The power grid of tomorrow

In brief

- Power grids are facing major challenges: the demand for electricity increases, demand management, however, is insufficient. A growing share of renewable energy should be incorporated into the system.
- Load management (demand response) is part of the solution: because of smoothing of load peaks as well as real-time, local consumption of supplied renewable power, efficiency can be increased in the power grid.
- Technologies for so-called demand-side load management are seen as key instruments for the electricity grids of the future.

What is it about?

Over the coming years, power grids need to be gradually extended and renovated in order to cope with new requirements. Increasing power consumption and increasing feed-in of electricity from decentralized renewable energy sources are the two major challenges. Intelligent control technology may help to make the network infrastructure more efficient and to postpone or even avoid costly network expansions.

Today's power grids connect large power plants, storage facilities and appliances. However, there is no communication between these units, resulting in the current in the network to be either used up in its entirety or not at all. Through communicative networking power grids can be controlled intelligently; individual units can be optimized. Electricity from renewable sources (for example from a decentralized wind park) could thus be better adapted to flexible power demand.

Overall, such a load management system could contribute to a better integration of intermittent generators such as wind or solar power into the grid, for example at times, when a lot of power is available in the grid but consumption is low. In addition, the surplus power could be 'stored' locally and used only when needed.

Power grids of today

Demand-side energy management (also called load management) is used to – from a consumption point of view – balance between power supply and consumption, to compensate for possible supply bottlenecks, and to smooth out peak loads (e.g. at lunchtime). It is designed to help consumers at times of peak loads or at times of low generation of electricity from renewable sources to consume less electricity or to shift consumption to times with low loads, e.g. during the night.

Load management is not necessarily intended to reduce the overall power consumption; however, by increasing efficiency it may help to avoid further increase in consumption. This works not only by controlling consumption patterns – for example, through time-dependent electricity tariffs – but also through automated solutions which are able to take over some of the consumers' tasks. For this reason, technologies for load management have to be considered as key tools for smart grids of the future.

Basic data

Project title:	Smart Response – Demand Response for Austrian Smart Grids
Project team:	M. Ornetzeder, P. Wächter, J. Haslinger, J. Sterbik-Lamina (ITA) as part of a consortium led by ICT, TU Vienna
Duration:	07/2010 – 06/2012
Funded by:	Climate and Energy Fund

Key results

The project ‘Smart Response’ was aimed at a better future handling of increased amounts of electricity from renewable generation and decentralized in-feed. The results of the study are based on a comprehensive environmental, economic and social evaluation of possible options. Four promising scenarios have been identified:

Building to grid: Large functional buildings such as office buildings require electrical power for ventilation, heating, air conditioning, etc. Through building automation, these appliances are controlled within a building; through interactive connection to the power grid selected devices are controlled indirectly. The building automation system reacts according to the existing capacity in the power supply system and controls the device without any significant reduction in comfort.

Microgrid for buildings with photovoltaic-system: A microgrid working as an independent power and communications network on a small scale allows for the largest possible portion of locally produced electricity to be consumed in the building itself. Only surplus electricity will be fed into the public power grid.

Microgrid for communities: In order to enable decentralized production without upgrading existing infrastructure, generated electricity must be consumed promptly and as close to the source of production as possible. This can be enabled with communication via microgrids at community level and storage facilities (e.g. water pumps) that can be used to shift and store loads.

Re-use of electric car batteries: Modern batteries, on the one hand, involve valuable resources during production; on the other hand, they are relatively quickly taken out of operation. Companies could collect these batteries and, following their re-conditioning, use them, as a ‘storage power plant’ to smooth out load peaks from renewable sources. Because of the batteries’ extended life cycle, the overall ecological balance is significantly improved.

From an ecological perspective, all four scenarios are reasonable. In all cases, the reduction of carbon dioxide emissions significantly exceeds the necessary expenditure. However, no scenario on its own has the potential to significantly contribute to avoid shortages in the grid and load balance problems. A successful implementation requires a range of or a combination of scenarios. To offer appropriate, situated working solutions, specific experience stemming from practical demonstration projects is needed. The scenarios need to be fully developed and continuously adjusted with important elements such as technology, pricing, legal frameworks or requirements of users.

According to experts, in the field of demand response there is a lack of development and establishment of business models to test different cost and price structures.

What to do?

Because of high potential of demand-side management, it is important to pursue this topic on several levels:

- **Pricing:** Although investments in grid development can be delayed or even avoided by implementing demand response measures, the resulting savings are difficult to quantify. Hence, it is important to build up a comprehensible basis that allows for a better calculation and allocation of costs.
- **Platform for networking activities:** We recommend setting up a platform that supports coordination and networking activities of major stakeholders in order to help develop promising scenarios further. If appropriate, even existing structures such as the federal energy agencies or the smart grid platform could take over these activities.
- **Promotion of package solutions**: Electrical load shifting and the technical capability to enable demand response should be considered as part of funding regulations for renewable energy as strong interactions between the two strategies exist.
- **Legal position:** Feeding into the general power grid by a larger number of private households (apartments in large-volume residential buildings) makes sense from a demand response point of view. However, this is problematic under the current legal situation and should be reassessed. Intermediate players should be supported to form a legal body and act as providers or distributors.

Conclusion: Essentially, the success of demand response depends on the improvement, dissemination and purposeful use of new technologies. Therefore, a coordinated development approach at policy and company level is necessary.

Further reading

M. Meisel et al.: Erfolgsversprechende Demand-Response-Empfehlungen im Energieversorgungs-system 2020, Informatik-Spektrum (2013) 36: 17-26

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