European Climate Foundation

Modelling the socioeconomic impacts of zero carbon housing in Europe (update)

A rerun of the study published in 2022

Final Report

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Cambridge Econometrics
Cambridge, UK

info@camecon.com
www.camecon.com

Contact person: Stijn Van Hummelen [svh@camecon.com]

Authors: Pim Vercoulen [pv@camecon.com], Francisco Arsenio [fa@camecon.com], Sachin Gulati [sg@camecon.com], Stijn van Hummelen [svh@camecon.com] (Cambridge Econometrics)

Project director: Stijn Van Hummelen [svh@camecon.com]

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List of acronyms

Acronym	Description
APP	Apartments. More than 4 floors.
BA	Baseline heat supply. Refers to a scenario setting.
BSM	Building stock model.
E3ME	Energy-Economy-Environment Macro-Econometric model.
ECF	European Climate Foundation.
EHPA	European Heat Pump Association
ETS	Emission Trading Scheme, applies to industry sectors.
ETS2	Emission Trading Scheme, applies to households and transport.
FTT	Future Technology Transformations.
HE	High Electrification. Refers to a scenario setting.
HEE	High Energy Efficiency. Refers to a scenario setting.
HP	Heat Pump
LEE	Low Energy Efficiency. Refers to a scenario setting.
MFH	Multi-family home. Less than 4 floors.
SFH	Single-family home.
TCO	Total cost of ownership
WRR	Weighted renovation rate for all of the EU.

1 Introduction

1.1 Objectives and scope

In February of last year, the European Climate Foundation and Cambridge Econometrics published a study on the "*Socioeconomic impacts of zero carbon housing in Europe".* The primary objective of that study was to investigate impacts of renovating the European housing stock in combination with several residential heating technology uptake scenarios. For that study a building stock model (BSM) was developed, and its outputs were fed into E3ME, the inhouse macro-econometric model developed and maintained by Cambridge Econometrics. All scenarios and inputs were determined through literature review, model simulations, and stakeholder consultations with prominent organisations in the field of renovations, energy, and heating technologies.

The main conclusion from that study was that electrification of the heat supply in combination with greater efforts to renovate the housing stock led to overall the greatest social, economic, and environmental benefits compared to hydrogen-based heating solutions or a mix of electrification and hydrogen-based heating. The results were driven by large-scale savings in final energy demand which led to reduction in energy bill payments for European households. These savings in spending on heat can unlock spending in other non-energy goods and services, promoting economic growth in the long-run.

The unexpected war in Ukraine and rebound effects from the Covid-19 pandemic have led to energy price inflation which has important implications on forward-looking studies such as this one. This new report presents the results of an updated modelling exercise that consider recent events, in particular:

- Increased fossil fuel prices, using two potential representations of future energy prices based on the fossil fuel price projections presented in the REPowerEU plan;
- The heat pump (HP) deployment targets implicit to the growth targets suggested by the REPowerEU plan;
- A revised projection for the ETS2 price, in line with the recent decision to postpone the implementation of ETS2 to 2027 and set a cap of the ETS2 price of 45 €/ ton carbon up to 2030 (Euractiv 2022).

The High Electrification scenario has been updated to incorporate these changes. All other assumptions have remained unchanged, and the High Gas Scenario has not been reassessed. **The objective of these revisions is to understand the impact that large-scale energy efficiency improvements and heat pump (HP) deployment could have, considering changed fossil fuel price projections.**

In the results presented in this report, we consider EU-27 and consider the time horizon up to 2050, with a special emphasis on results by 2030.

1.2 Modelling approach

Like the previous study, this analysis is based on a three-stage modelling framework:

- First, the building stock model was to estimate the demand for heating and the effect of renovation assumptions. The BSM tracks dwelling characteristics for 21 building archetypes (age and type) based on demographic developments, historical renovation rates and depths, climate conditions,
- Second, a heat supply model was used to allocate heating technologies on a Member State level based on exogenous EU-wide technology trajectories. A system of allocation rules was developed to disaggregate the results from an EU-wide level to MS level.
- Third, the outputs of the BSM and heat supply model were used as inputs to E3ME to determine the socioeconomic impacts. E3ME follows a macro-econometric approach to determine the impacts due to renovation investments, energy use, carbon costs, and energy prices. For more information, please consult the E3ME Model Manual[1].

Incremental technology innovation was obtained from the EU Reference Scenario 2020. Estimating future technology costs or efficiencies is not without issue as it requires an estimation of learning-by-doing and economies of scale effects. The incremental learning applied in this study is modest compared to other studies (e.g. Knobloch et al. (2017)). Therefore, it is deemed that the estimates in this study are conservative.

A more detailed description of the methodology can be found in the technical report of the previous study[2].

This study considers various scenarios by mixing assumptions on Net-Zero, renovation efforts, heat supply deployment, and fossil fuel price shocks. Net-Zero measures include a representation of a decarbonised power generation sector, a carbon tax on top of the ETS price on electricity generation, and a representation of the new ETS2 price projection for households. Renovation efforts knows two variants, low and high. Heat supply deployment is either a baseline representation without a technology transition and a scenario with increased uptake of HPs. Lastly, we expose the EU economics to 2 sets of energy price projections: one that is in line with the REPowerEU report (EC 2022) and one adaptation of that projection where fuel prices reach a plateau followed by a slower decline. See Chapter 2 for more detail.

HP deployment is different in this study compared to the previous. Based on projections by the European Heat Pump Association (EHPA), estimates were made for HP uptake up to 2050. These projections show significantly higher HP diffusion than the one assumed in the previous study.

1.3 Limitations

This study focuses on the socioeconomic impacts due to decarbonisation of the European housing stock and makes use of several computer models to provide insights. Models can be insightful, but they can also be misleading when misused. The modelling performed in this study relies heavily on data and therefore data quality and availability are noteworthy limitations in this study. The building stock model applied here builds on past trends and can

[1] See: https://www.e3me.com/what/e3me/

[2] See: (European Climate Foundation 2022, Cambridge Econometrics 2022)

mimic those trends. However, due to the reliance on data inputs, there are discrepancies between regions due to data availability.

A more in-depth discussion of the limitations can be found in the report of the previous study. In short, the models used here lack detail on the consequences on infrastructure due to the imposed transitions. Energy efficiency improvements can lead to a rebound effect and thereby negating some of the environmental benefits. Other aspects are out of scope of this study. Land-use impacts due to biomass consumption are not covered in this study. Similarly, socio-environmental externalities due to exposure to pollutants are not included. The macro-economic modelling can report on employment impacts but lacks a treatment of skills. Therefore, the results are agnostic of reskilling requirements needed to support any transition simulated in this study.

Furthermore, it is vital to note what this study does show and does not show. We are not calculating the likely heating technology deployment. Instead, we are imposing deployment scenarios. This study considers Net-Zero settings of the power sector, but not of the whole EU economy. The reason is to focus on the impacts heat decarbonisation, including the downstream power sector. A full Net-Zero scenario would make it difficult to isolate impacts due to renovation and heat supply scenarios.

1.4 Chapters

Chapter 2 summarizes the scenario design and focusses on the building stock, heat supply, and energy price sensitivities. The outcomes of the scenarios are presented in Chapter 3. When presenting the socioeconomic impacts, we will compare results in a staged manner to investigate the impacts of various scenario assumptions in isolation. First, the impacts of including Net-Zero measures are isolated and compared to the reference scenario of the previous study. Second, the isolated impacts of the 2 inflated energy price projections are depicted. Third, the impacts of transitioning the heating technology and ramping up renovation efforts are compared for each energy price scenario. This represents two levels, so in total there are four levels of results. Lastly, chapter 4 highlights the key conclusions from the report.

2 Scenario design

2.1 Scenario overview

In this study we present several scenarios containing various combinations of policies and assumptions. First, we consider the effects of a Net-Zero power sector, aligned with a carbon tax on top of the ETS for industry to facilitate decarbonisation, and include the ETS2 for consumers. Second, we consider two renovation waves. One that is in line with the current renovation rate observed in the EU with an anticipated amplification around 2030 (from 1% to 1.5%), and one that shows an even greater amplification (from 1% to 3.5% pa). Third, we impose two representations of heat supply technology uptake upon the system. One shows constant market shares of technologies but includes a phase out of the inefficient non-condensing boilers. And one that includes the HP projections obtained from the EHPA based on the European Commission's REPowerEU targets. Fourth and lastly, we consider three energy price projections. The first is in line with the EU Reference Scenario 2020 and was the one used in the previous study. Then, there are two variants showing inflated energy price levels. Projection A follows the projections for fossil fuels as published in the REPowerEU document. Projection B is an adaptation therefore with a short plateau of high gas prices and slower decline thereafter.

Table 2-1: Overview of scenarios and scenario settings. Bold-faced scenarios are used as reference cases for various socioeconomic variables in the results section.

