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Policy and Regulatory Implications of Distribution System Operators' Economic Incentives to Promote Demand Response

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ELEMENTS OF A NEW TARGET MODEL FOR EUROPEAN ELECTRICITY MARKETS: Towards a Sustainable Division of Labour between Regulation and Market Coordination, 8 July 2015, Université Dauphine, Paris

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“Market based policy instruments in the residential sector”

The overall aim of the project is

- to estimate the efficiency and savings potential in residential electricity use of business models for increased demand response and individual feedback

- to quantify the economic and environmental consequences as part of implementing these policy instruments and

- to enhance knowledge on electricity consumers driving forces and incentives in this context.

Swedish Energy Agency

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Publications for reference

Koliou E, Bartusch C, Picciariello A, Eklund T, Söder L, Hakvoort R A. Quantifying distribution system operators' economic incentives to promote residential demand response. Utilities Policy 2015; in press.

Bartusch C, Alvehag K. Further exploring the potential of residential demand response programs in electricity distribution. Applied Energy 2014; 125: 39-59.

Bartusch C, Wallin F, Odlare M, Vassileva I, Wester L. Introducing a demand-based electricity distribution tariff in the residential sector: Demand response and customer perception. Energy Policy 2011; 39(9): 5008-5025.

The Swedish power market

- deregulated in 1996
- production and trade are since then subjected to competition
- distribution and transmission are still state regulated monopolies
- all Nordic countries but Iceland are included in a common power market
- the rationale for deregulating the power market was to increase competition in supply and customers' freedom of choice, thus reducing retail prices
- moving towards a European power market

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The Swedish regulatory model

- distribution operations are regulated and supervised by the Swedish Energy Markets Inspectorate
- monitors whether distribution system operators fulfil their obligations in accordance with the Electricity Act, which involves inspecting that the network fees are reasonable, objective and non-discriminatory
- remuneration is determined by an ex-ante revenue cap
- the revenue cap should cover reasonable costs for running network operations and provide a reasonable return on the capital (asset base) required to run it
- when the revenue cap is determined the quality of the distribution system operators' way of operating the network in terms of security of supply and quality of voltage is taken into account

Energimarknadsinspektionen
Swedish Energy Markets Inspectorate

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The forthcoming Swedish regulatory model

- as a direct result of the EU Energy Efficiency Directive an amendment to the Swedish Electricity Act was made in 2014

- the amendment states that in determining the revenue cap, the extent to which the distribution operation entails and furthers an efficient use of the network is to be taken into account

- in light of this amendment the regulatory model of the next period (2016-2019) also includes incentives for the distribution system operator to reduce grid losses and level the load profile, thus reducing peak demand

- the rationale behind using grid losses as an indicator for an efficient use of the network is that these have a direct impact on distribution operation costs and the amount of energy used, thus bringing about evident gains for consumers and society as a whole

- levelling the load profile and reducing peak demand is expected to increase the grid capacity, thus allowing for more renewable energy and connecting additional end users without investing in further capacity

