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

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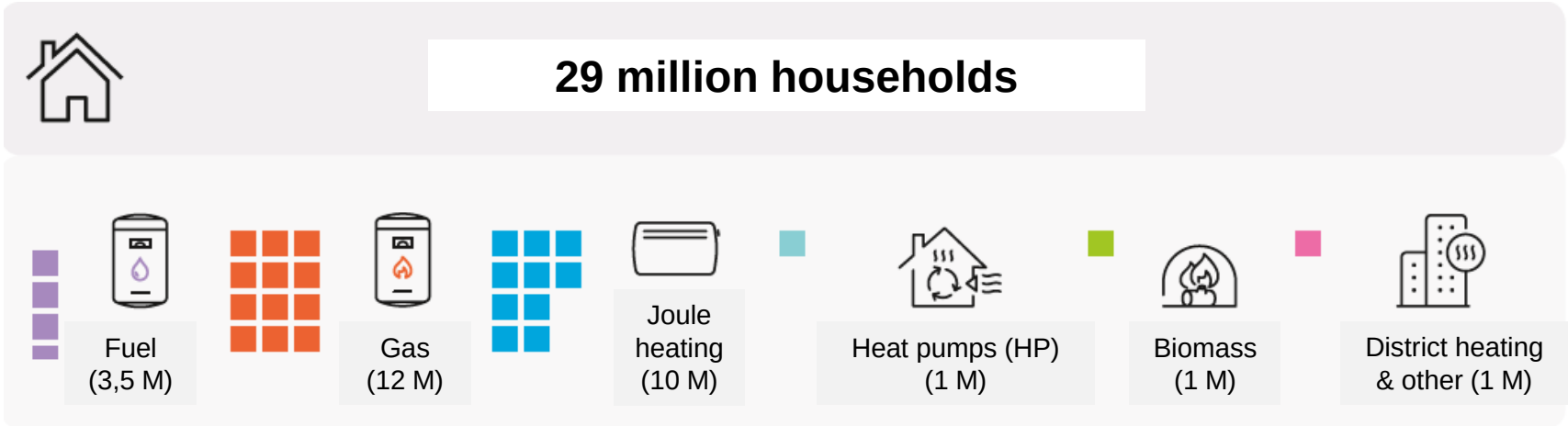
Context

Context (1/2):

Today, French households rely mostly on gas (~40%) and electricity (~40%) for heating



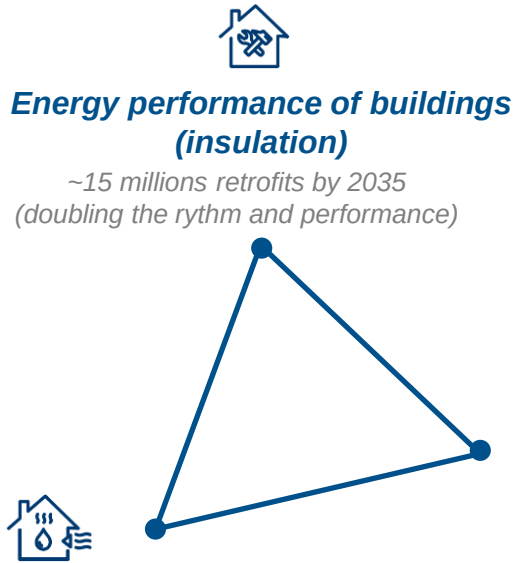
Source : CEREN

The National Low-Carbon Strategy in France aims at reducing emission generated by heating through ambitious renovations, and through the shift to low carbon energies : biomass and electricity (since power generation is 93% low carbon in France).

In particular, **electricity for heating should increase from 16% of final energy demand for today, to 28% in 2050,** mostly through the use of **heat pumps.**

Context (2/2) :

The National Low-Carbon Strategy relies on 3 measures to reduce CO_2 emissions from heating in the building sector



Energy performance of buildings (insulation)

~15 millions retrofits by 2035
(doubling the rythm and performance)

Shift from fossil fuels to low-carbon energies for heating, including electricity

Households with electric heating : from 40% today to 50% in 2035

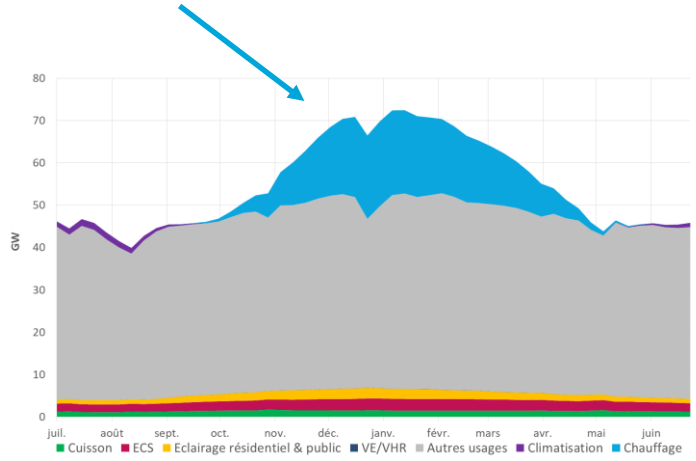
High efficiency heating systems

Heat pumps rather than Joule heating

Source : MTES, SNBC 2020.