Scenario designation	Power sector & ETS2	Renovation rate	Heat supply	Energy prices
REF-LEE-BA-O	**EU Ref**	**Low**	**Baseline**	**EU Ref**
REF-LEE-BA-A	EU Ref	Low	Baseline	Projection A
REF-LEE-BA-B	EU Ref	Low	Baseline	Projection B
NZ-LEE-BA-O	**Net-Zero**	**Low**	**Baseline**	**EU Ref**
NZ-LEE-BA-A	**Net-Zero**	**Low**	**Baseline**	**Projection A**
NZ-LEE-BA-B	**Net-Zero**	**Low**	**Baseline**	**Projection B**
NZ-LEE-HE-A	Net-Zero	Low	High Electrification	Projection A
NZ-LEE-HE-B	Net-Zero	Low	High Electrification	Projection B
NZ-HEE-BA-A	Net-Zero	High	Baseline	Projection A
NZ-HEE-BA-B	Net-Zero	High	Baseline	Projection B
NZ-HEE-HE-A	Net-Zero	High	High Electrification	Projection A
NZ-HEE-HE-B	Net-Zero	High	High Electrification	Projection B

2.2 Net-Zero electricity and carbon costs

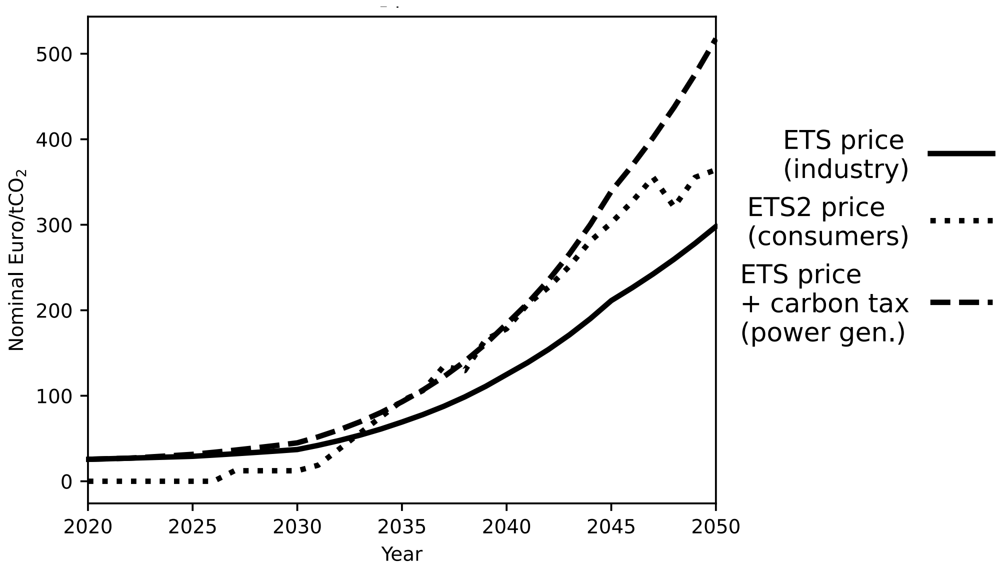

Figure 2-1: ETS, ETS2, and carbon tax inputs, applied to all Member States, 2020-2050, in nominal Euro/tCO$_2$.

An emission trading scheme (ETS) is already in place in the EU for selected industries. In the future another ETS will be implemented for consumers (ETS2). The ETS2 will target emissions due to transport and heating and therefore is important to incorporate in this study. The finalised negotiations on the ETS2 noted that the implementation will be delayed until 2027 and that up to 2030, the aim will be to keep the price at or below 45 €/ ton carbon up to 2030. Thereafter, we follow the year-on-year growth projection that was used in the previous study. The ETS for industry applies throughout all scenarios as that has already been put in place. The ETS2 is only implemented in scenarios that have the Net-Zero assumption for the power sector. In a Net-Zero power sector setting, we apply an additional carbon tax to facilitate the decarbonisation of the power sector. See Figure 2-1.

Electricity supply plays a paramount role in any scenario that involves electrification of the heat supply. A power sector that is Net-Zero in emissions provides the additional benefit of preventing indirect emissions due to electricity consumption. The technology configuration in the power sector for the baseline and Net-Zero assumptions have not changed since the last study. See Figure 2-2.

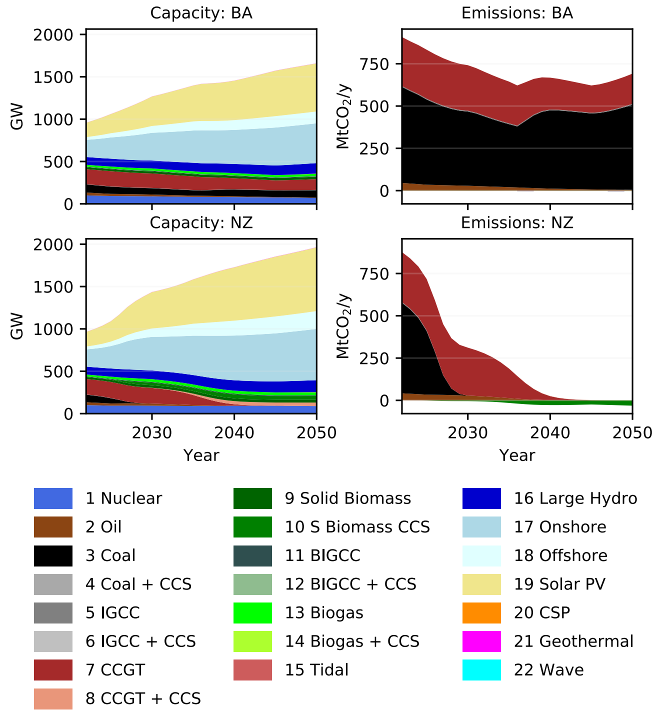

Figure 2-2: Power generation capacity and emissions by technology, EU aggregate, 2020-2050, in GW (left column) and $MtCO_2/y$ (right column)

2.3 Building stock and renovations

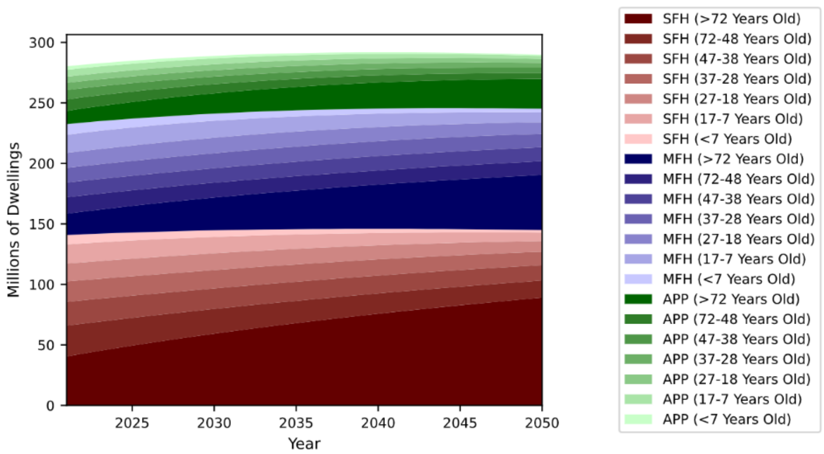

Figure 2-3: Development of archetypes, EU total, 2022-2050, million dwellings.

The development of the building stock in the EU is based on demographics, urbanisation rates, area per dwelling projections, and heat-degree days/cooling-degree days projections. The BSM provides two main outputs: a representation of the building stock composition by archetypes (see Figure 2-3) and the energy need for heating as an aggregate of hot water and space heating. The outcomes of these variables are obtained by setting a weighted average renovation rate for all of the EU. The national renovation rates change in line with the weighted average and their historical renovation rates. In the Baseline Efficiency scenarios (LEE) we assume that the weighted renovation rate increases from 1% to 1.5% around 2030. In the High Efficiency scenarios (HEE) we assume that the rate increases further to 3.5% around 2030. See Figure 2-4.

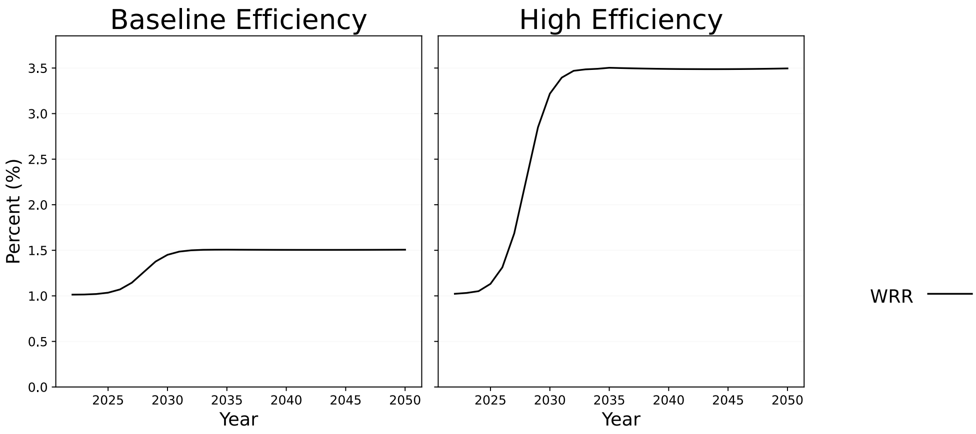

Figure 2-4: Weighted average renovation rate, 2020-2050, rate

2.4 Technology pathways

Using HP sales data and projections up to 2030 from the European Heat Pump Association (EHPA) in line with the growth targets stipulated in the REPowerEU plan, market shares based on heat demand delivered were calculated. Furthermore, a continuous depreciation rate of 5.56% was applied.

It was assumed there is one HP per dwelling and also current usage of HPs is predominantly in single-family homes and in countries in colder climate zones – these latter assumptions imply that the HP share of heat demand delivered is greater than the share of HPs in dwellings.. Based on these assumptions and matching the HP share of heat energy delivered to the previous study projections, a scaling factor of 2.65 was applied up to 2030; HPs were assumed to deliver 2.65 times their share in dwellings to the overall heat demand.

Using sales data from the EHPA, the above method was applied to three different types of HPs: ground, air-air and air-water. After 2030, the growth rate of HP sales decayed to reflect heat pumps beginning to reach their saturation point in the market.This leads to final projections of 52.5% HP share of heat energy delivered by 2030, and 64.1% by 2050.

To accommodate increasing HP shares, other technologies are also impacted. District heating (which also contains some portion of heat pumps) is capped at a share of 25%. Some portion of solar thermal (2.7%) and electric heating (7.6%) are retained at the expense of fossil fuel heat sources (oil and gas, condensing and non-condensing boilers) which are no longer present in the heat supply by 2050.

As per the methodology, the EU-wide market shares of technologies are connected to EU-wide heat demand for hot water and space heating. This is then distributed to the Member State level by following a system of allocation rules and building on history. Figure 2-5 displays the broad technology shares for 2030 while Figure 2-6 does the same for 2050.