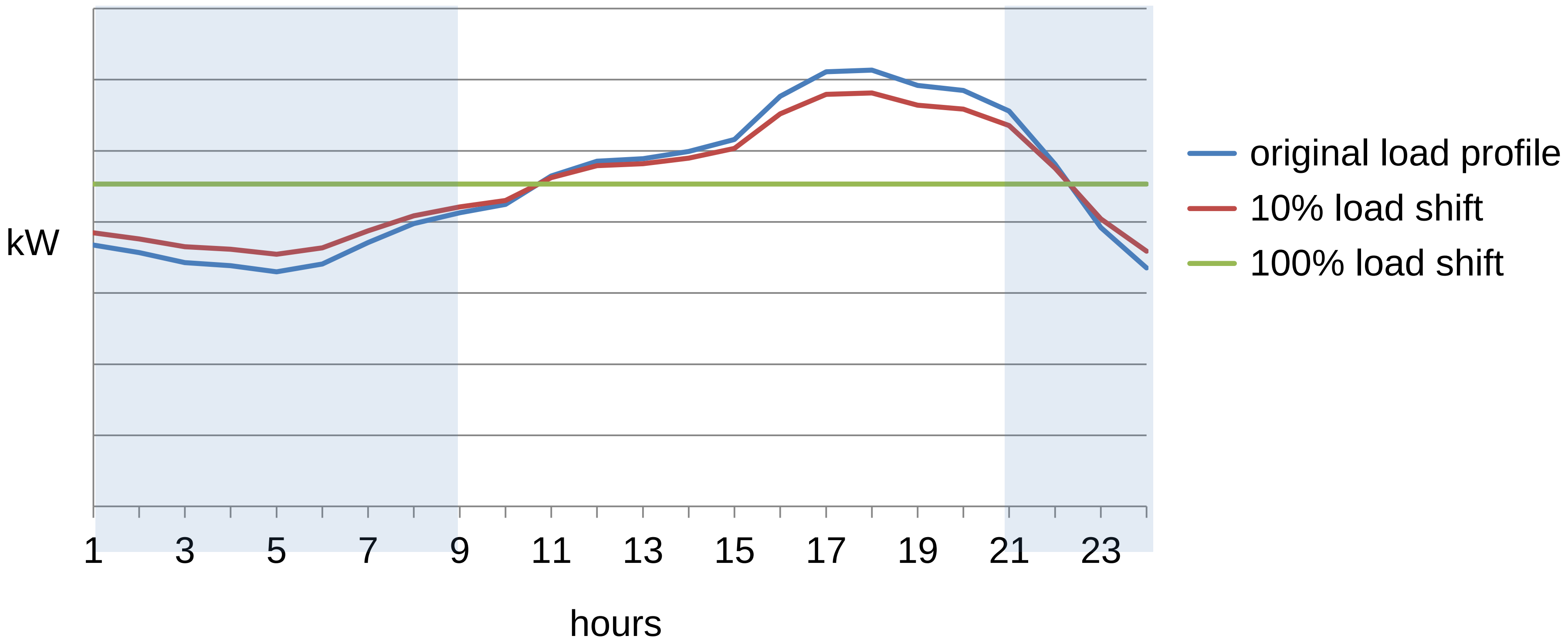
Energimarknadsinspektionen
Swedish Energy Markets Inspectorate

Aim

To estimate the economic consequences of demand response for distribution system operators focusing on costs related to

