***Decarbonisation of energy consumption through electrification : right or wrong ? The case of heating in France.***

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## Overview

In a context of growing climate concerns, several countries have set targets to achieve zero greenhouse gas emissions levels or at least significant emissions reduction. In addition to the deployment of low-carbon energies in order to shift towards a low-emitting energy mix, an increasing number of policies encourage emissions reduction through action on the demand side. In France, the National Low Carbon Strategy was announced in January 2020, and presents the French strategy to be carbon-neutral in 2050. It relies on reducing significantly energy consumption through energy efficiency and sobriety, and decarbonising energy use through biomass and electrification - since power generation is mostly decarbonised in France.

Among major GHG emission sources is heating, which represents more than two thirds of emissions from the building sector. Heating is already extensively electrified in France, where 40% of households have electric heating, mostly equipped with Joule heating – a higher share than in most European countries. The French Low Carbon Strategy aims at reducing emissions from heating through both energy efficiency and electrification, as ambitious targets have been set for buildings insulation improvements and electric heat pumps penetration rather than Joule heating. However, given the seasonal consumption profile of electric heating, there is a concern that increasing the share of electric heating might actually trigger more emissions. In terms of daily demand profile, electric heating is a baseload demand in winter; throughout the year though, it creates a seasonal peak at the heart of winter and rises significantly the thermosensitivity of electricity consumption, while offering limited flexibility in terms of demand response. As a result, there is a significant possibility that additional electric heating might rely mainly on flexible fossil fuelled power generation, in France or from imports, which could actually trigger more emissions than gas heating in a traditional boiler given heat losses in fossil fuelled power plants. Currently announced energy efficiency objectives are ambitious. However, recent trends have shown that building renovations - whether in terms of insulation or change of heating system - especially in the residential sector, actually occur quite slowly and are far from being on track to meet the government’s targets. In a low efficiency context, electrification of heating could thus lead to amounts of electricity consumption that would be significantly higher than the ones projected by the French Low Carbon Strategy.

In light of these issues, this paper offers a quantitative assessment of the impact of further electrification of heating in France in terms of CO2 emissions. Two main scenarios are studied : a scenario where the electrification takes place in a high energy efficiency context, provided that all the targets in terms of insulation and heat pumps sales have been met, and a scenario where the electrification takes place in a low energy efficiency context, where targets have not been met. In the second scenario, thermal insulation of buildingsfollows a business-a-usual trend, and so does the penetration of heat pumps - electrification thus mostly occurs through the installation of Joule heating systems. Intermediary scenarios are considered, where only one of the energy efficiency targets has been met: insulation of buildings or heat pump penetration. For these scenarios, the reference electricity mix is the one planned by the government’s Pluriannual Energy Program (‘PPE’), and variations around this scenarios are modelled – ‘reduced mix’ or ‘extended mix’ according to the amount of electrification.

## Methods

The study relies on a detailed bottom-up modelling of French electricity consumption and of the European electricity system, both robusts tools used for the elaboration of RTE’s yearly adequacy reports.

The bottom-up modelling of electricity consumption includes more than 30 electricity uses. Seasonal, weekly, daily, hourly demand variation are modeled for each use based on the extensive observation of historical data and past demand profiles. The thermosensitivity of the French electricity demand is addressed by using 200 climate scenarios generated by Meteo France’s ARPEGE climate model (national weather organisation) to represent climate variability. In the building sector, the modelling of heating consumption includes a thorough description of the rebound effect usually associated with energy efficiency improvements (whether insulation or a new heating system).

The European electricity system is modelled with RTE’s tool ANTARES – a probabilistic software simulating the hourly electricity demand and supply equilibrium. The French electricity system is modelled power plant by power plant with refined representation of their hourly disponibility; 18 neighbouring countries and their interconnections are modelled based on ENTSOE’s and national utilities’ data.

The scenarios considered in this study were quantitatively built and simulated with these tools, resulting in quantitative assessments of each scenario’s impacts in terms of CO2 emissions.

## Results

First results show that in a context of high energy efficiency, electrification of heating appears to reduce CO2 emissions while improving significantly consumers’ heating comfort. Lower energy efficiency scenarios show mixed results. The electrification scenario where no energy efficiency target still results in some emissions reductions, but with contrasted effects in terms of comfort for the users and also with a significantly highel level of constraint on the electricity mix.

## Conclusions

If the successful implementation of all measures in energy efficiency and electrification of heating conducts unsurprisingly to the reduction of greenhouse-gas emissions, missing some of the key targets will still bring some emissions reduction, but will not allow to achieve the target in terms of CO2 emissions reduction. Beyond the particular case of heating, this study shows that any decarbonisation measure relying on electrification is closely tied to all measures impacting the electricity systems : potentially significant variations on electricity consumption such as electric vehicles penetration or electrification of hydrogen production, risks on power capacities… Decarbonisation of energy consumption through electrification should thus always be studied within the whole electricity system and through multiple complementary studies on all related energy uses.

## References

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