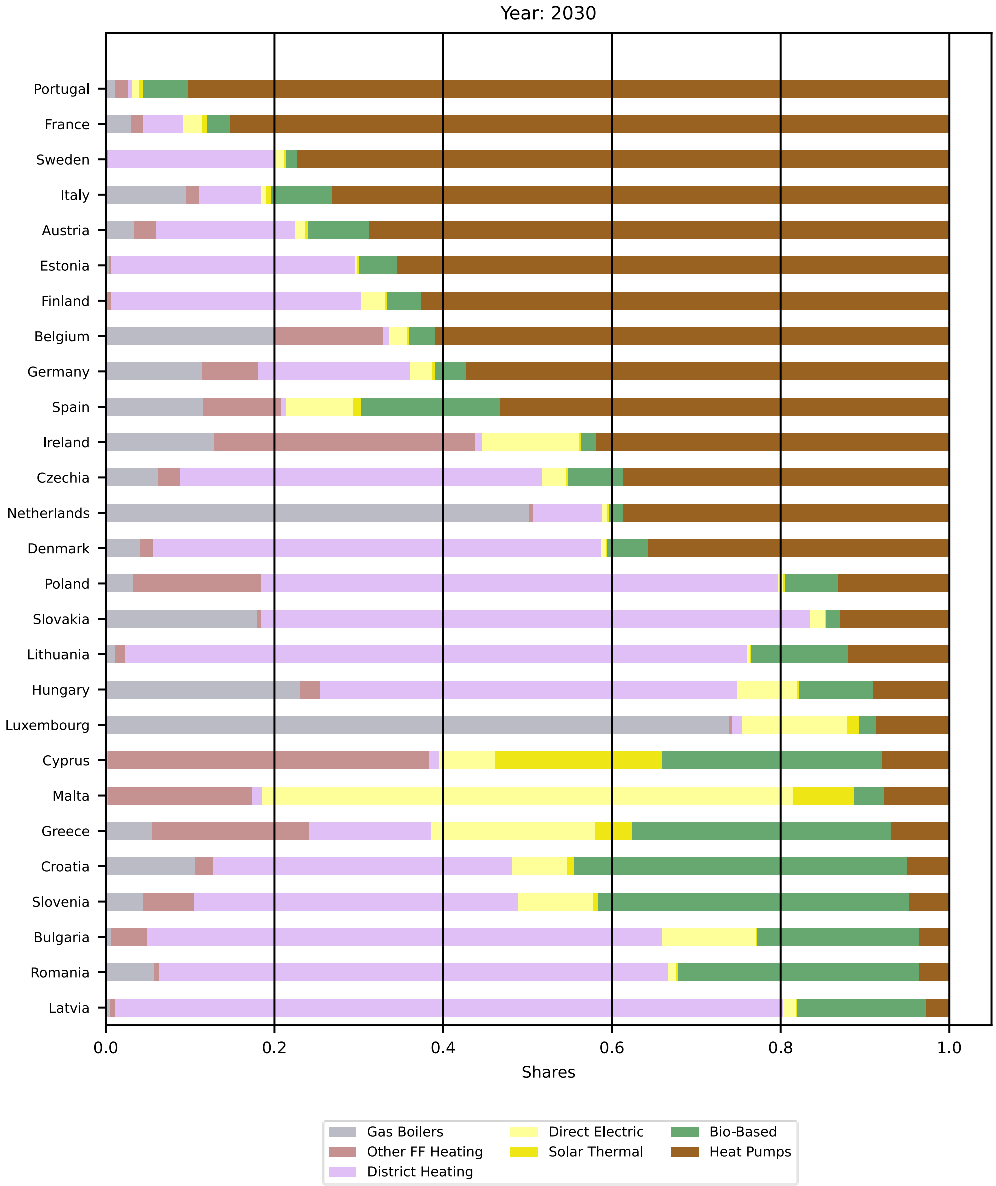

Figure 2-5: Technology market shares, Member State specific, for the year 2030, in market shares of heat delivered
Note: Member states have been sorted by the share of heat pumps in the residential heat supply mix.

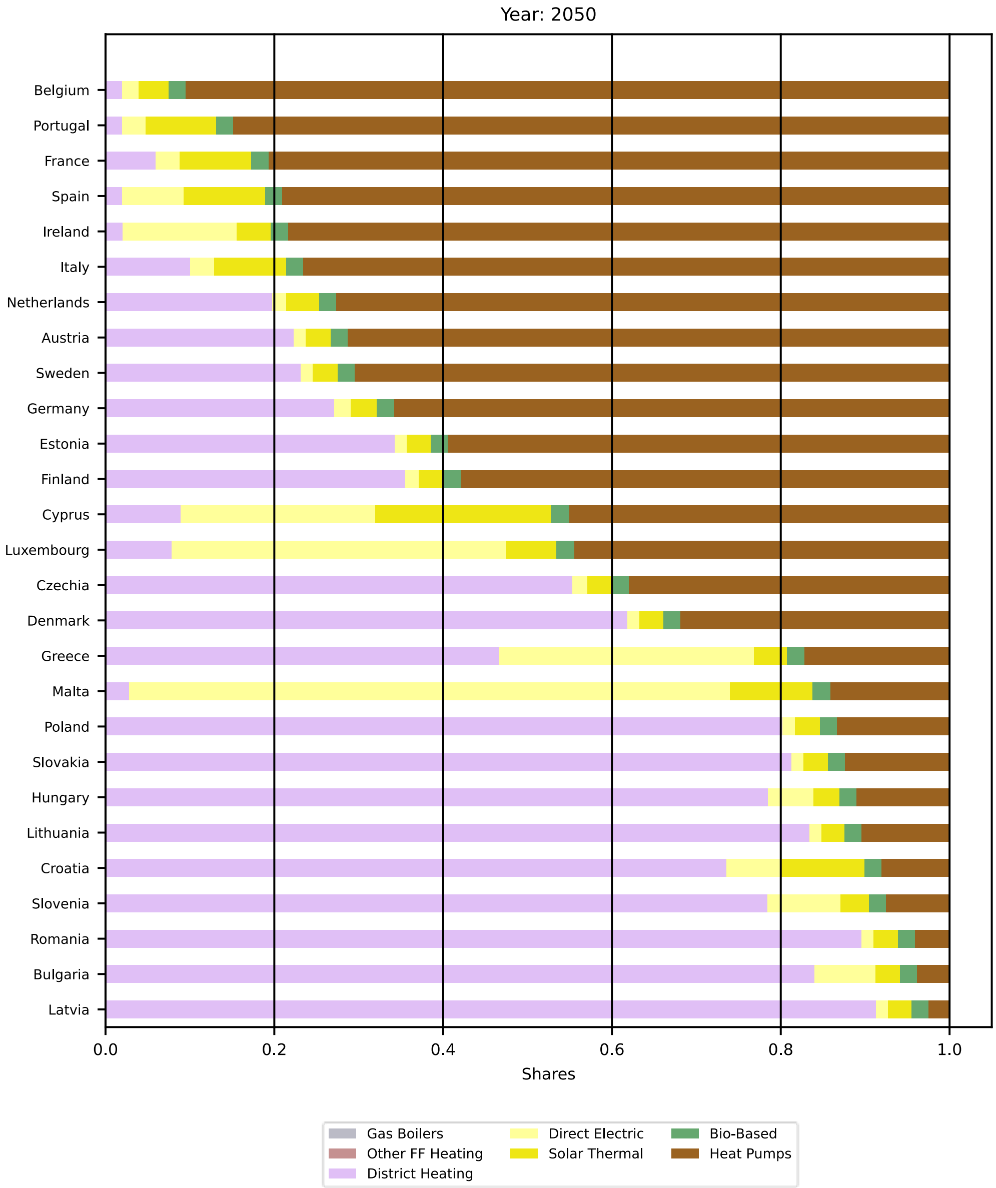

Figure 2-6: Technology market shares, Member State specific, for the year 2050, in market shares of heat delivered.
Note: Member states have been sorted by the share of heat pumps in the residential heat supply mix.

2.5 Energy price shocks

Conditional on the scenario in question, the model utilises one of three different energy prices projections: EU Ref, Projection A, or Projection B. All three projections consist of the energy commodity price average of the EU27 member-states in the context of different price evolution scenarios.

As in the previous iteration of this study, the EU Ref projection follows the energy price projections of the EU Reference Scenario 2020. This price projection shows a gradual increase of energy prices over time, and it does not take into account the price shocks that took place since 2020.

The two other price projections, Projection A and Projection B, are instead based on the REPowerEU forecast, produced with the PRIMES model. Projection A is taken directly while Projection B is an adaptation thereof. These projections, unlike the first one, are subject to the shocks that occurred in the years after 2020, exhibiting a striking increase of energy prices, particularly gas, in the following years. The two projections, however, differ in the speed in which the market is able to return to prices similar (but still elevated) to those before the shock took place. Projection B details a slower price level recovery from the shock.

Together with power technology inputs, such as electricity capacity shares by technology, these fossil fuel price projections were inputted in the FTT:Power model (Mercure 2012) in order to estimate the effect of the different price evolution pathways and technological compositions on the electricity prices for end-users across the EU27.

