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Influence of massive heat-pump introduction on the electricity-generation mix and the GHG effect: Comparison between Belgium, France, Germany and The Netherlands

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Abstract

To evaluate the environmental impact of massive heat-pump introduction on greenhouse gas (GHG) emissions in different electricity-generation systems, dynamic simulations have been carried out for four European countries, namely, Belgium, France, Germany and the Netherlands. For this purpose, the simulations are performed with Promix, a tool that models the overall electricity-generation system. Three heating devices are considered for each country, namely classic fossil-fuel heating, heat pumps and electric resistance heating. Both direct heat-pump heating with a coefficient of performance (COP) of 2.5 and accumulation heat-pump heating with a COP of 5 are investigated. The introduction of electric heating in an electricity-generation system increases the demand for electricity and generates a shift of emissions from fossil-fuel heating systems to electrical plants. The results of the simulations reveal that the massive introduction of either heat pump or resistance heating is always favourable to the environment in France. The most environmentally friendly scenario in 2010 is projected to reduce GHG emissions by about 3.8 Mton compared to the reference scenario. In Belgium and Germany, the largest reduction in GHG emissions occurs with accumulation heat pumps. Belgium can save up to 220 kton of GHG emissions, while Germany can attain reductions of 800 kton in 2010. In the Netherlands, a significant reduction can be achieved

Abbreviations: CC, combined cycle; COP, coefficient of performance; GHG, greenhouse gases; IEA, International Energy Agency; kWh_e, electric kWh; kWh_{th}, thermal kWh; LHV, lower heating value

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by considering the addition of gas-fired combined cycle (CC) power plants, together with the introduction of electric heating, resulting in emissions savings of 410 kton.

Keywords: Heat pump; Greenhouse gas (GHG); Electricity-generation system; Belgium; France; Germany; The Netherlands; Dynamic simulation; Promix

Contents

1. Introduction

This paper compares the environmental impact of a massive heat-pump introduction for Belgium, France, Germany and the Netherlands. As has already been investigated in a previous paper [1], partly replacing classic fossil-fuel heating systems by heat pumps or electric resistance heating has an effect on the greenhouse gas (GHG) emissions. The increased demand for electricity due to a shift from conventional to electric heating will reallocate emissions from fossil-fuel heating systems to electric power plants. Apart from a reference scenario, direct heat-pump heating with a moderate system coefficient of performance (COP) of 2.5, accumulation heat-pump heating[1] with an elevated system COP of 5 and direct resistance heating are investigated for the years 2000 and 2010.[2]

In a general context, this study aims to provide a deeper insight on the interaction between electricity-generation systems and electricity demand. More specifically, the effect of the relation between demand-profile changes and varying electricity supply on the GHG emissions is studied. Just as in previous work done on this topic [1], where the Belgian electricity system was considered, the focus is now on the operation characteristics of the

[1]The idea of accumulation heating is the utilisation of electric power generated off-peak, mainly during night-time, for heating purposes during daytime.

[2]The choice of the years 2000 and 2010 should not be seen as a realistic timeframe for massive heat-pump introduction but rather as an indication on how the evolution of an electricity-generation system over a certain amount of time will impact the operation of the system and the ensuing emissions.