ECONOMIC IMPACT OF DEMAND RESPONSE ON COSTS TO DISTRIBUTION SYSTEM OPERATORS

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Overview

European energy policy for 2020 is aimed at reducing greenhouses gases by 20%, increasing renewable generation by 20% and curbing energy consumption by 20%. Along these lines the Swedish government has adopted a national planning framework which will expand wind power capacity to 30 TWh (20 TWh onshore and 10 TWh offshore) by 2020 [1] [1] In order to meet policy objectives the current power system will undergo radical changes as a result of steadily rising demand, advanced technology integration and increasing penetration levels of renewable energy sources (RES).

Power generation, transmission and distribution units are designed to cope with extreme cases of maximum power demand, which sparcely occur. Dimensioning the grid to such specifications and keeping power reserve generators on standby for the purpose of meeting temporary peak load is therefore a costly endeavour [2] As such, following the liberalization of electricity markets discussions have shifted the focus of system security on measures away from the supply side. Besides increasing generation capacity, demand may also be exploited [3] Demand Response (DR) is regarded as a modification of electricity consumption in response to price of electricity generation and state of system reliability [4] [5] The potential demand response resources in Sweden are estimated between 3300–5500 MW[1], which equals 10 to 20% of maximum power output [2]

Although DR potential is high, implementation has been slow to emerge in Swedish (and in general European) power markets commonly attributed to a limited knowledge on the scope of potential savings that can be achieved [6] More specifically, there is lacking insight into the quantitative impact on loss reduction through active load management [7] This study focuses on uncovering the economic impact Demand Response from residential users has on the costs to Distribution System Operators (DSO) in Sweden.

Methods

A model has been developed which estimates the magnitude of positive economic effects following the implementation of DR for a Swedish DSO Sala-Heby Energi Elnät AB. Note, although data is used form a single Distribution System Operator, the identified factors investigated for the distribution business can be easily replicated to assess others as well. Identified simulation factors include *power losses*, *grid fee to feeding grid* and *postponed future investments*. These factors were chosen for their economic impact following a 10% DR from all users in the distribution area. More specifically benefits from demand response arise in the following manner:

- *Power losses*: technical variable losses increase squared with the amount of load therefore DR is interesting for overall load reduction and peak load shifting.
- *Grid fee to feeding grid*[2]: DR can reduce the maximum power transferred with load shifting in addition to helping reduce the overall energy transferred.
- *Postponed future investments*: DR reduces demand side consumption fluctuations in this way facilitating overall better asset utilization.

To reflect current DR implementation for Swedish DSO's, a Time of Use (TOU) tariff was chosen for the simulation. To determine the effect of DR that should be implemented, an analysis was performed regarding the average load curve over a day on an hourly basis. Model calculations are performed on the total load curve over the whole year considering average hourly values.

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[1] Megawatts

[2] The Swedish Grid has three levels (i) transmission grid (ii) regional grid (iii) distribution grid. The *grid fee to feeding grid* is based on the cost imposed on the DSO by the owner of the regional grid which transfers electricity into the DSO's grid. If the power transferred is higher than the level of the subscribed maximum power, this fee has to be paid to the regional grid manager. This fee is quite costly to the DSO, and in order to hedge against there are contracts between grid mangers resulting in a high subscribed max power

The average load peaks occur between 09:00 and 20:00 in Sweden so it was decided to reduce consumption during these hours, with the amount of reduction set at 10% for each peak hour. The reduced energy was then distributed evenly among the off-peak hours, which was considered to be between 23:00 and 08:00. The hours between the peak hours and the off-peak hours were considered to be unaffected by the DR program.

Results

Shifting load from peak hours of the day to off-peak hours of the night a secondary effect is detected. If the DSO is using the day-ahead spot market price to purchase energy to cover losses instead of using a fixed price, the prices will typically be higher during the days and lower during the nights. This results in a positive economic secondary effect when more losses are transferred from the day to night. Further exploration in comparing fixed pricing contracts and variable pricing contracts when compensating for losses in an environment where DR exists may prove very useful.

Table 1: Economic impact of Demand Response

Results of losses model for DR	
Reduction in kWh over the year	346,756 kWh
Reduction in mean arithmetic loss	3,99%
Annual difference in SEK[3]	251,626 kr
Annual difference in SEK per customer	**19,05 kr**
Results of Grid fee to feeding grid model from DR	
Decrease in maximum subscribed power	1,88%
Annual difference in SEK	166,780 kr
Annual difference in SEK per customer	**12,62 kr**
Results of investment model from DR	
Difference in SEK	2 037 900 kr
Years of postponed investments	2
Difference in SEK per customer	**154,26 kr**
Yearly savings per customer (SEK)	***185,93 kr***[4]

Conclusions

The above results illustrate savings in accordance with the three factors affecting Distribution System Operators: power losses, grid fee to feeding grid and postponed future investments. As summerized in Table 1 the annual savings for consumers are still quite small, estimated at approximately 185,93kr (28,55 USD) per year. Note, this may be a result of the fact that grids are typically designed with the capability of coping with peak demand/transport and the kind of peak shaving capacity of DR is more or less already physically built in the grid in its thermal capacity which allows overloading for a short period of time. As a result, it may prove extremely tricky to design demand management programs which exactly provide the desired response. Overall though, it is important to keep in mind that the above results serve as a rough estimate of what may be possible to achieve through a Demand Respose implementation when considering the current DSO regulatory remuneration structure. The period of supervision is running from 2012 and will end in 2015. A further simulation can be conducted utilizing alternative regulatory frameworks which allow for the encorporation of more DR flexibility (e.g. allowing for further technological integration). Nonetheless, this analysis illustrates overall benefits from Demand Response in turn raising awareness of implementation to DSOs. This study seves as an initial assessment of the savings DSOs can currently incur with load management.

References

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[3] Swedish Krona

[4] A total of $28,55