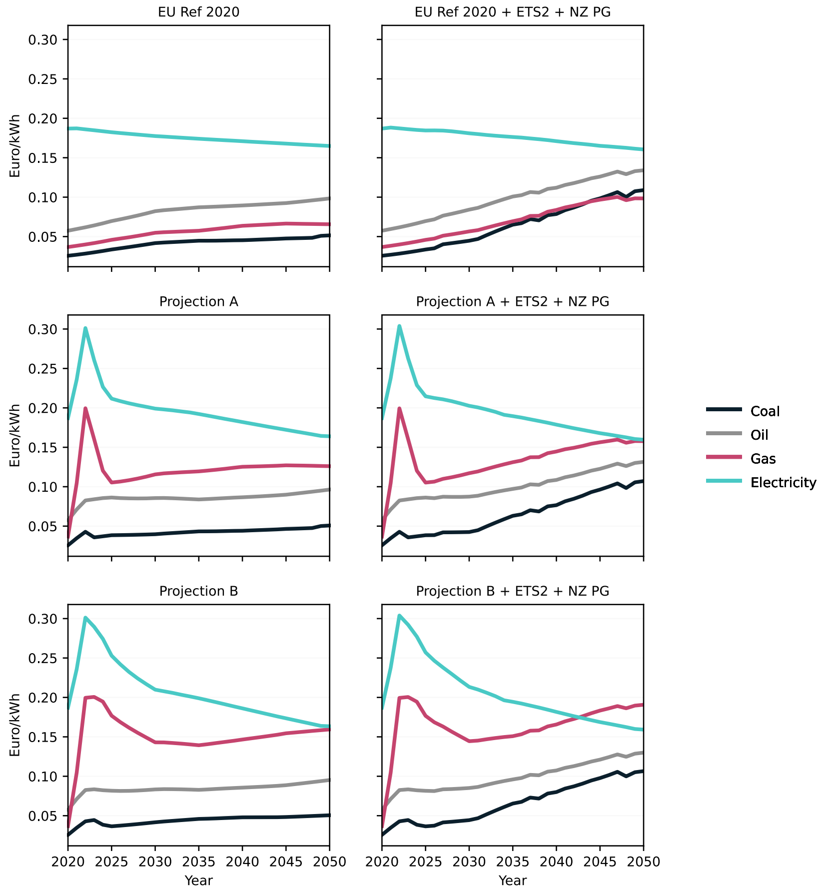

Figure 2-7: Energy price projections, EU average, 2020 – 2050, in €$_{2020}$/kWh.

3 Results

3.1 Building stock modelling outcomes

Energy demand for heating

Different levels of energy efficiency improvements take place in each of the renovation scenarios. The cumulative effect of renovations leads to decreased demand for hot water and space heating. In the Baseline Efficiency (or LEE) scenario we find that the energy need for heating decreases by 9% in 2030 and 32% in 2050 compared to 2022 levels. In the High Efficiency scenario, we note a similar decrease in the energy need for heating by 2030 (13%), but by 2050 the decrease amounts to 49% compared to 2022. There are only small differences between the two scenarios up to 2030 due to the renovation wave kick-starting around that year. See Figure 3-1.

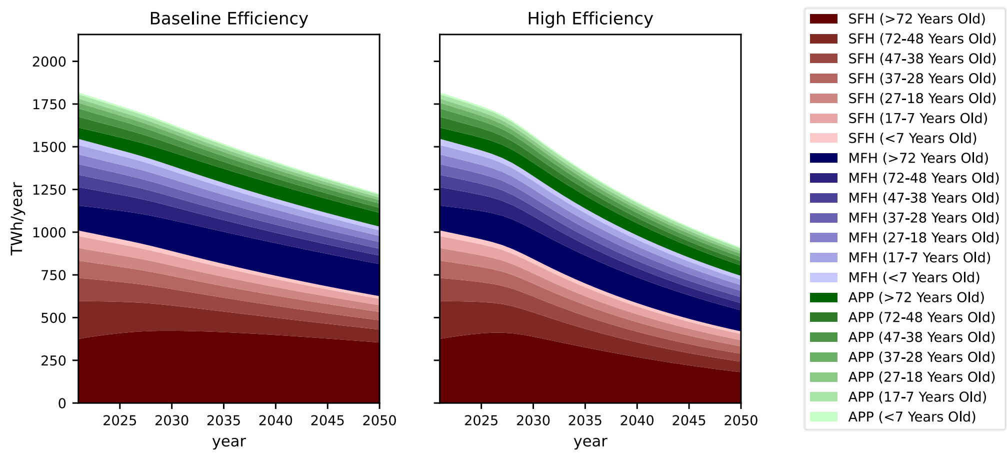

Figure 3-1: Demand for hot water and space heating by each archetype, EU aggregate, 2022-2050, in TWh/y.

Renovation investments

While renovations contribute to reduced demand for heating, they do come at a cost. In our scenarios, we assume that the cost of renovations in the baseline are imbedded and therefore we only consider the differences between scenarios. Furthermore, different agents will be responsible for the cost of renovations. National governments are assumed to subsidise all of the renovations applied in social housing, and a portion of the costs of renovations in owner-occupied and rented dwellings. The bulk is assumed to be paid by owner-occupiers and landlords. The economic feedbacks depend on which agent pays what.

In the baseline, we find that the aggregate renovation costs amount to 132 bn€ in 2050, while they amount to 362 bn€ in the High Efficiency scenario. The difference amounts to 152 bn€ by 2030 and 230 bn€ by 2050. See Figure 3-2.

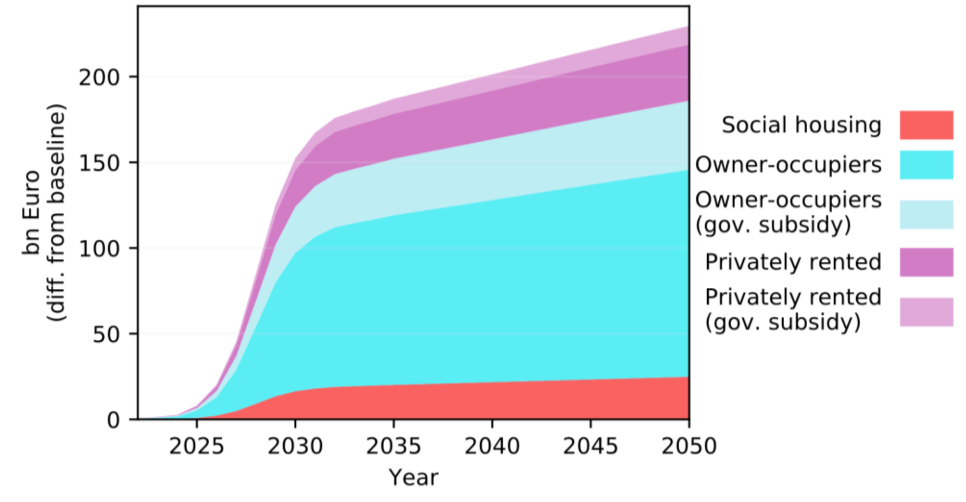

Figure 3-2: Renovation investments, EU aggregate, 2022-2050, bn€ as a difference from the baseline.

3.2 Residential heat supply

Heat demand delivered by technology

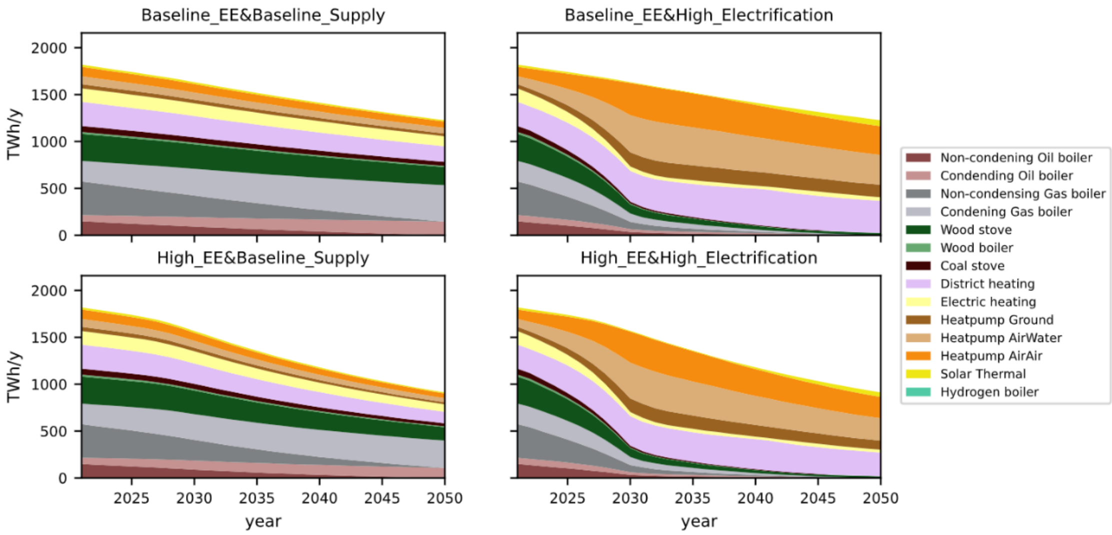

Figure 3-3: Heat Delivered by technology, EU aggregate, 2020-2050, in TWh/y.

Under the High Electrification (HE) scenarios, heat pumps and district heating begin to dominate, and fossil fuel sources eventually disappear completely. The three HP technologies alone make up greater than 60% of heat demand delivered under the HE scenarios by 2050. This is in comparison to just 12% under the Baseline Supply (BA) scenarios. Significant progress in heat pump installation is completed by 2030 in the HE scenarios - thereafter the rate of installation begins to decline.

Comparing the Low Efficiency (LEE) scenarios to the High Efficiency (HEE) scenarios, there is a significant decline in total heat delivered by 2050 (from 1200 TWh/y to 900 TWh/y). Following on from section 3.1, moving from LEE to HEE means all technologies are required to produce less heat.

Although heat pump installation declines after 2030 in the HE scenarios, efficiency improvements in the HE/HEE scenario ensure heat pumps only continue to grow in their share of heat delivered.

