

Heat pumps and tradable emission permits: On the carbon dioxide emissions of technologies that cross a tradable emission market boundary

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Abstract

Since January 2005, there is a system with tradable emission permits/allowances in the European Union. Currently, power producers and district heating plants are included in the system, but not the residential sector. In this analytical study, it is discussed how a separation between a trading sector, in which power producers are participating and a non-trading residential sector affect carbon dioxide emissions consequences from heat pumps in households. It is concluded that a replacement of heat pumps in the residential sector results in a leakage of emissions. The emission target in the trading sector is partly achieved at the expense of increased emissions in the residential sector.

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1. Introduction

Space heating in households is one of the major energy users and also a major source of carbon dioxide (CO₂) emissions in many societies [1]. For this reason, it is of interest to find measures in households that can contribute to less energy use and/or less carbon dioxide emissions. However, residential energy systems are often connected to other energy systems. It might be district heating systems or/and the electric power generation system. In such cases, measures in residential sector energy use, interact with connected energy systems. Depending on the characteristics of the connected energy systems, different conclusions regarding the energy savings and/or emission reduction potential of measures might be possible. In a Swedish study different measures in a building is presented and compared [2]. In the study, the building is connected to a district heating system, which through combined heat and power is also connected to the power grid. The conclusions regarding CO₂ emissions depend on how the measures and district heating system interact with the power grid. Another study also highlights the interaction between energy systems with respect to the CO₂ consequences

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Nomenclature

CO ₂	carbon dioxide
TEP	tradable emission permit/allowance
<i>M</i>	carbon dioxide emissions in marginal power plant (kg/year)
<i>H</i>	carbon dioxide emissions in household before changing residential energy system (kg/year)
<i>I</i>	carbon dioxide emissions in industry before introduction of tradable emission permits (kg/year)
ΔH	change in carbon dioxide emissions at household due to change in residential energy system (kg/year)
ΔM	change in carbon dioxide emissions in marginal power plant (kg/year)
ΔI	change in carbon dioxide emissions in industry (kg/year)
$-D$	emission reduction to be achieved in the tradable emission permit system (kg/year)
<i>P*</i>	market equilibrium price of tradable emission permits (€/kg)
MC	marginal CO ₂ emission abatement cost (€/kg)
<i>T</i>	total CO ₂ emissions within system (kg/year)

Subscripts

HP	situation with a heat pump in household
Gas	situation with a gas heater in household
<i>I</i>	industry
<i>M</i>	power plant

Superscript

Sys	total system
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and costs of measures in households [3]. In an empirical study in Nova Scotia, it was concluded that the connection between the residential sector and the power sector is of importance for residential sector emission statistics [4]. The emission consequences of a decrease in the use of fossil fuels and an increase in electricity use in the residential sector were in statistics assigned to the residential sector and power sector respectively and a new method on how to calculate residential sector emissions is suggested. However, no study known to the authors, discusses CO₂ consequences of residential energy measures in a context where the power and/or district heating plants are included in a tradable emission permit system.

Since January 2005, there is a system with tradable emission allowances¹ (TEP) in the European Union (EU) [5]. One important feature of the TEP system implemented in the EU is that, currently, not all parts of the energy sector are obliged to have emission permits for their CO₂ emissions. The TEP system includes² approximately 12,000 plants within the EU. These plants are thermal combustion plants, process industries like pulp and paper, steel and glass industries, district heating systems etc. The residential sector is not participating³ in the EU emission trading system and other policy instruments, like taxes, are applied on fuels used for residential heating. With a technology like heat pumps, the heat is used in the residential sector, which is not part of the TEP system, and power to the heat pump is produced in the power sector, which is a part of the TEP system. Heat pumps in households will thus provide a link between the trading sector and the residential sector as illustrated in Fig. 1, or in other words, the heat pump will cross the boundary between the trading and the non-trading sector. The above reasoning has the implication that due to measures in residential energy system, emissions can be transferred, not only between the residential and the power sector, but also between the emission trading sector and the non-trading sector.

¹ In the rest of the study, the term tradable emission permit (TEP) is used.

² With participating and included in the TEP system means that actors are obliged to present as many permits to the regulatory authority as they have released emissions during a specified time period.

³ It is possible to participate on a voluntary basis.

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