- grid losses
- fees of the regional transmission system operator

Modifying the original load profile based on the average yearly load profile

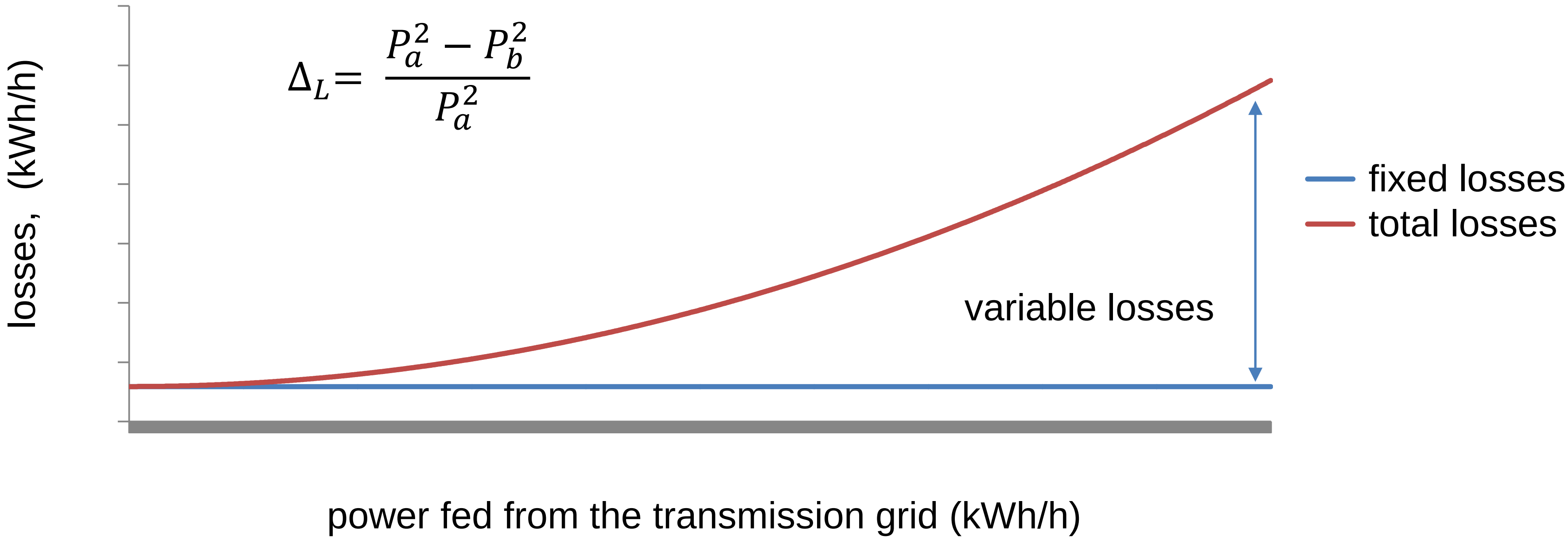


Estimating grid losses

- variable losses are assumed to be proportional to the square power

- the simulation uses a loss vector (Δ_L), which varies with load demand (P) as follows:

$$\Delta_L = \frac{P_a^2 - P_b^2}{P_a^2}$$



Estimating grid losses and related costs

- the load is assumed to be equal in all parts of the grid
- total losses are defined as the difference between the amount of power fed from the transmission grid and consumed by end users
- demand response only affect the variable technical losses
- average losses in the distribution area in question is 4.3%
- the proportion of fixed to variable losses is 1 to 5
- the current spot price is used to estimate the costs of covering losses
- the economic consequences of demand response is estimated by comparing the results using the original and the modified load profiles