Final energy demand

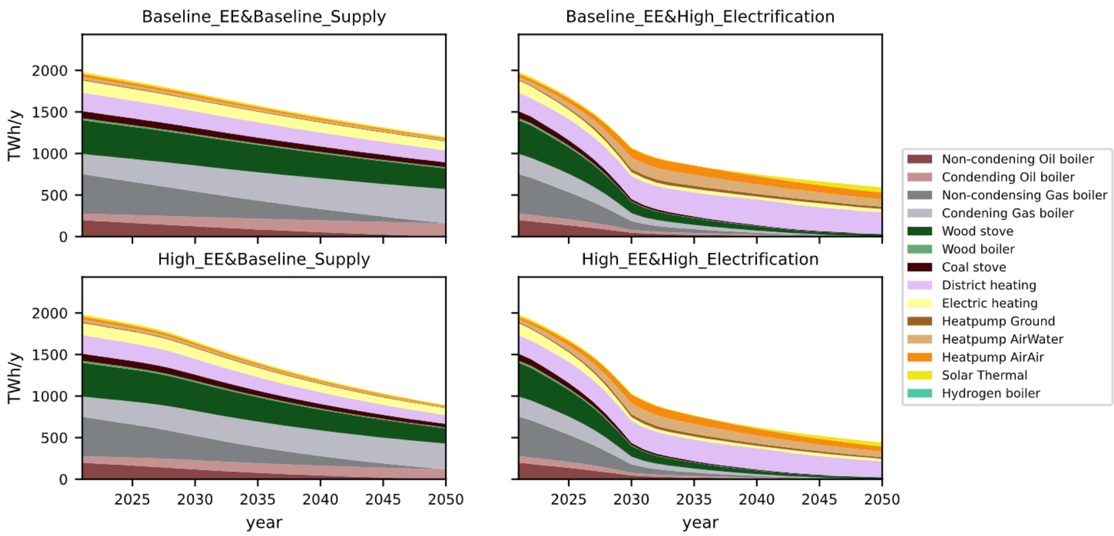

Figure 3-4: Final Energy Demand by technology, EU aggregate, 2020-2050, in TWh/y.

Greater efforts to renovate the European housing stock reduces the energy need for heating and thereby increase the efficiency of the housing stock on the demand-side. Electrification of the heat supply leads to another wave of efficiency improvement but on the supply-side. Combining the two effects leads to the greatest decline in total final energy consumption, from 1200 TWh/y in 2050 under the baseline conditions to 440 TWh/y in 2050.

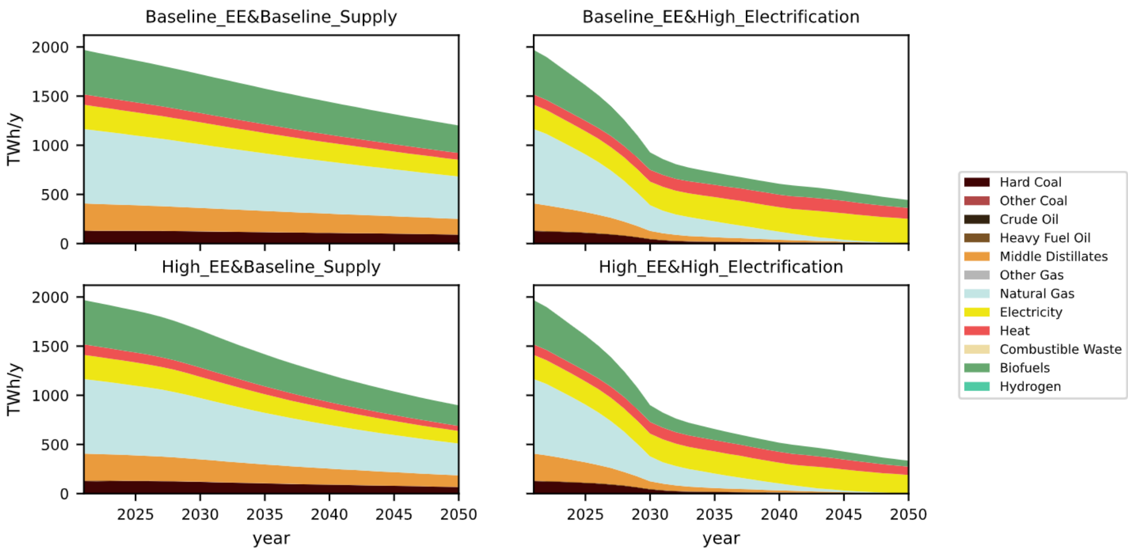

Figure 3-5: Final Energy Demand by energy carrier, EU aggregate, 2020-2050, in TWh/y

The impact of phasing out fossil fuel technologies is also visible in Figure 3-5, particularly for Natural Gas. Middle Distillates and Hard Coal also decline significantly under HE conditions. Most progress in declining final energy demand (and replacement of fossil fuel demand by Electricity and Heat) is achieved by 2030.

Emissions

There is a drastic decline visible for all pollutants in the High Electrification scenarios due to a transition towards HPs. Renovating the housing stock further has some effect on pollutant emissions due to avoided use of the heating units.

All pollutants due to residential heating decline to almost zero in both High Electrification scenarios. Due to the heat pump installation rate declining after 2030 (and conversely the phasing out of fossil fuel technologies), the rate of reduction in pollutants also slows and most progress is made before 2030.

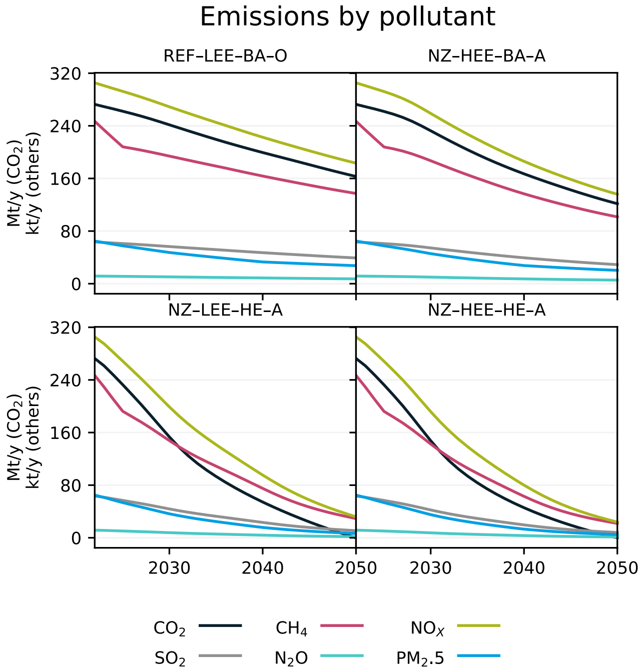

Figure 3-6: Total Emissions by pollutant due to residential heating, EU aggregate, 2022-2050, in Mt/y for CO_2 and kt/y for other pollutants.

3.3 Socioeconomic impacts

Aggregate household spending on heating and cooling

When we isolate the effect of the Net-Zero power sector scenario setting to the counterfactual reference scenario where energy prices are in line with the EU reference scenario 2020, then the effect of ETS2 is clearly visible (see top row, Figure 3-7). Energy costs increase by approximately 75 bn€ by 2050, while there is only a minimal increase by 2030 which is due to the ETS2 being capped until that year.

If we expose the Net-Zero power sector scenario without the elevated energy prices (NZ-LEE-BA-O) to the new energy price projections (NZ-LEE-BA-A and NZ-LEE-BA-B), energy costs would increase substantially (see second row, Figure 3-7). Around the peak in 2022, aggregate household energy bills increase by another 150 bn€. By 2030, an increase of 40 bn€ is seen in the NZ-LEE-BA-A scenario and an increase of 60 bn€ in the NZ-LEE-BA-B scenario.

Against the background of high fossil fuel prices, Electrification through HPs leads to a large improvement in supply-side efficiency and a transition away from natural gas boilers. This prevents a sizeable chunk of the higher energy costs that would be incurred should the conventional heating technologies continue to be used to the same extent in the future. However, households spend relatively more on heating equipment due to the transition from gas boilers to heat pumps (see third and fourth rows and first column, Figure 3-7).

Energy efficiency measures without electrification of the heat supply leads to smaller but still substantial reductions in energy costs. A minor saving on upfront costs of heating technologies is seen as well, because increased energy efficiency leads to smaller heating units (see third and fourth rows and second column, Figure 3-7). The combination of electrification and increased energy efficiency shows the largest savings (see third and fourth rows and third column, Figure 3-7).