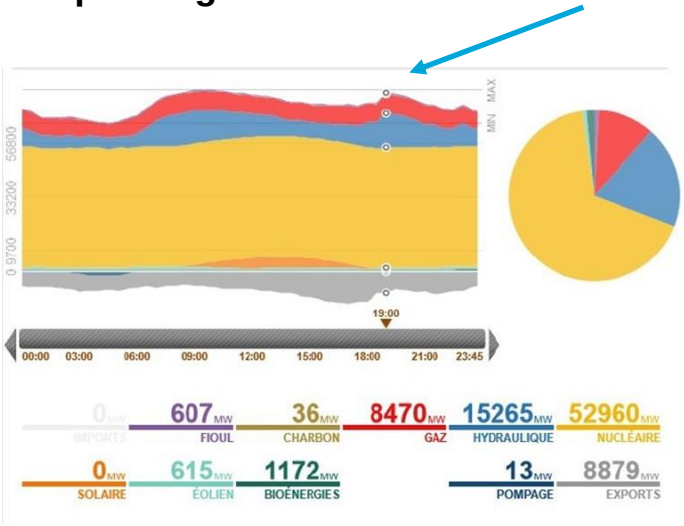
Electrification of heating may raise some concerns…

- **Regarding security of supply : it may increase the winter peak**



RTE, 2017

- **Regarding emissions : it may activate fossil fuelled power generation**



Is electrification of heating efficient to reduce emissions ? With which effects on security of supply ? At what costs ?

*As the French electricity transmission system operator, **RTE** has a **legal duty** to ensure **real-time adequacy** between electricity supply and demand and to **provide long-term scenario analyses** to anticipate major changes in the power system, such as the development of renewable energy sources or the massive development of electric uses: e-mobility, hydrogen, **heating**...*

Objectives

1. Analysis of the technical impacts of the development of electric heating on security of supply - consumption and peak demand

