purchase electricity is estimated using a purely software-based solution. Once this option is exhausted, the energy purchase may be further optimized with the help of properly dimensioned storage units, CHP plants, solar panels and the like. This is done without sacrificing building comfort and security. Even if energy prices will be differentiated to a greater extent in the future, a complex algorithm can map this differentiation and calculate the best price-performance purchasing profile.

Communication and coordination between consumption points and the grid are crucial. Many current smart grid pilot projects need to be significantly improved in this area. For example, some central management systems today switch off all heat pumps across the board during times of high power consumption in order to cap consumption peaks. If the pumps are then restarted all at once, consumption increases disproportionately due to the accumulated demand, which produces another unnecessary peak. However, if a smart building is organized based on an incentive concept, it can respond flexibly to stimulation and intelligently use the building as an overall system instead of involving only individual, predefined loads such as the heat pump. One thing is clear: Without knowing the processes in the building, uncoordinated external intervention always has a negative effect on comfort, security and efficiency.

Balance between comfort and security

Thanks to its demand response principle, a smart grid responds directly to specific grid situations and energy prices. A viable demand response concept also includes a security component that protects against blackouts. For this reason, the smart buildings of the future will also provide shutdown potential for emergencies. If an energy bottleneck occurs, heating or cooling systems, for example, could be shut down according to predefined priorities while the access control system remains operational. In this case, security takes priority over a temporary loss of comfort.

During normal operations, a smart compromise must be maintained between the need for comfort and security, for instance when switching entrance doors in office buildings or hotels. To minimize energy consumption in regulating the building climate in a hotel, the door should be opened as infrequently as possible from an energy management perspective. In terms of comfort and security, however, the door should remain open as much of the time as possible when a lot of hotel guests are going in and out in order to avoid bottlenecks. In an office building, on the other hand, the access control system would keep the door closed by default and open it only briefly to allow authorized persons to enter. These varying requirements must be weighed against each other and coordinated.

Consumers and producers under one roof

The more energy a building produces and stores on its own – for example, using photovoltaics – the better it can supply its own needs, making the total energy consumption all the more cost-efficient. This requires a smart energy management system that continuously ensures optimum operation. In this scenario, the building-generated energy, which is temporarily stored according to demand, facilitates the purchase of additional energy from the grid right when its price is low.

To optimize electricity consumption in the building, however, the building itself must first be optimized by reducing energy consumption and exploring how much flexibility the consumption will support. Once these requirements are met, the equipment needed for participating in the smart grid can be optimized, that is, scaled down.

Market incentives

Currently, variable prices on the energy market are not being passed on directly to the consumers. However, one thing is clear: Improving energy efficiency through the demand response principle and by integrating large central and small local generation units and consumers into the smart grid will require a new energy market segmentation. In extreme scenarios, today’s “classic” energy providers will no longer provide the basic load on the general grid but possibly only cover the peak loads.

They will act as a kind of emergency provider for buildings. We can expect the price of this emergency supply to be correspondingly high.

It will certainly be up to legislators to define the future conditions for resegmenting the market. Yet it is quite safe to assume that financing for peak loads will be allocated to the originators since they place a disproportionate burden on the entire power supply system. According to a 2009 peak study for the United States, a peak load of around one percent accounts for approximately ten percent of the cost of the necessary infrastructure.

Looking ahead

On the smart grid of the future, it is vital to view the participating smart buildings as autonomous, intelligent subsystems. Future solutions will aim at optimizing the entire chain of all power-generating and power-consuming components of a smart building, from the in-house power plant to individual lamps at the workplace. One important aspect is to develop better storage methods. Local photovoltaic systems, for example, should produce energy as continuously as possible from a management perspective. Instead of the batteries that are commonly used today, it would be conceivable to temporarily store energy in the form of hydrogen, methane or in compressed air storage units.

As the world’s biggest single energy consumers, buildings offer enormous savings potential. They can be made more efficient by integrating them into a smart grid, and modern building automation systems form the basis for this approach. As intelligent and local participants on the grid, smart buildings perform an important balancing function within the smart grid. Building operators and users benefit from this through power that is cost-effective, reliable, environmentally friendly and future-proof.

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