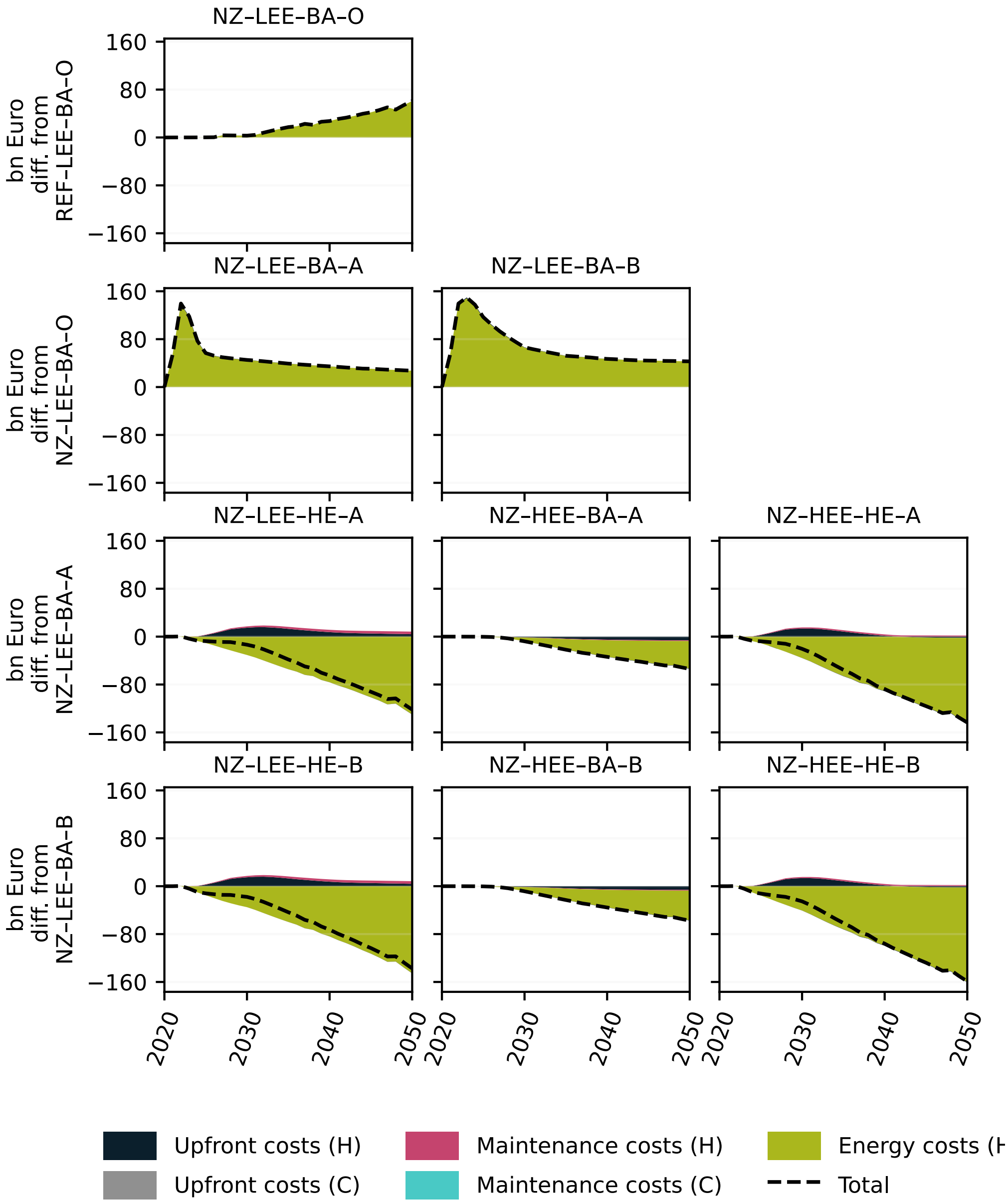

Figure 3-7: Household spending on energy and equipment for heating and cooling, EU aggregate, 2020-2050, bn€ as a difference from respective reference scenarios.

Table 3-1: Energy costs and upfront costs faced by households for heating and heating equipment respectively, EU aggregate, in billion Euro.

Scenario	Energy costs due to running heating equipment			Upfront costs on heating equipment		
	2022	2030	2050	2022	2030	2050
REF–LEE–BA–O	121	122	93	29	24	18
NZ–LEE–BA–O	121	125	154	29	24	18
NZ–LEE–BA–A	273	170	181	29	24	18
NZ–LEE–BA–B	273	190	197	29	24	18
NZ–LEE–HE–A	273	139	51	29	38	22
NZ–LEE–HE–B	273	155	51	29	38	22
NZ–HEE–BA–A	273	164	135	29	22	12
NZ–HEE–BA–B	273	183	147	29	22	12
NZ–HEE–HE–A	273	134	39	29	37	15
NZ–HEE–HE–B	273	149	39	29	37	15

Total cost of ownership

The various heating technologies included in this study have different cost profiles associated to them, as indicated on an aggregate level in the section above. For example, HPs require greater upfront costs and – depending on the electricity price – lower or equal energy costs compared to a condensing gas boiler. Here, we compare the total cost of ownership (TCO) of the heating technologies at various ownership periods and scenarios. See Figure 3-8. TCO is calculated over a 10-year period without discounting of the costs and with upfront costs annualised.

If the households in the EU are exposed to the energy prices as presented in the EU Reference Scenario 2020, then we find that HPs are slightly more expensive than the presently dominant condensing gas boilers. However, even without interference of policies or the effect of energy prices, HPs outperform condensing gas boilers by around 2030. The gap becomes even larger towards the end of the simulation period.

However, households in the EU currently face much higher energy prices and accounting for that effect suggests that HPs already outperform condensing gas boilers. This effect is exacerbated by implementing ETS2. If we track the development of the TCO over time for selected heating technologies and scenarios, then it becomes clear that HPs – on average – outperform condensing gas boilers, even if ownership started in 2016. See Figure 3-9.

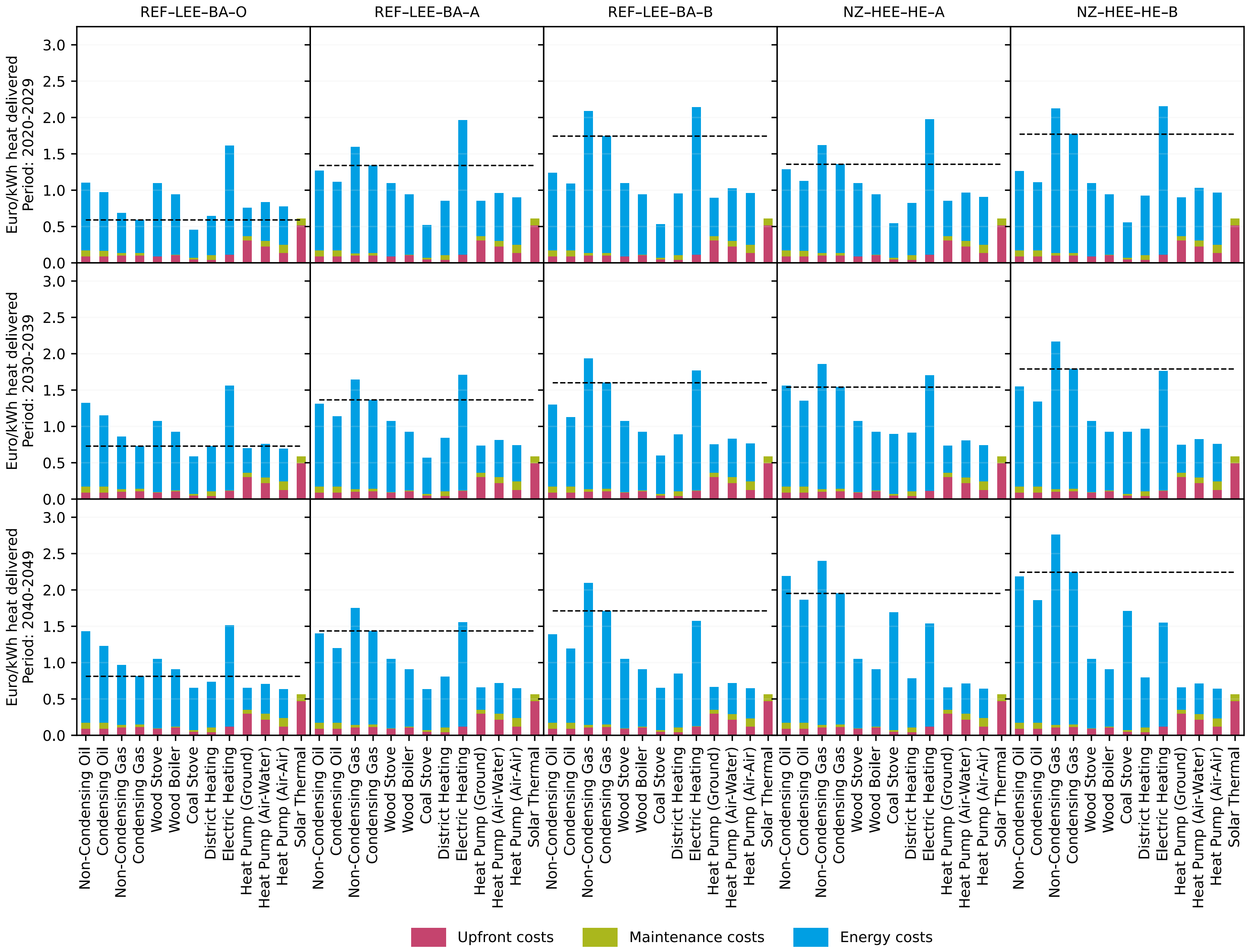

Figure 3-8: Total cost of ownership by technology for selected periods and scenarios, EU averages, €/kWh heat delivered, estimated over 10-year periods, dashed line tracks TCO of condensing gas boilers.

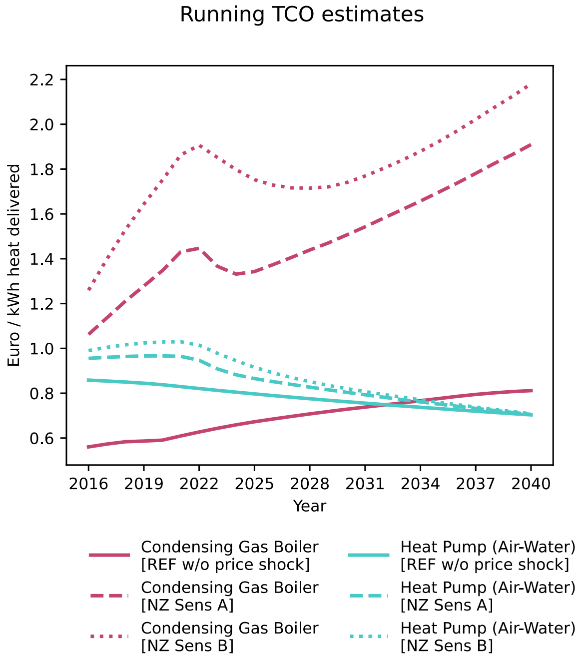

Figure 3-9: Running total cost of ownership developments for selected technologies and scenarios, EU average, 2016-2040, in €/kWh of heat delivered.

The TCO estimates indicate that HPs are cost competitive already given the new energy price projections. However, the upfront costs are often a big hurdle to households. For that reason, it is useful to consider payback periods. Table 3-2 displays the payback periods when switching from a condensing gas boiler to the various HP types at different times and different scenarios. We see that under energy price projections in line with the EU Reference Scenario 2020, the payback period for each HP type is much longer than the average lifetime of 18 years. By 2030, air-to-air HPs are expected to pay back their upfront costs in energy bill savings before the end of its lifetime. Ground-source HPs will likely need their whole lifetime. After that, all HPs should show gradually shorter payback periods as HP technology costs are expected to decline. The price projections in the EU Reference Scenario 2020 are not valid anymore though. Under either of the new price projections we note that HPs have a much shorter pay-back period, even today. The payback period ranges from 2 to 6 years depending on the type and scenario. This declines to 1 to 3 years by 2050. Note that these are average payback periods using annual average values. These estimates can be different due to dynamic electricity price profiles and its overlap with heat demand profiles.