2. Environmental impacts on CO2 emissions

3. Economic analysis

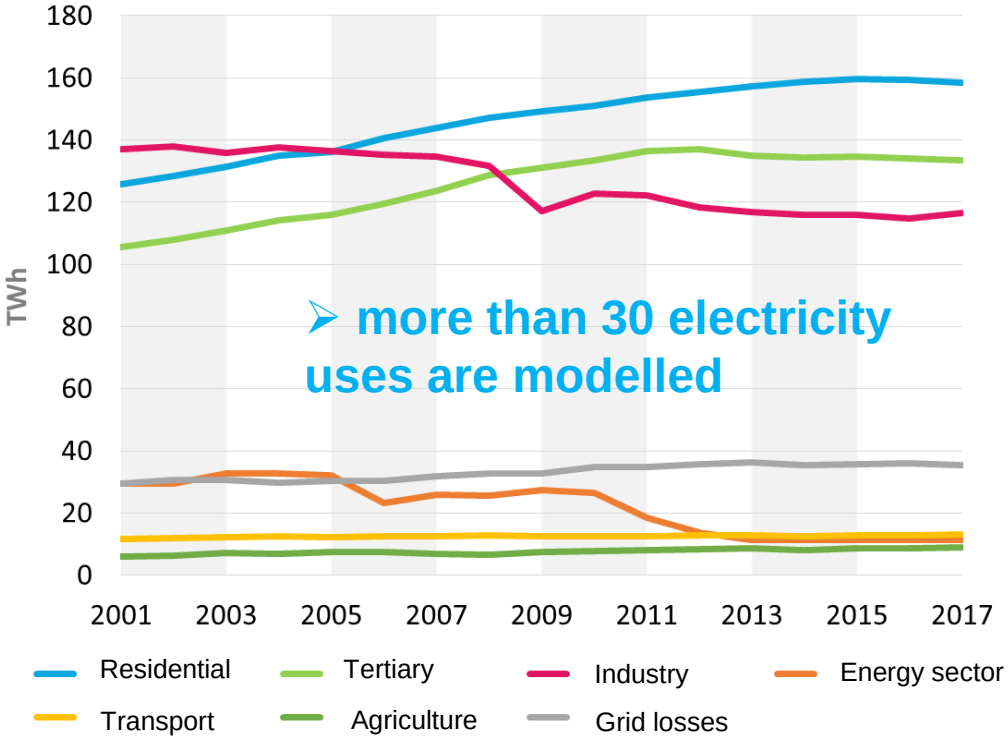
Outline of the presentation

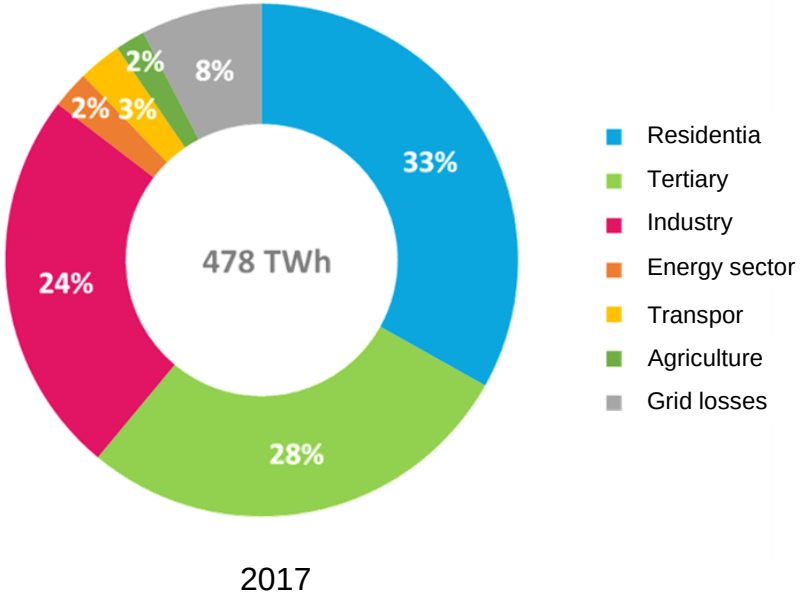
02

Models and method

Consumption model Amadeus : Bottom-up modelling of electricity consumption by sector

Evolution of electricity demand per sector

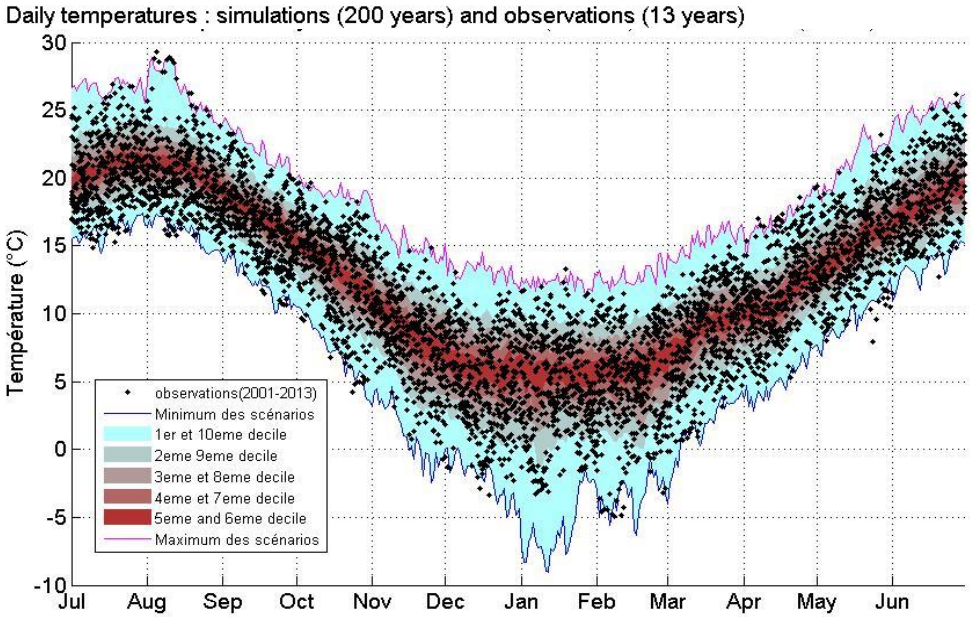




Corrected from meteorological variations & leap years

Modelling of the sensitivity of electricity consumption to meteorological conditions

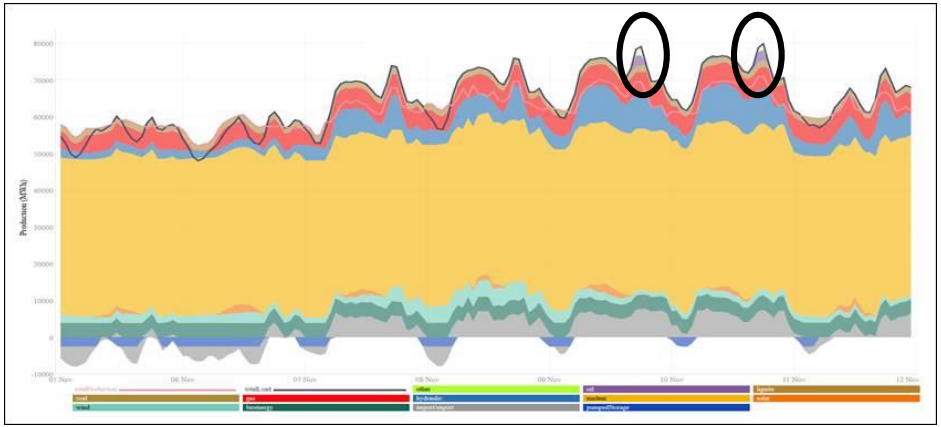
200 scenarios generated by ARPEGE Climat model (Meteo France, national weather organisation)

