Demand Response – Temporal Availability and Actual Use for the Electricity System

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Overview

The share of electricity from intermittent renewable resources is steadily increasing. This will lead to a higher dependendy on weather conditions and a higher flexibility in the electricity systems is needed. Amongst others, back-up capacities and energy storages are seen as important options to cope with the intermittent feed-in. But also Demand Response (DR) could be one option to provide higher flexibility. In this way, demand can follow electricity supply when available. As a result curtailment of feed-in from renewables as well as the need for back-up capacity and energy storages could be decreased. DR can have a strong effect on several market players as well as on the whole electricity system. However, in contrast to the supply side, DR is not available at any time and the time of intervention is limited. Therefore, it is important to know, how many DR applications are available at what time and for how long. With these information, the role of DR in future electricity systems and the contribution to the system integration of renewables can be assessed.This paper aims to identify the hourly available DR potential, which actually can be used to increase the feed-in from renewable energies. Thereby technical and economic restrictions of DR will be considered. Both characteristics determine the actual commitment of DR applications.

Methods

Due to technical restrictions and consumer habits the full DR potential cannot be used at any time. To investigate the hourly available DR potential, a typical profile for each DR application needs to be considered. This profile is calculated in a first step for the most relevant applications. Thereby their main technical restrictions, as temporal constraints (e.g. concerning the time of the day) or outdoor temperature dependency, are taken into account. Especially the use of night storage heaters or air conditioners depend on the outdoor temperetaure. Therefore, this parameter highly affects the corresponding DR potential.

In a second step the European electricity transhipment market model ELTRAMOD is used, to investigate how much of the available DR potential can actually be used in 2030 in Germany and what effect it has on the electricity system. Thereby more detailed analysis, e.g. regarding the reduction of curtailment from feed-in from renewable sources, will be done. The main technical restrictions, e.g. shifting time, as well as the hourly available DSM potential will be implemented into the model to cope with the relevant restrictions of DSM and to allow a profound analysis of the impact of DR on the electricity system.

Results

First analyses concerning the flexibility of DSM showed that the hourly available DR potential varies with seasen and daytime as well as differs between sectors (see Figure 1). While industry applications mainly reduce load without fetching it later[1], the applications in the tertiary and residential sector can shift the load to other points in time. Exemplary applications, which are applicable for DR, are electric arc furnace, cement mills or aluminium electrolysis in the industry sector and cold storages, heat storages (e.g. night storage heaters or heat pumps) or air supply in the residential and tertiary sector. The availability of the DR potential in the industry sector faces in general no temporal restrictions (e.g. concerning the time of the day) or temperature dependency. As opposed to this, all load shifting applications in the tertiary and residential sector are time dependent and partly temperature dependent (Gils 2014). Hence, changes in the available DR potential result mainly from load shifting devices.

The DR potential is highest in winter at night and lowest in summer at night. Besides, in summer occurs the peak at the daytime while the highest potential is available in winter, spring and autumn at night. However, the highest demand occurs in Germany during winter in the morning or evening. In contrast, the maximum DR potential is available in winter during nighttime due to night storage heater. Hence, the maximum DR potential is not necessarily available when needed. The same applies for balancing renewable feed-in. For example, electricity production form PV is highest during summer in the daytime. Most load shifting applications, like ventilation or air conditioning

[1] Most energy intensive processes have high fixed costs. Therefore, many companies operate 24 hours a day and each days of a week. Reducing demand would mostly lead to production downtime. If a company do not operate in shift work, but can vary production time, it could provide load shifting instead of load shedding.

systems, run already at that time. Therefore, increasing the load during times with high PV feed-in is limited as well. Consequently, the total available DR potential might not be used because it is not needed at that time. To investigate how much of the available DR potential can actually be used in future electricity systems, a detailed analysis with ELTRAMOD, showing the impact of DSM on the electricity system, will be presented in this contribution.

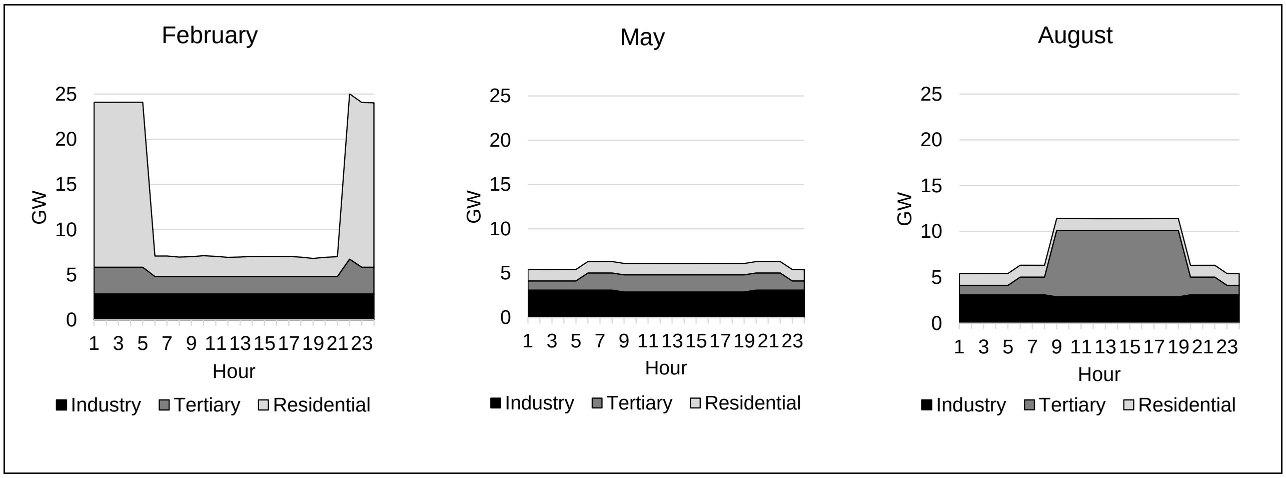

Figure 1: Time-resolved DR potential for typical working days in February, May and August (Source: Own illustration based on Klobasa 2007)

Conclusions

DR can provide flexibility to the system and improve security of supply. However, the use of DR strongly depends on the available DR potential which is not available at any time but features daily and seasonal fluctuations. These variations result from the availability of each DR application. However, the maximum DR potential is not always available when needed, namely during peak times or low renewable feed-in. Therefore, it might not be cost efficient from a system perspective to exploit the full DSM potential. Furthermore, the capability of DR for cupping peak load is limited and back-up capacities are still needed. Hence, DR can mainly balance short term fluctuations and is a complement to energy storages and back-up capacities.

References

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Klobasa, M., 2007: Dynamische Simulation eines Lastmanagements und Integration von Windenergie in ein Elektrizitätsnetz auf Landesebene unter regelungstechnischen und Kostengesichtspunkten. Diss., Karlsruhe.