Table 3-2: Average pay-back period of replacing a condensing gas-boiler with various HPs under different conditions, EU average, in years.

Scenario	Technology	2022	2030	2040	2050
REF	Heat Pump (Air-Air)	45	13	8	7
	Heat Pump (Air-Water)	88	24	14	13
	Heat Pump (Ground)	32	18	14	13
NZ-A	Heat Pump (Air-Air)	3	2	1	1
	Heat Pump (Air-Water)	5	4	3	2
	Heat Pump (Ground)	6	5	3	3
NZ-B	Heat Pump (Air-Air)	2	2	1	1
	Heat Pump (Air-Water)	4	3	2	2
	Heat Pump (Ground)	4	4	3	2

Distributional impacts (real income)

The isolated effect of the ETS2 leads to increased energy costs if the supply of heat remains reliant on fossil fuels. This suppresses real income slightly on an aggregate level (top row of Figure 3-10). The lowest income groups see the greatest relative reduction in real income as they tend to spend more on energy proportionally (top row of Figure 3-11). However, this is overshadowed by the higher energy prices (second rows of each figure). Real income is reduced by nearly 10% across income groups around 2022 in the worst-case scenario with regards to energy prices (NZ-LEE-BA-B compared to NZ-LEE-BA-O).

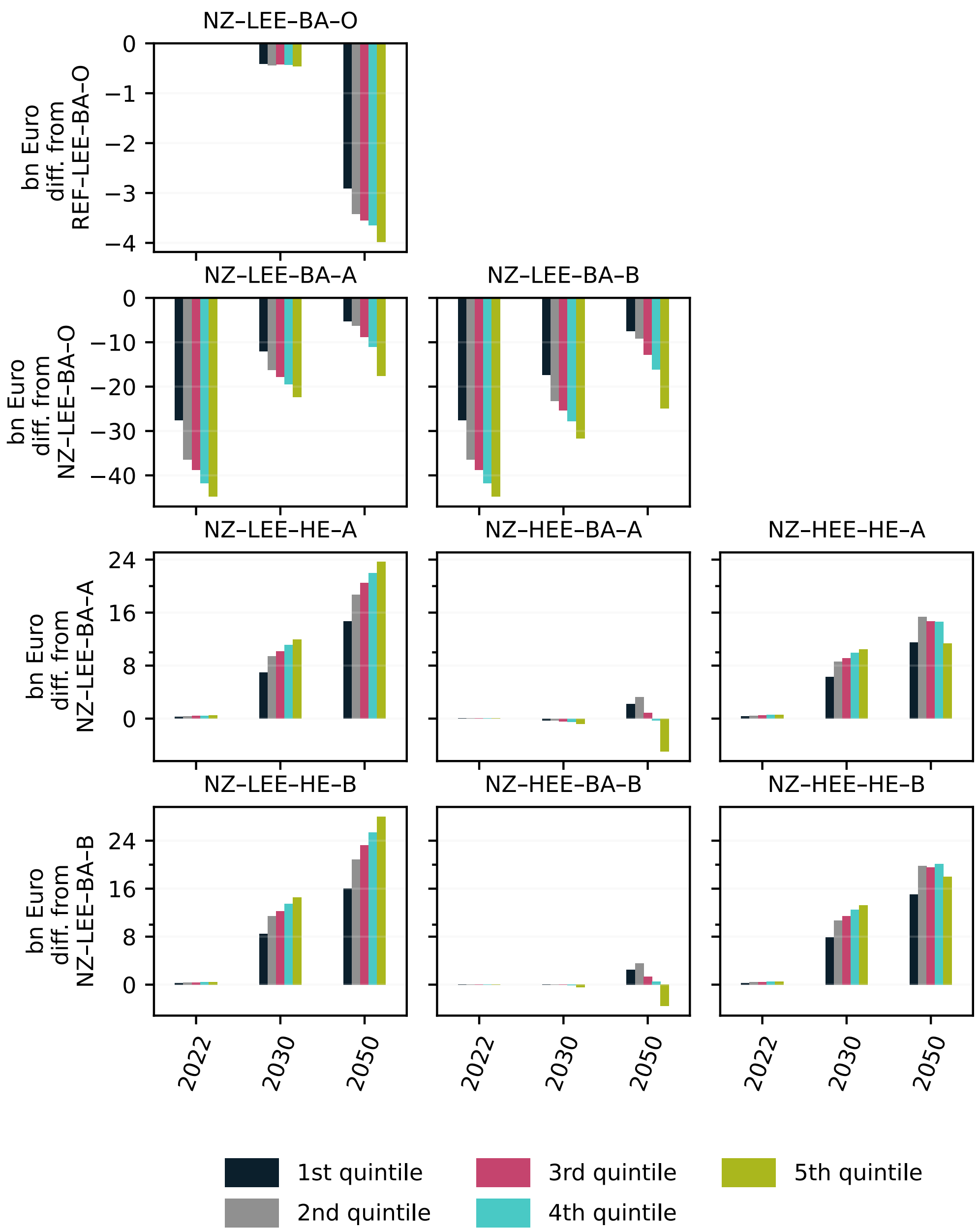

Figure 3-10: Real income by income quintile, EU aggregate of intra-national income distributions, only shows 2022, 2030, and 2050, in bn€, difference from respective reference scenarios.
Note: Different scales are applied to the y-axis to highlight differences.

Some of these negative effects can be mitigated by electrification of the heat supply through installation of HPs and through greater efforts to renovate the building stock. The cost of renovations affects higher income groups most as they are most likely to be owner & occupiers of their homes which causes them to bear the bulk of the renovation costs. The largest effects are due to electrification, though. The increased fossil fuel costs are avoided in those cases completely (see NZ-LEE-HE-A and NZ-HEE-HE-A versus NZ-LEE-BA-A, and NZ-LEE-HE-B and NZ-HEE-HE-B versus NZ-LEE-BA-B in Figure 3-10 and Figure 3-11).

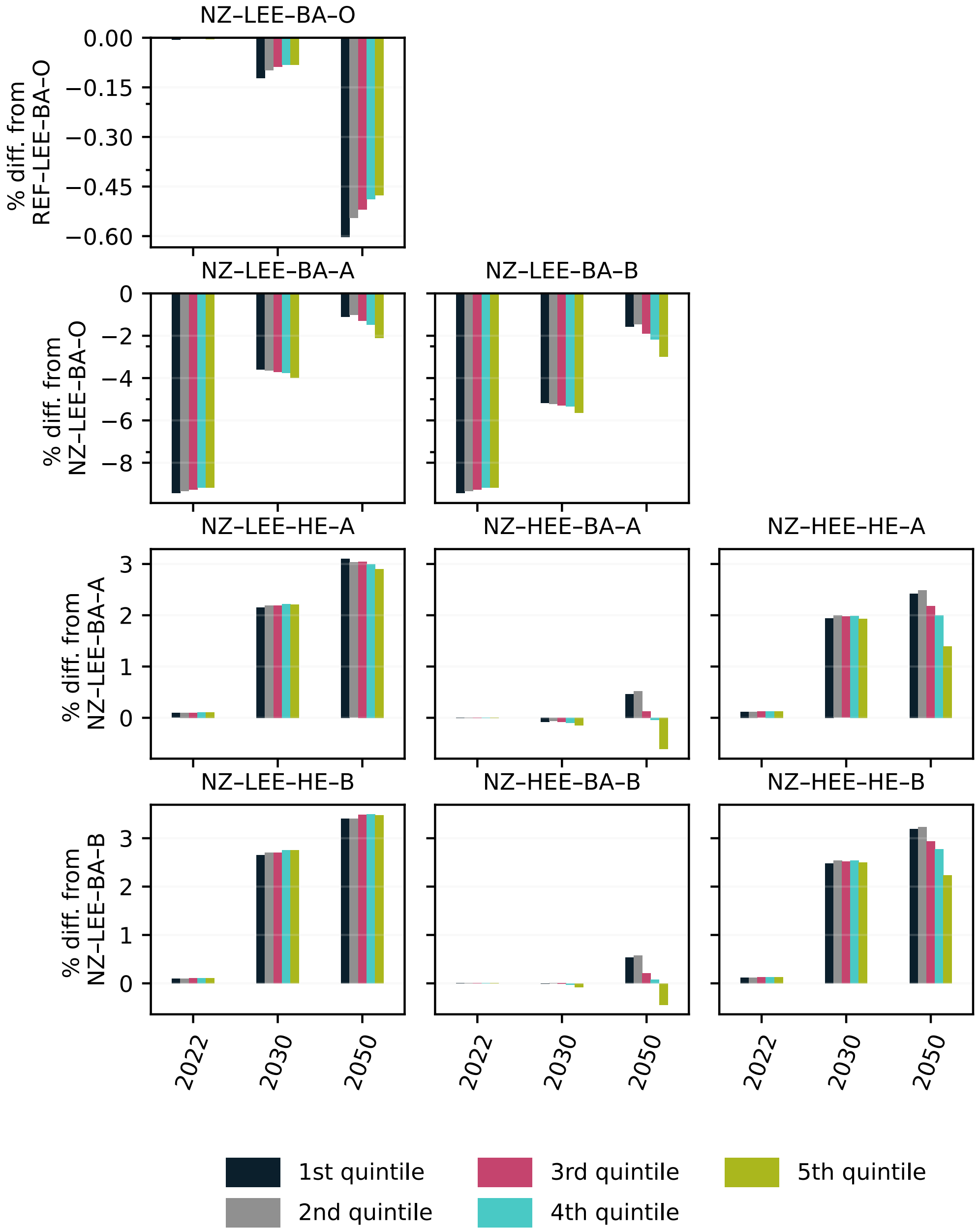

Figure 3-11: Real income by income quintile, EU aggregate of intra-national income distributions, only shows 2022, 2030, and 2050, as a % difference from respective reference scenarios.
Note: Different scales are applied to the y-axis to highlight differences.