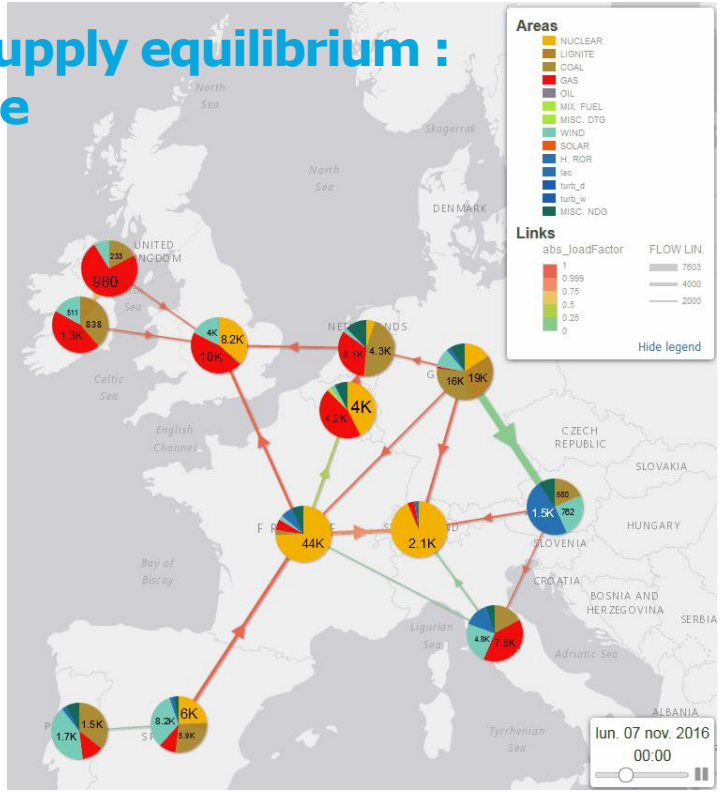


Modelling of hourly demand and supply equilibrium : ANTARES – a probabilistic software

For each scenario studied, ANTARES **optimizes the unit commitment** in order to meet the demand at the lowest cost.

- Analyses in terms of security of supply, CO_2 emissions and economics





Exchanges between neighbours are possible, within the limits of the **network**. 18 countries are modelled in the latest version of the model

Method

Inputs

Evolution of the power generation mix

Evolution of electricity consumption for heating

Evolution of electricity consumption for other uses (EV, H2…)

Simulation of the electricity system through an hourly model

Outputs

CO_2 emissions

Impact on winter peak

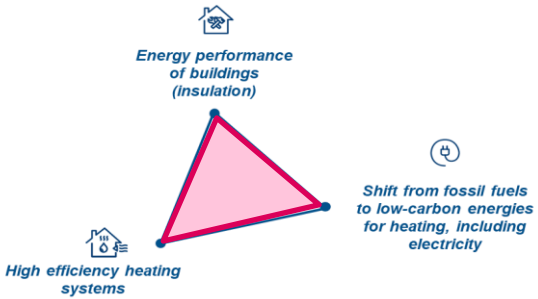
System costs

03

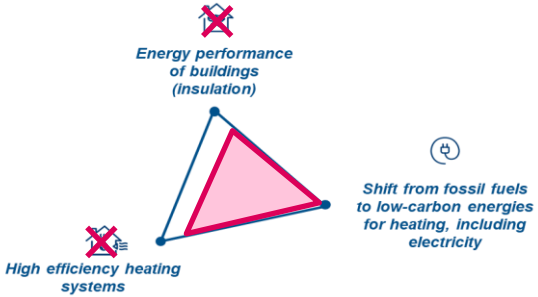
Scenarios

Focus on three scenarios

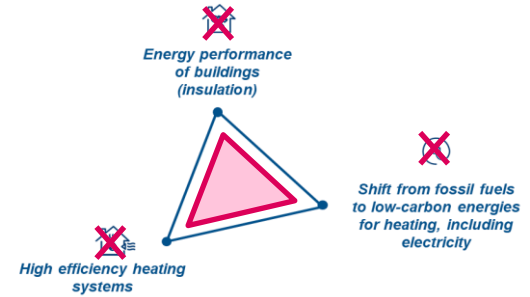
If all measures are implemented – reference scenario



If efficiency targets are not met



If all targets are not met: efficiency & electrification



04

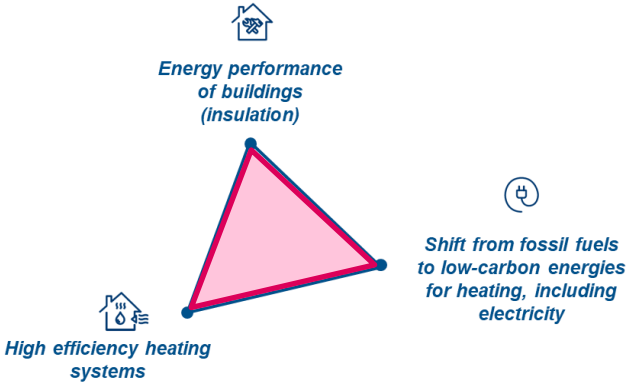
Results

4.1

Technical impacts on the electricity system : peak and consumption

If all measures are implemented

➢ **Impacts on the electricity system are negligible**



On electricity consumption

\+ • Electrifying an additional 10% of households with heat pumps, compared, increases slightly electricity demand