Estimating costs related to the fees of the regional transmission system operator

- the tariff includes a fixed capacity charge (€), a variable energy charge (€/kWh) and a variable capacity charge (€/kW)

- the fixed capacity charge is set ex-ante and these costs will consequently not be affected by demand resonse

- seeing as the total energy consumption remains the same, the variable energy charge will not be affected by demand response

- the price per kW of the variable capacity charge increases considerably if demand exceeds the subscribed level of peak load

- the tariff design varies between transmission system operators and in this case the tariff of Vattenfall has been used for the simulations

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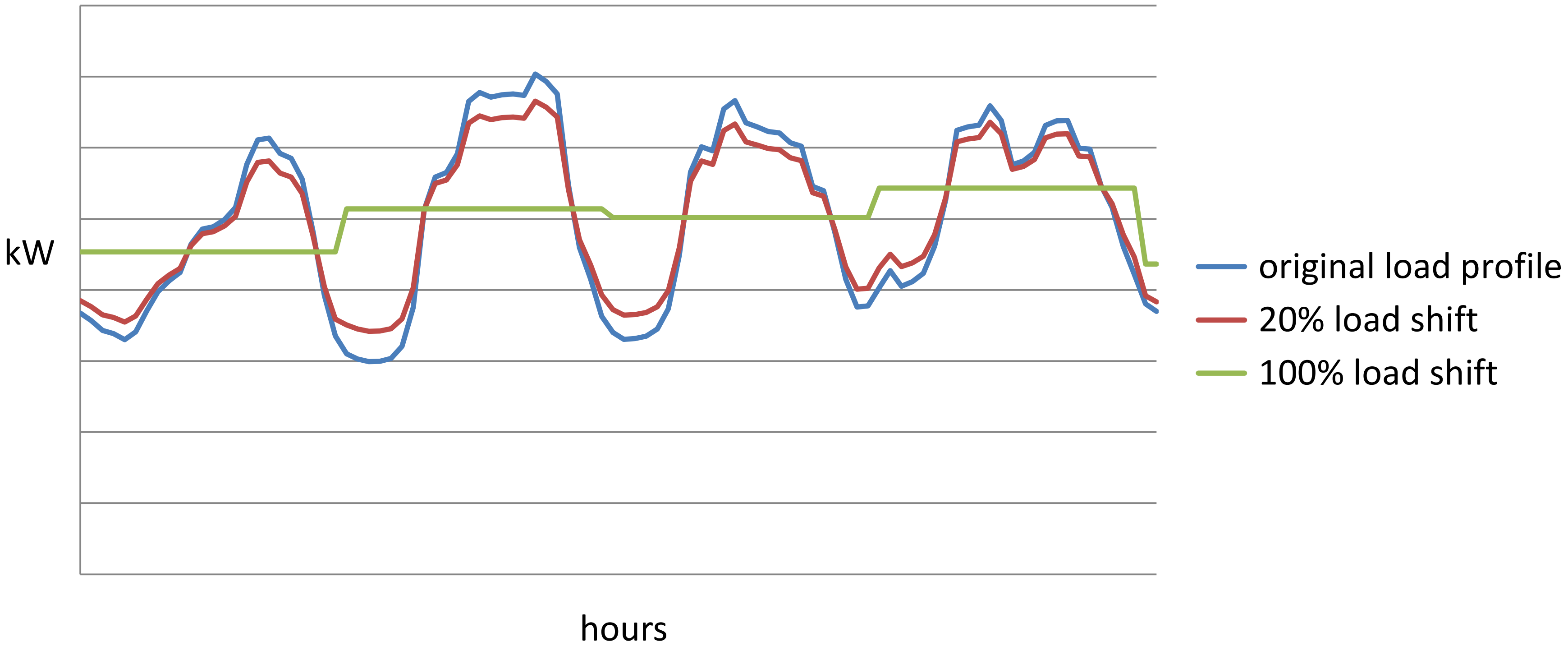
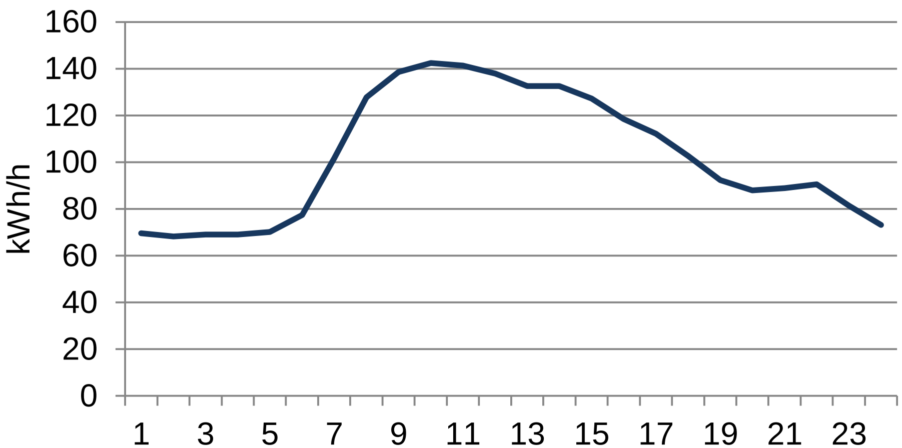
Modifying the original load profile based on daily load profiles

