SCENARIOS FOR THE GERMAN HEATING AND COOLING SECTOR: A MODELLING APPROACH INTEGRATING BUILDINGS, INDUSTRY AND DISTRICT HEATING

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Overview

For some considerable time, energy demand for heating and cooling has been identified as the largest energy demand sector. However, energy policy on European and national level has just focused on the sector for the last few years by integrating efficiency and renewable energy targets (RED *2009/28/EC*, EPBD (recast) 2010/31/EC). Thus, the German government has initiated the development of an integrated modelling tool of the German heating and cooling sector in order to identify perspectives to reduce energy demand and carbon emissions and increase renewable heating and cooling. Moreover, the tool should be able to investigate the impact of policy instruments on these future perspectives.
Against this background, the core objectives of this paper are:
1) Set-up of an integrated model of the German heating and cooling sector including buildings (residential and non-residential), industrial appliances and district heating. The model will allow to develop various scenarios of the heating and cooling sector projecting energy demand and use of renewable energy sources as well as the impact of policy instruments.
2) Development and discussion of scenarios of the German heating and cooling sector up to 2020
3) Discussion of the impact of various policy instruments
This paper has been written in frame of the project "Development of an integrated heating and cooling strategy", commissioned by the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety. The project is coordinated by Fraunhofer ISE and will be completed in September 2012.

Methods

The methodology for setting up an integrated model of the German heating and cooling sector is based on a soft link of five sector-models. All these sector models can be classified as techno-economic bottom-up models. Invert/EE-Lab covers space heating, hot water and air conditioning; ProcServ and ProcIndustry model the heating and cooling demand of the service and industry sector; the District Heating /CHP Model represents the German district heating sector including the corrosponding centralised supply technologies, whereas the CHP-Industry-Model comprises industrial CHP applications.

Invert/EE-Lab is a dynamic bottom-up simulation tool that evaluates the effects of different promotion schemes on the energy carrier mix, CO2 reductions and costs of support policies which target renewable heating installations as well as energy efficiency of builidngs. The core of the tool is a myopical, logit approach, which optimizes objectives of agents under imperfect information conditions. Invert/EE-Lab models the stock of buildings in a highly disaggregated manner. (see e.g. Kranzl et al., 2010, Müller et al., 2010).
ProcServ: The process heat and cooling demand of the German service sector has been methodically derived by the ProcServ model building strongly on the existing survey Schlomann et al. (2011). ProcServ calculates the process relevant fraction of the service sector's fuel (12 energy carriers) and electricity demand, differentiating the results for eight branches, heating and cooling uses as well as for three different temperature levels of the needed process cooling up to 2020.
Furthermore ProcServ gives information about investments, energy costs, maintenance costs, etc. in the different scenarios.
ProcIndustry: The process heat and cooling demand of the German industry sector is calculated with the bottom-up model Forecast/ISI Industry . The process heat demand in the industry was derived bottom-up based on specific energy demands of different industrial processes, the statistical energy consumption as well as technological knowledge and measuring results. *ProcIndustry*, a submodel of *Forecast* model, calculates the industry sector's fuel and electricity demand, differentiating the results for heating and cooling uses as well as for different temperature levels, lost heat, investments, energy costs, maintenance costs in the various scenarios.
The District Heating / CHP-Model bases on a typification of existing residential buildings and settlements and on an allocation of heat demand of the service sector within different settlement types. This allows to estimate the costs of district heating distribution in all main German cities (including the 614 largest cities of Germany). The cost calculation is based on

statistical data on municipal level taking into account, among other, typical cost per pipe meter, the expected increases in house connections, the development of spacial heat demand and existing district heating networks.
CHP Industry bases on the fact that the annual production period of a factory is depending on the number of employed persons. With the help of stastitical data and under consideration of special conditions of industrial branches it is possible to estimate the heat demand and the annual operation period of a suitable CHP-plant. There will be a CHP potential if the electricity generation cost is lower than the market prize.

Results

The results of the paper consist of two parts. The first part describes the structure of the model itself. The second part shows scenarios and the impact of different combinations of policy instruments addressing the heating sector. Figure 1 shows the structure of the integrated heating and cooling model and its interfaces. It turns out that the feed-back loops, e.g. between *Invert/EE-Lab* and the *District Heating / CHP-Model* can be covered in sufficient accuracy by one iteration between the models (which whill be shown in the full paper in more detail).

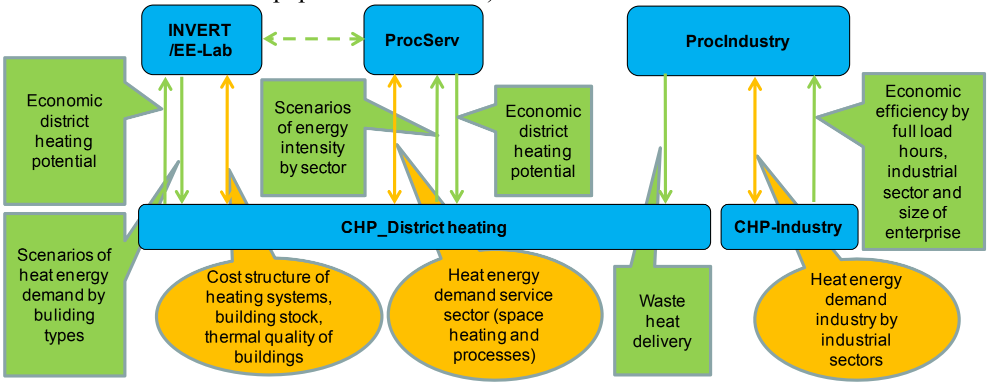

Figure 1. Structure of the integrated heating & cooling model

The scenarios show the development of overall and sectoral energy demand, energy carrier mix, share of renewable energy, CO2-emissions, investments, policy programme costs. Different policies are modeled that change the framework conditions in the heating and cooling sector. This concerns cross-sectoral instruments (such as ETS, energy taxes, technology standards) as well as approaches being target group, sector and technology specific. The list of modeled measures includes instruments that are currently on the political agenda (e.g. instruments proposed by the governmental energy concept from September 2010), approaches that proved to be successful in other countries as well as measures proposed by the project team. The *Frozen Policy* scenario analyses the effect of an extrapolation of the current policy framework in Germany until 2020. The results of this *Frozen Policy* scenario show a decline of total final enery demand for heating and cooling by 142 TWh from 1 588 TWh (in 2008) to 1 426 TWh (in 2020). Thereby, most of the energy savings (about 91 %) are realised in the building sector. The share of renewable energy source on heating and cooling demand increases to 9.5 % (6.8 % in 2008). In the building sector the share of renewable heating increases to 16.9 %. The underlying energy price projections are based on PROGNOS et al.(2010) which determines a moderate increase in consumer prices for fuels and electricity. In order to capture the effect of energy price development on energy savings and the development of renewable energy sources, an alternative high price scenario is calculated based on BMU (2011). The results show a decrease of the total final enery demand in the heating and cooling sector of 211 TWh with a 10.2 % share of renewable energy sources.

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