BALANCING OF FLUCTUATING REGENERATIVE GENERATION BY DSM

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ABSTRACT

Distributed generation in micro grids creates significant fluctuations in power. In distribution networks with weak interconnection or with insulated autonomous regenerative generation Demand Side Management (DSM) of consumer load is used to balance the fluctuating power. As a precondition a sufficient load potential, which can be managed in time, is necessary.

1. INTRODUCTION

Due to the increased promotion of electricity from renewable energy sources (RES) in the EU-directive 2001/77/EC renewable power generation will be forced.
Therefore wind energy plants will contribute a main part with an installed capacity up to 1.700MW in Austria.
Wind power production is characterized by stochastic generation trait and so it can be predicted with limited accuracy. Standard deviations of wind power forecast errors are about10% to 20% of installed wind generation (state of the art). Therefore additional balancing energy of about 20% of the yearly wind energy generation must be available.
The aim of the following investigation [1] is to dissipate balance energy locally. For this purpose DSM is a precondition and useable domestic loads are researched.

2. HOUSEHOLDS

2.1 Classification of home appliances

The following figure [2] shows the classification of typical electrical home appliances according to their potential for DSM and the acceptance of consumers.

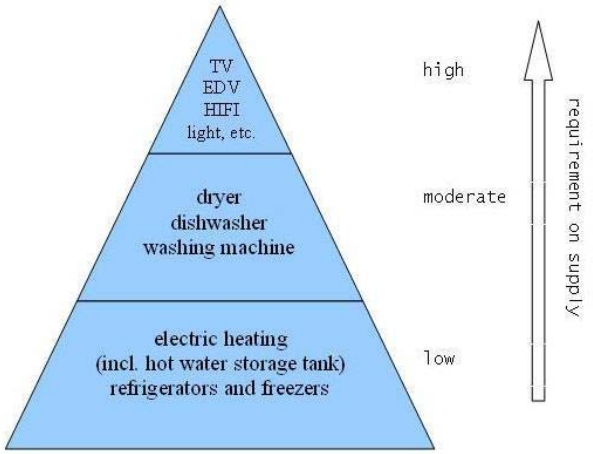

Figure 1: Classification of home appliances

There are a numerous of home appliances which are not suitable for DSM. Some examples you can see in the top of the pyramid. Consumers will not accept a restricted use of these devices.
Electric heating in combination with a hot water storage tank and all kinds of refrigerators or freezers have a very high potential for DSM. The consumer will not realize that a DSM-system is controlling the electrical loads which you can see in the bottom of the pyramid.
Now there are still some home appliances left. The devices with moderate requirement on supply belong to the group of "white goods". It will not be easy to exert influence on these appliances without restriction of consumer needs. Nevertheless there is also a considerable potential for DSM.

2.2 Demand characteristics

In a first investigation consumer loads in households have been evaluated according to their typical dependence in demand characteristic related to season, weekday and daytime. The background is build by different studies which have been carried out in Austria and Switzerland.

Because there are a lot of household appliances which have

been evaluated and there is not much space on this paper, the following pictures shows some typical examples.

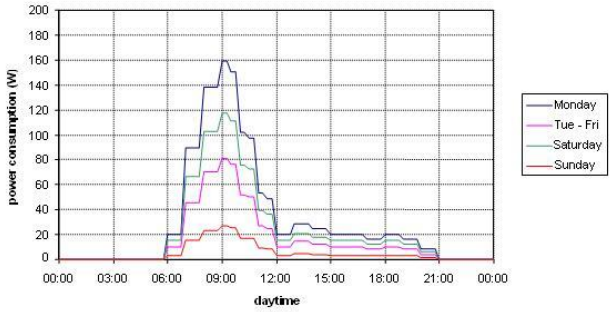

Figure 2: Demand characteristic of washing machines

The typical daytime demand characteristic of washing machines is shown in figure 2.
(The power consumption is relating to a "standardized Austrian household".) Additionally the figure offers valuable clues to different use of washing machines during a week. That is to say there is for example an increased requirement on Mondays and Saturdays.
The figure 3 shows the seasonal dependence of dryers.

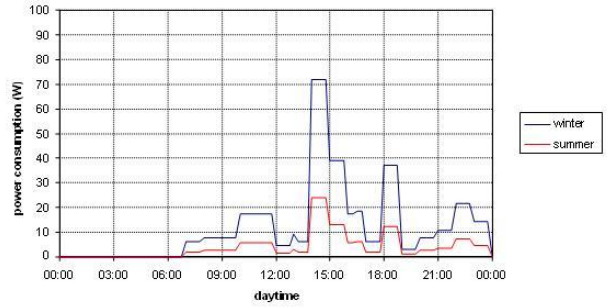

Figure 3: Demand characteristic of dryers

The detailed investigation [1] and [2] includes also the demand characteristics of dishwashers, electric heating, refrigerators, freezers and some others.

3. DSM-POTENTIAL AUSTRIA

Starting from demand characteristics mentioned above, load curves were generated. The resulting load curves of the relevant applications are shown in *figure 4* to *figure 6*. These loads determine the theoretical DSM potential in the APG balance zone (Austria power grid) and in Austrian wind region respectively.