\- • Retrofits on half of buildings reduce energy demand for heating (even if there is a rebound effect)

= • Electricity demand for heating is stable

Annual electricity consumption for heating (adjusted for climatic differences)

Today	2035 (reference scenario)
61 TWh	58 TWh

(about 12% of total electricity demand)

On winter peak:

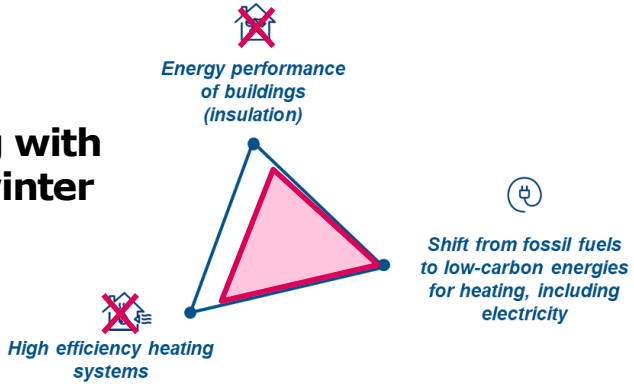
• Slight decrease as well

"One in ten" peak demand

Today	2035 (reference scenario)
~100 GW	-3 GW

If efficiency targets are not met:

Failing to achieve the retrofit target and electrifying with Joule heaters instead of heat pumps may rise the winter peak and bring constraints to the electricity system



On electricity consumption

- Compared to the reference scenario, electricity consumption for heating would increase by 10 TWh
- Such an amount of energy does not represent any difficulty for the electricity system

***Annual electricity consumption for heating** (adjusted for climatic differences)*

Today	2035
61 TWh	72 TWh

On winter peak:

- The winter peak would increase by several GW compared to today's levels

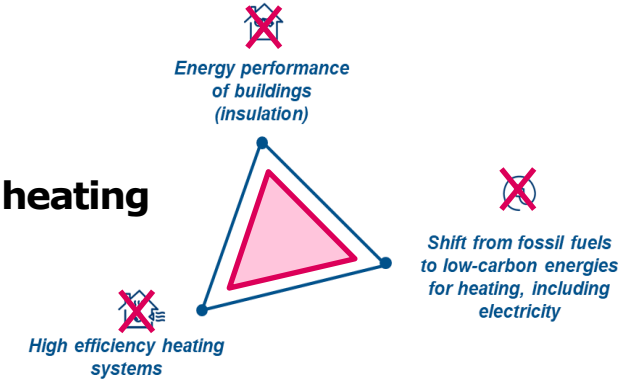
➢ Higher need for flexibility

"One in ten" peak demand

Today	2035
~100 GW	+6 GW

If all targets are not met (efficiency & electrification):

Failing all three targets (efficiency of buildings and heating systems, electrification) does not generate much constraint on the electricity system



On electricity consumption

- Compared to the reference scenario, electricity consumption for heating would increase by 5 TWh, by implementing only a business-as-usual electrification
- Such an amount of energy does not represent any difficulty for the electricity system

Annual electricity consumption for heating (adjusted for climatic differences)

Today	2035
61 TWh	63 TWh

On winter peak:

- The winter peak would slighly increase

➢ No major need for flexibility

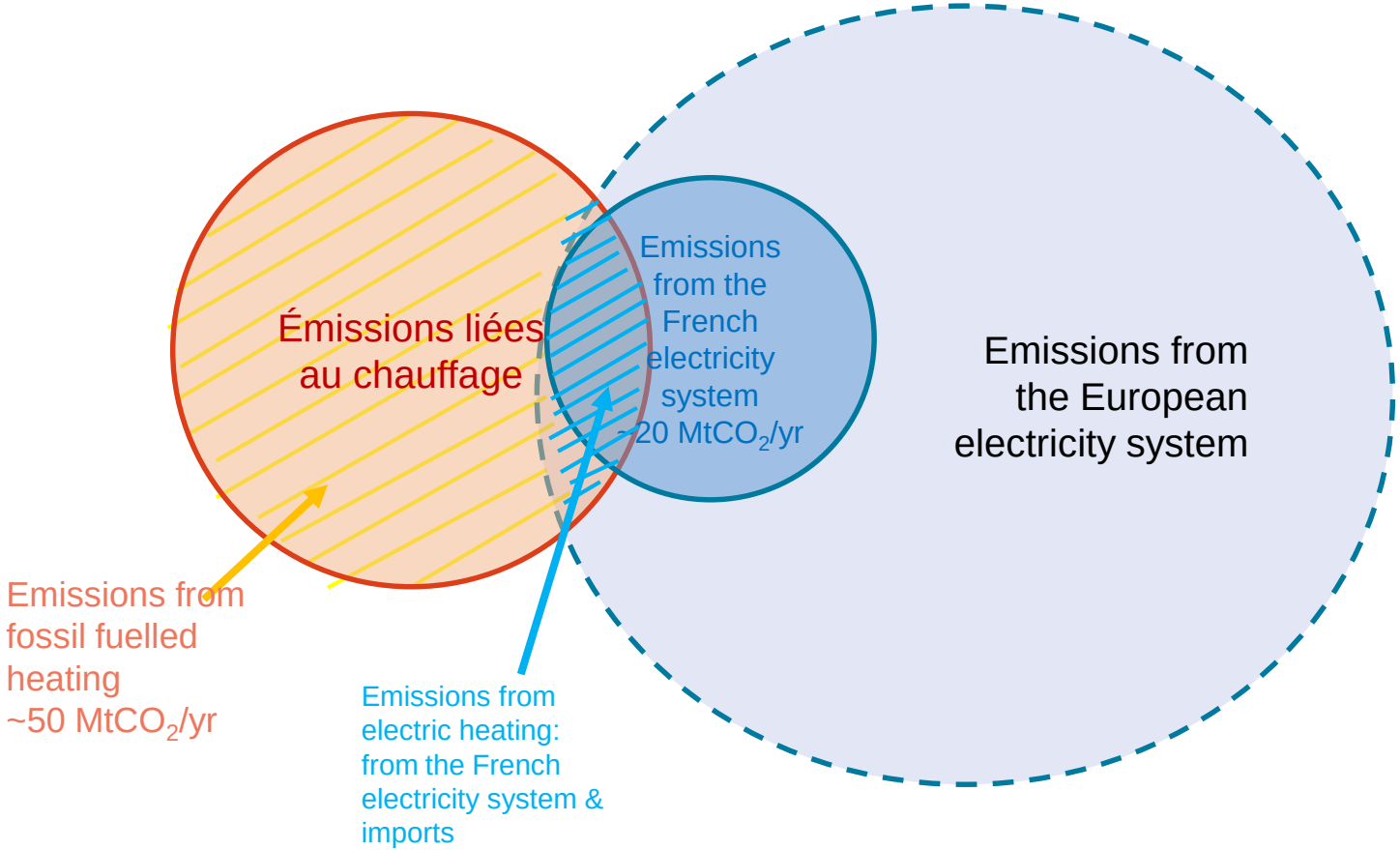
"One in ten" peak demand

Today	2035
~100 GW	+2 GW

4.2

Environmental impacts: CO2 emissions

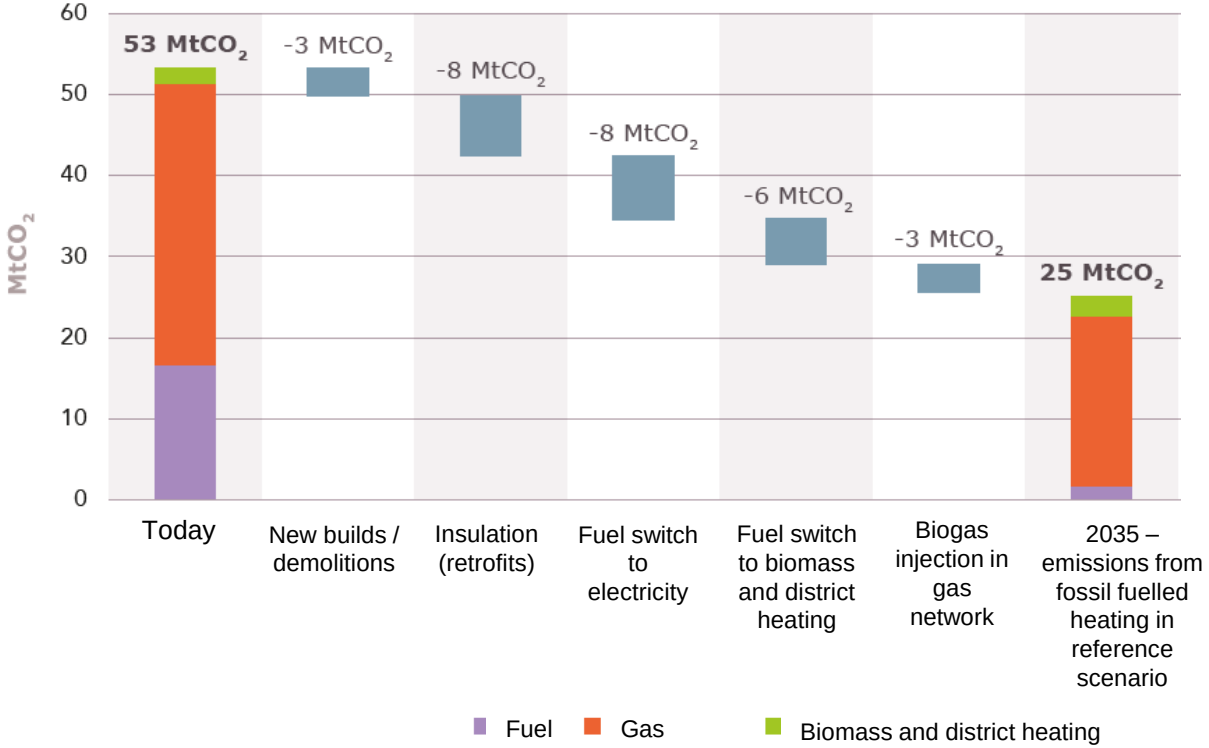
Emissions from heating are particularly difficult to assess