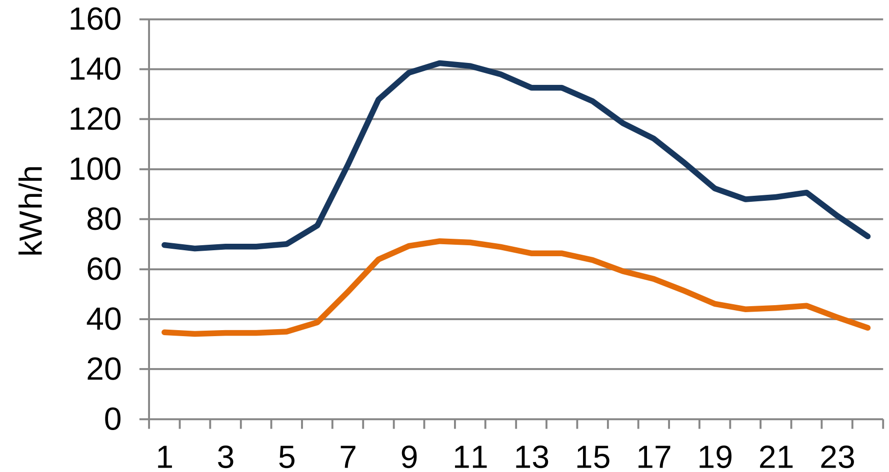


Methodology in modifying the original load profile

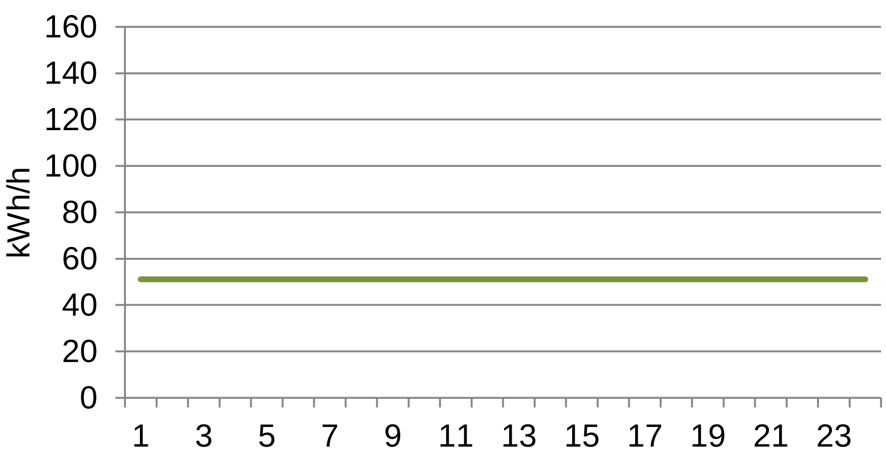
original load profile



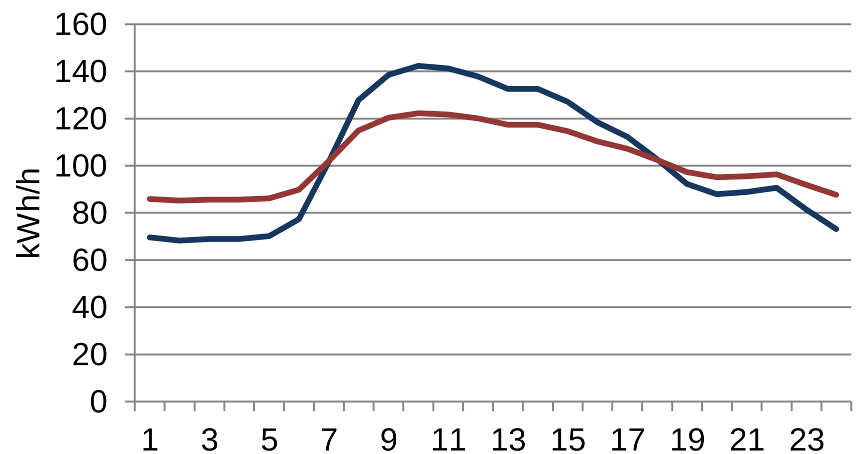
subtract 50% of the demand each hour



calculate the average of the subtracted demand



add the average of the subtracted demand



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The findings of the first simulation suggest that a

- shift from peak to off-peak hours by 10% leads to a reduction in grid losses by 4%, which in turn entails a reduction in related costs by 8%

- completely levelled load profile leads to a reduction in grid losses by 19%, which in turn entails a reduction in related costs by 36%

The findings of the second simulation suggest that a

- load profile that is leveled by 2% leads to a reduction in grid losses by 0.9%, which in turn entails a reduction in related costs by 1.8%

- completely levelled load profile leads to a reduction in grid losses by 2.6%, which in turn entails a reduction in related costs by 5.2%

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The findings of the first simulation suggest that a

- shift from peak to off-peak hours by 10% leads to a reduction in peak demand by 2%, which in turn entails a reduction in related costs by 5%

- completely levelled load profile leads to a reduction in peak demand by 51%, which in turn entails a reduction in related costs by 46%

The findings of the second simulation suggest that a

- load profile that is leveled by 2% leads to a reduction in peak demand by 3.7%, which in turn entails a reduction in related costs by 2.8%

- completely levelled load profile leads to a reduction in peak demand by 14%, which in turn entails a reduction in related costs by 10.7%

Discussion of the results

- the main reason for the varying results is the different methodological approaches, i.e. using average yearly vs. daily load profiles

- the results using the latter is more realistic in the short term perspective

- given the rapid technological development, the results using the former might become more representative in the long term perspective

- this assumption also applies to the results of the different scenarios simulating various magnitudes of demand response

- a moderate flexibility might be more realistic today, but an extensive demand response might become reality tomorrow

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A study on demand response in distribution

Applied Energy 125 (2014) 39–59

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Further exploring the potential of residential demand response programs in electricity distribution

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- estimate the long term response in single-family homes
- estimate the response in bland condominium and rental apartments