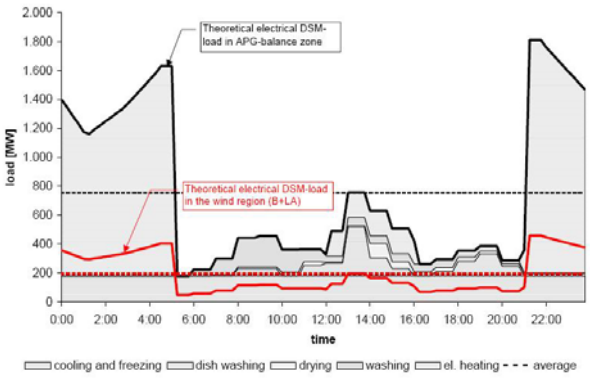

Figure 4: Theoretical DSM-Potential (winter day)

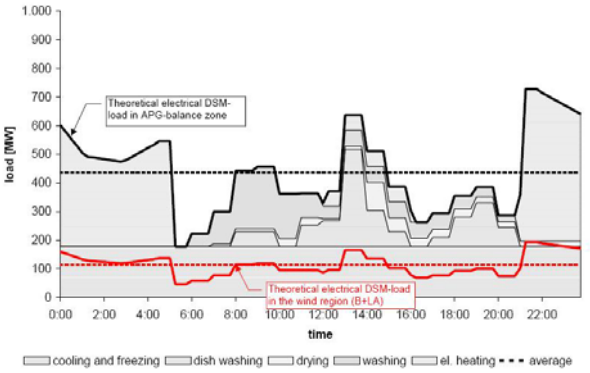

Figure 5: Theoretical DSM-Potential (spring or autumn day)

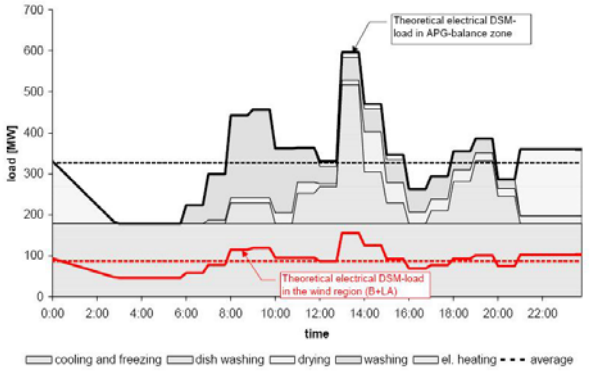

Figure 6: Theoretical DSM-Potential (summer day)

The main results of these analyses are:

- The theoretical DSM potential of electrical applications in households is characterized by large daily and seasonal variations. In the APG balance zone it is on average about 760 MW on a winter day, 360 MW on a summer day and 440 MW on a day in transitional period.

- Applications like washing machines, dryer, refrigerators and freezers make only a small DSM potential. The main part within the group gives refrigerators and freezers, which cause a base load of 180 MW.
- Heating applications dominate the theoretical DSM potential based on the fact of fundamental seasonal variations of the DSM load.
- In the Austrian wind region (Lower Austria and Burgenland) the average of the theoretical DSM potential is 200 MW on winter days, 90 MW on summer days and 120 MW on spring or autumn days. Without heating applications it is on average 80 MW per day.

4. VIRTUAL OIL SOURCE

The analyses have shown that heating applications are the main parts of DSM potential. The storage abilities of buildings and heat reservoirs suit for load shifting without any loss of convenience. This potential can be increased by using bivalent (fuel/electric) heating systems.
In the following investigation they are used to balance the fluctuations of wind power generation as an example of regenerative energy. Under high generation condition the electrical heaters are switched on by remote control and substitute the fossil burners in this simulation.

4.1 Substitution of fossil heating systems

In the following example a fictive DSM-load was generated, which substitutes 10% of fossil heating systems. That is to say 10% of fossil heating systems in a defined area are bivalent systems and can be used with DSM. As mentioned above the largest potential is in winter. In figures 7 to 9 the theoretical DSM-load on a winter day, a day in transitional period and a summer day are illustrated.

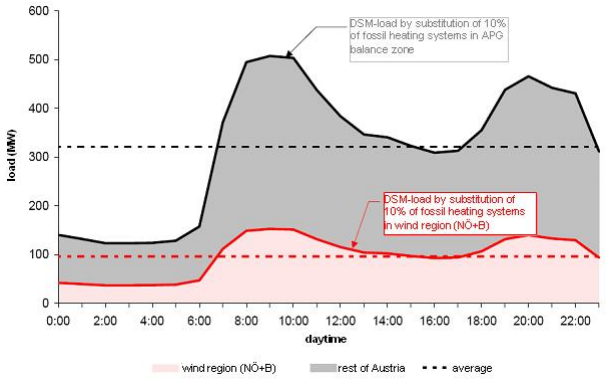

Figure 7: Potential for substitution (winter day)