If all measures are implemented

Decomposition of emission reduction from fossil-fuelled heating

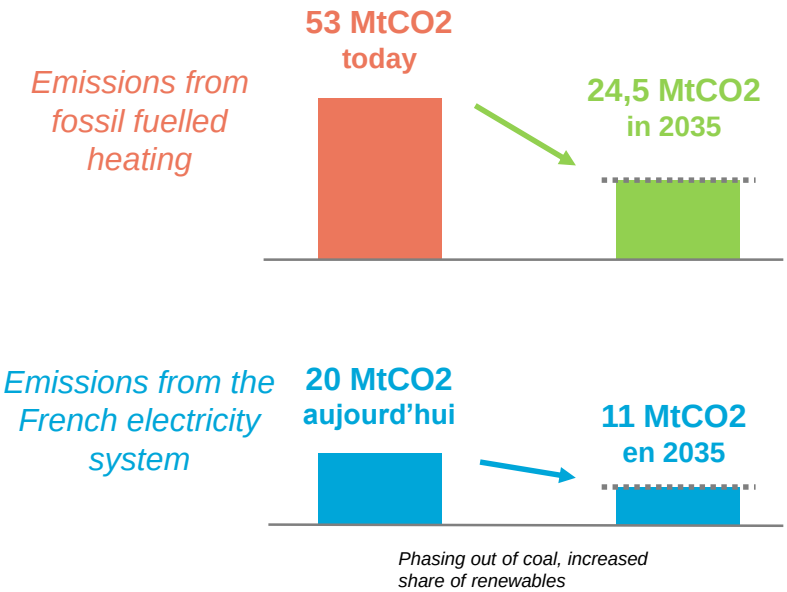
Main sources for CO_2 emission reduction expected from the implementation of all measures



If all measures are implemented

The CO_2 emissions reduction target is achieved

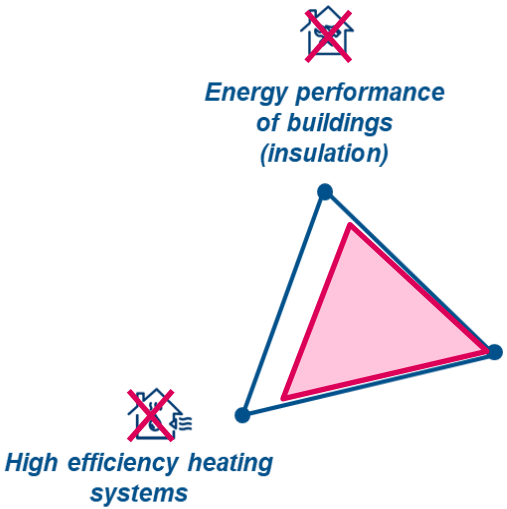
- CO_2 emissions from fossil fuels are divided by two by 2035 (halfway from the zero emission target in 2050)…
- … without increasing emissions in the electricity sytem in France…
- … and even counting emissions on the European level (no increase in imports)

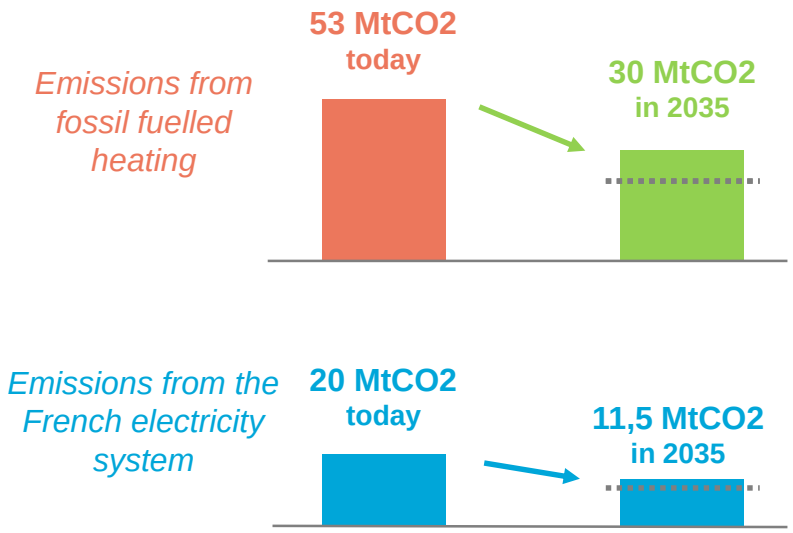


→ **In the reference scenario of the National Low Carbon strategy, there is no carbon leakage towards other countries due to the electrification of heating.**

If efficiency targets are not met:

Failing to achieve the retrofit target and electrifying with Joule heaters instead of heat pumps generates
→ 6 additional millions de tons of CO_2 in France compared to the target

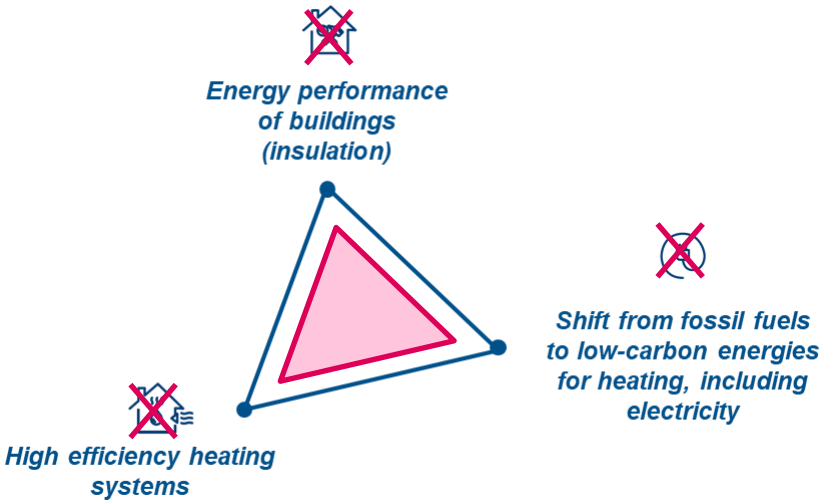


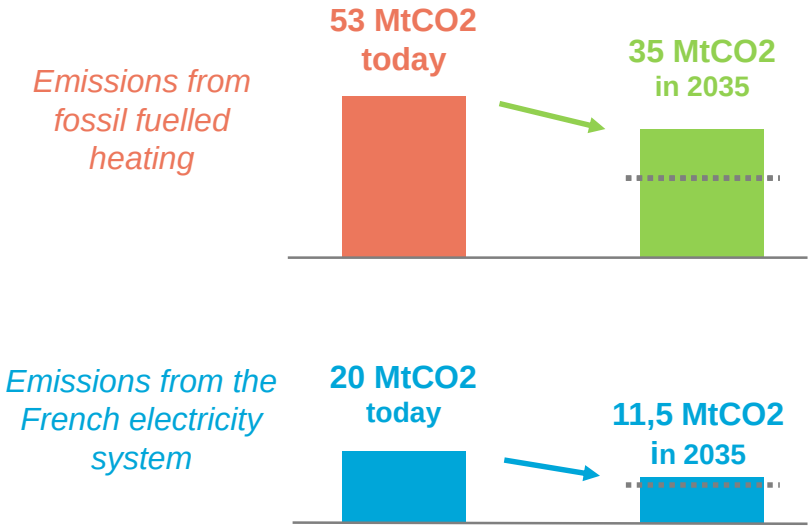


+ ~6 $MtCO_2$ / year in France
(mostly from fossil-fuelled heating – less retrofits)
+ ~11 $MtCO_2$ / an in Europe
(including France – increase in fossil-fuelled generation oustide of France)
in 2035, compared to the reference scenario

If all targets are not met (efficiency & electrification):

Failing all three targets (efficiency of buildings and heating systems, electrification) does not generate much constraint on the electricity system but causes
→ 11 additional million tons of CO_2 in France compared to the objective





+ ~11 $MtCO_2$ / year in France
(mostly from fossil-fuelled heating – less retrofitss & less fuel switch)
+ ~14 $MtCO_2$ / an in Europe
(including France – increase in fossil-fuelled generation oustide of France)
in 2035, compared to the reference scenario

4.3

Economic analysis

Economic analysis – cost assumptions

Costs assumptions based on retrofit literature

- Retrofit cost assumption: 100 – 160 €/m^2 (calculated based on ADEME, 2019)
- Average costs for heating systems (ADEME, 2019)

Heating system	Average price (excluding tax)
Air-water heat pump	13 000 €
Air-Air heat pump	8 000 €
Water-water heat pump	16 000 €
Gas boiler	6 000 €
Joule heater	400 € (~3 600 € for an average household)
Biomass boiler	12 500 €
Fuel boiler	8 500 €

Economic analysis

Economic perspectives

- Such measures are costly : ~430 €/tCO2 for the reference scenario
- Focusing on electrification through heat pumps only is economically more attractive (~100 €/tCO2) but not sufficient to achieve the target
- Focusing on the most energy consuming buildings seems economically relevant (~290€/tCO2)
- Energy efficiency also includes an increase in comfort with a rebound effect: without the rebound effect in the reference scenario, the abatement cost becomes 240 €/tCO2

Conclusions & perspectives

- **All measures** need to be implemented to achieve the target in terms of CO_2 emissions
- Avoided emissions from fossil fuelled heaters **are not transferred** to the electricity system either in France or Europe
- Each individual measure has an impact on emissions reductions
- But retrofits and energy efficiency in buildings in general seem costly: multiple benefits beyond energy savings and emissions cuts that are difficult to quantify

Thank you for your attention