Power tariff features

- time differentiated (time of use)

  peak hours: 7 am - 7 pm on weekdays

  off-peak hours: 7 pm - 7 am on weekdays and weekends

  summer season: April - October

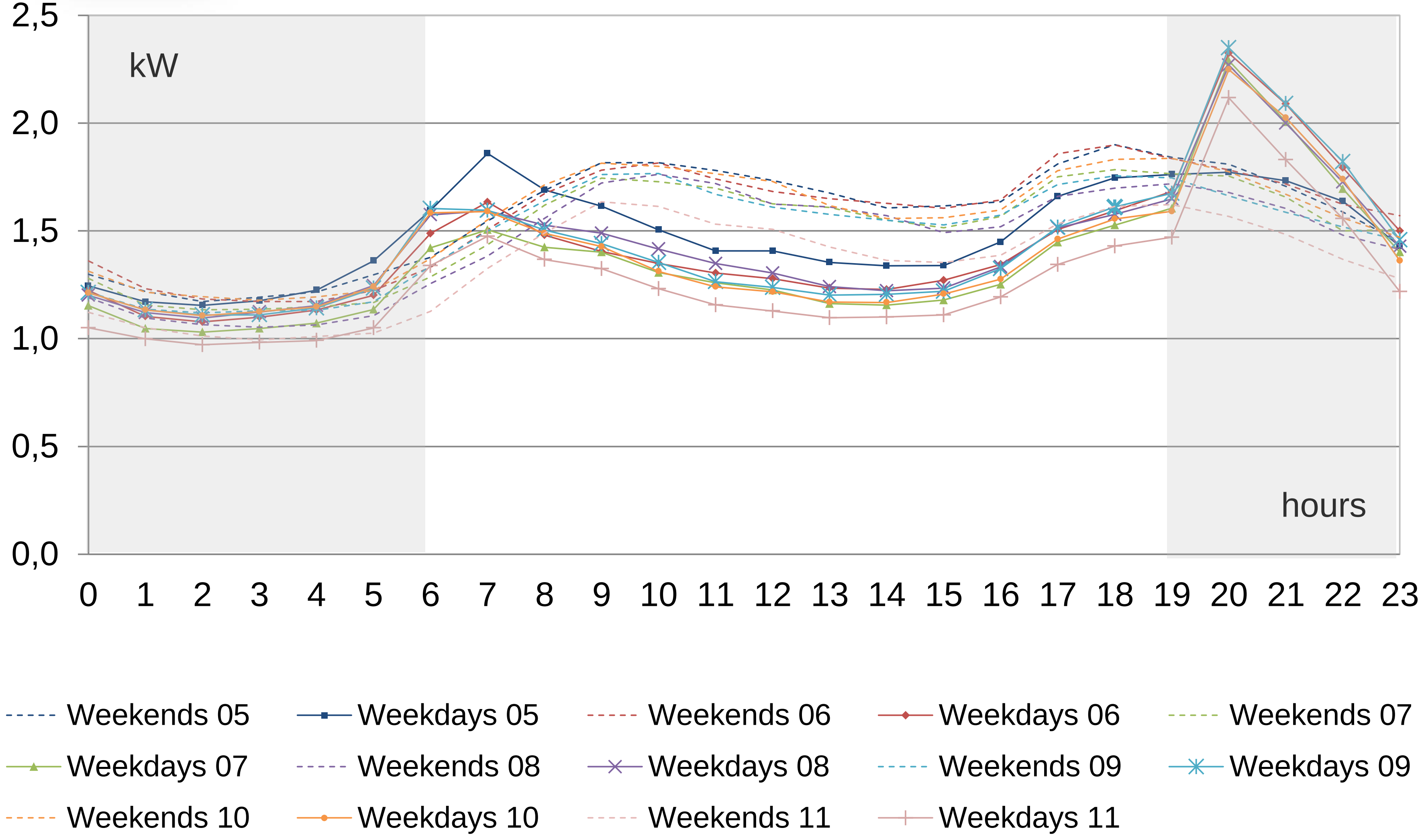
  winter season: November - March

- demand based

  SEK/kW

  the costs are based on the average of the 5 highest meter readings in peak hours

Load profiles in single family homes



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Demand response in the long term

- The implementation of the power tarifff on average resulted in

  - a shift from peak to off-peak hours by 2,4 and 0,2 %
  - a decrease in individual peak demand by 9,3 resp. 7,5 %
  - a decrease in diversified peak demand by 15,6 resp. 8,4 %

during the 6 summer and winter seasons following the introduction.

- awareness was slow to emerge
- the economic incentive was very limited
- marginal response among consumers in apartment blocks
- very high variance in the data set

I started by asking how much distribution system operators costs would decrease as a result of promoting demand response and I will end this presentation by asking how much it would cost us not to increase flexibility.