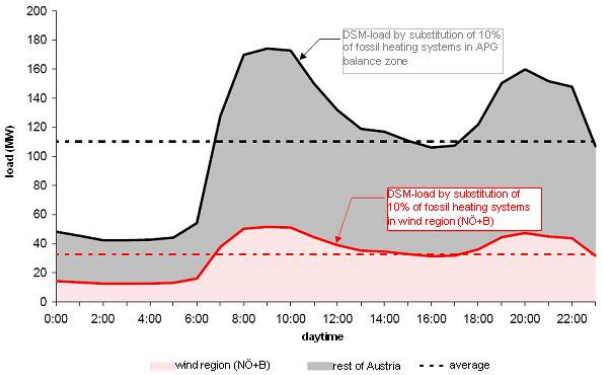

Figure 8: Potential for substitution (spring or autumn day)

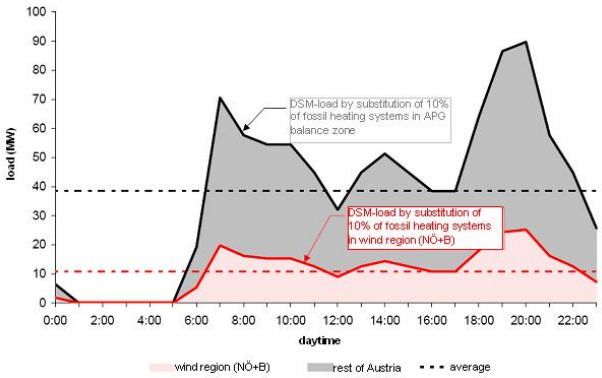

Figure 9: Potential for substitution (summer day)

4.2 CO_2 saving

The last example shows that the fluctuations of wind can be balanced locally and this works like a virtual oil spring because of using regenerative wind energy instead of fossil heating energy. Therefore fuels and CO_2 emissions can be saved on the one hand at households and on the other hand by not using balancing power plants.

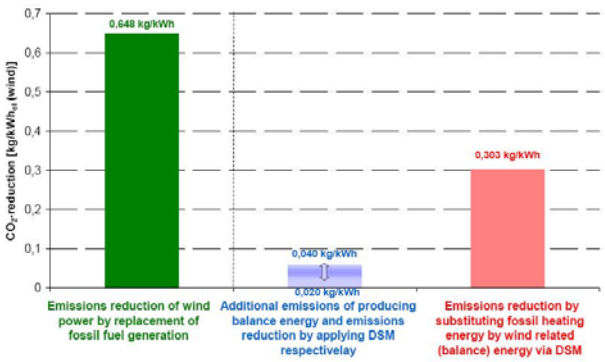

Figure 8: CO_2-reductions related to wind and DSM

The results shows that wind related CO_2-reductions are mainly determined by the replacement of conventional thermal electricity production. Additional CO_2-emissions causes by producing balance energy are very small because of the big contingent of pumped storage power plants in Austria. So there are moderate emission reductions by applying DSM.

High CO2-emission reductions can be effectuated by substituting fossil heating energy by wind related balance energy via DSM. Therefore the use of bivalent heating systems can increase the climate efficiency of wind power plants.

Another effect of using bivalent heating systems can be used if the Austrian high voltage network will be completed adequately: Shut downs of wind power plant as a result of bottlenecks can be avoided by using wind energy locally in the wind region. This will also decrease CO2-emissions in domestic fuel at least.

4.3 Efficiency of virtual oil source

Because of the high efficiency of the electrical heaters and the distribution grid in relation to the fossil operated heating systems one kWh of regenerative energy can substitute an equivalent of about 1.25 kWh of oil or gas.
The efficiency of a virtual oil source can be described by

$$\eta = \frac{\eta_{EL} \cdot \eta_{PG}}{\eta_{FHS}} = \frac{0{,}95 \cdot 0{,}92}{0{,}7} = 1{,}25$$

η_{EL} efficiency of electric heating system

η_{PG} efficiency of power grid

η_{FHS} efficiency of fossil heating system (average)

This forms a "**virtual oil source**" with a fictive efficiency more than 100 %.

5. CONCLUSION AND PERSPECTIVES

The investigations about the DSM potential in Austria and in wind region specially have shown that electrical heating applications represent the major part. Nevertheless there is also a considerable potential for DSM by white goods like refrigerators and freezers as well as washing machines, dryers and dish washers. Additionally this potential can be increased by using bivalent (fuel/electric) heating systems. Altogether household appliances have a potential of about 20 to 30 % of their load for DSM without restriction of consumer needs

The technical and economical implementations depend on the technical complexity and costs of the control equipment. There must be also financial incentives for the customers to stimulate the acceptance of DSM. The valuation also depends on prices for balancing energy.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] G. BRAUNER, G. POEPPL, D. TIEFGRABER, 2006, "Verbraucher als virtuelles Kraftwerk", *Berichte aus Energie und Umweltforschung*, 44/2006.

[2] T. SIEBENHÜNER, 2006, "Demand-Side-Management von Kleinverbrauchern", *Diplomarbeit IEAW*.