Danish household load profiles and the effect of savings for appliance categories

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Overview

Energy savings are seen as contributing substantially to reducing the fossil fuel dependence in Denmark and improving energy efficiency. Electricity savings in households is contributing to this through the marginal effect of generating the electricity. As the fossil fuel content of generation varies across the hours also the fossil fuel reduction varies based on the hourly profile of the electricity saved. Furthermore, the hourly profile of savings may have very different effects on capacity requirements in the power sector depending on which category of household demand is reduced. The value of the savings hereby depends on the profile of the reduced electricity demand.

We establish the link between the aggregated hourly household load profile in Denmark and a number of household appliance categories. The objective is to evaluate the fossil fuel effect and value of increasing the average efficiency of different types of appliances. Potentially it may be relevant to support electricity savings (investment in efficient appliances) differently depending on the hourly profile of the savings. We want to clarify if some end-uses provide better social return on the investment in the efficient appliance model/version than others?

In a next step we will develop the profile for household electricity savings in the future depending on the changes in composition of household appliances and their projected average efficiency developments.

Methods

We use a combination of three datasets:

1) Danish load profile by hour for the aggregated household demand in 2008 (Danish Energy Agency, (1))
2) Danish composition of stocks of appliance categories and the their annual electricity consumption (Danish Energy Agency)
3) REMODECE project data for appliance category load profiles (3,4)

By combining the three types of data we are able to scale the REMODECE load profile for each type of appliance with the Danish annual consumption for a similarly defined category. Following this we calibrate to the total Danish load profile for households.

Construction of the aggregated Danish households load profile:

First of all the actual aggregated Danish load profile for one household during an average day of 2008 had to be calculated. The chosen year was 2008 in order for it to be comparable with REMODECE project which is dated to 2008. Data were taken from (1) The available data set contains the aggregated load of an average Danish household as percentage of the total yearly load, for each of the 8760 hours of the year. Therefore, in order to obtain the average weekday and weekend of the year, the 365 days of one year were sorted in weekdays and weekends first. Afterwards, the average of each of the 24 daily hours for weekdays and weekends were calculated separately, resulting in the load profile of the actual Danish average weekday and weekend. This procedure was repeated for each of the five different types of buildings considered in the data set. The results are presented in Figure 1

Results

Figure 1 Load profiles in DK for three categories of households, comparison of weekdays and weekends
Conclusions

It is evident from Figure 2 that the load profile of households in Denmark is very differently influenced by the appliance categories. Some of the categories have a stable profile whereas e.g. lighting, dishwasher, TV has a large fraction of the consumption in peak hours (household peak).

The value of demand reduction is highest for the peak hours and therefore also the value of appliance efficiency increases is the highest for those categories that have the largest fraction of consumption in these hours. We therefore find that lighting, dishwasher; TV appliances are categories where annual efficiency increases should be supported (incentivised) more than for other categories with more stable load pattern (for example, freezers).

To some extent the peak load hours coincides with hours with high fossil fuel content, whereas other low demand hours will be dominated by renewable resources. An energy policy with a fossil fuel reduction objective should thus focus more on reducing consumption from these appliance categories than from others given that the (support) costs per annual reduction unit is similar.

Further work ongoing work link with a power systems model to determine the hour by hour fossil fuel reduction from savings (efficiency increase) in specific appliance categories in future policy scenarios.

References

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