Overall, our results show that the three lowest income groups stand to gain in the long-term if their supply of heat is electrified via HPs and their homes become more energy efficient. Lower income households spend a greater proportion of their income on energy. Lowering the energy expenses of low-income households will therefore unlock more consumption of other goods & services. Where the additional demand for goods & and services has a higher domestic content, this can create more jobs and an increase in aggregate income. That is regardless of the negative impacts the ETS2 and price shocks may bring. Yet, in the short-term, no income group can escape the negative effects due to the exposure to higher energy price levels.

Macroeconomic indicators

The implementation of the ETS2 without mitigation of the residential heat supply shows small negative effects mainly attributable to the relatively lower real income of households highlighted in the previous section. This is visible in the aggregate consumer expenditure effect (see first column, second row, Figure 3-12).

However, the impact of the ETS2 implementation is very small in comparison to the impact of the higher energy prices (see second column, Figure 3-12). Employment is expected to decrease by a further 2-3%, consumer expenditure by 6-8%, and GDP by 4-6% in the short-term as the peak of the energy price inflation is reached. In the long-term the trends nearly go back to the respective reference (NZ-LEE-BA-O) as the energy prices decline. However, they remain at higher levels.

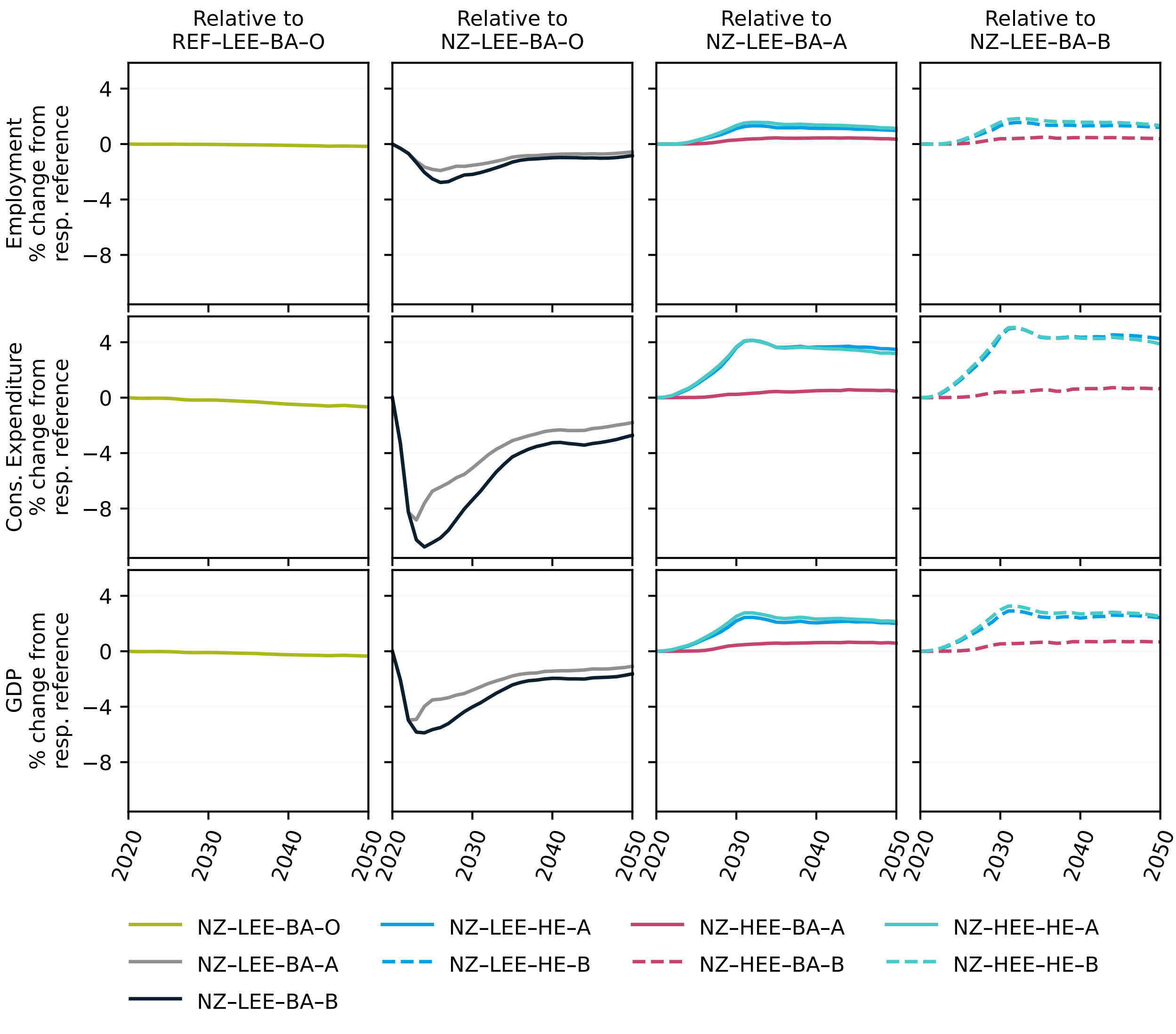

Figure 3-12: Macro-economic indicators (employment, consumer expenditure, and GDP), EU aggregate, 2020-2050, as a % difference to the respective reference scenarios. Note: In this graph the scenarios are colour-coded.

Irrespective of which energy price projection is applied, electrification of the heat supply shows positive results as high energy costs are prevented via technology substitution when compared to the scenarios that are exposed to the same energy price projections but exclude electrification (see third column of Figure 3-12). By 2030, the steep uptake of HPs as projected in the High Electrification scenarios leads to positive impacts on employment, consumer expenditure, and GDP. As Figure 3-7 showed, after 2030 the energy costs borne by households are comparatively lower due to electrification and/or increased energy efficiency which drives the continued positive differences to the respective reference scenarios (see third column of Figure 3-12)

Detailed sectoral impacts

While the previous section displayed the percentage difference of the total number of jobs, Figure 3-13 displays the change in job-years (cumulative jobs)

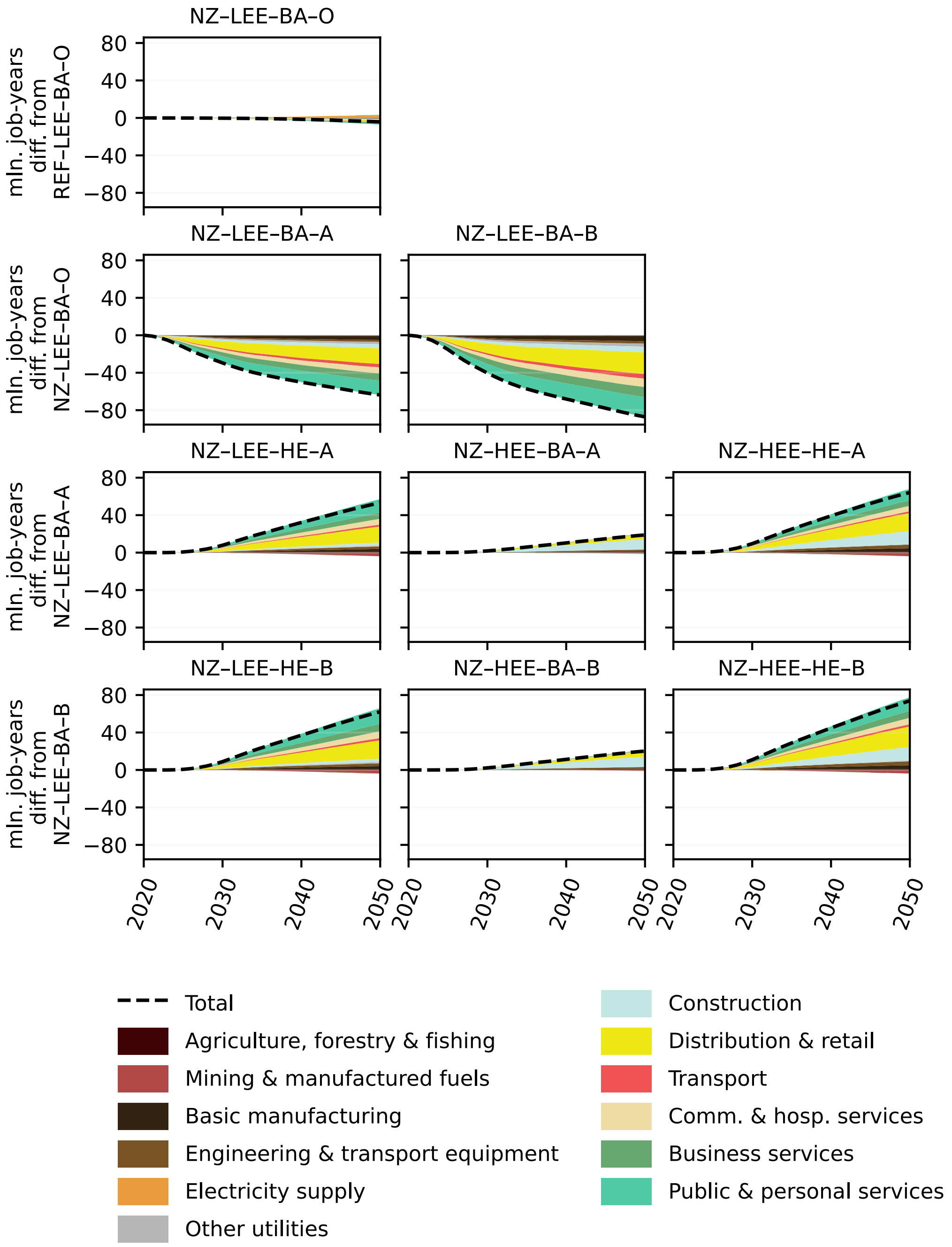

Figure 3-13: Employment by sector, EU aggregate, 2020-2050, in million job-years, difference from various reference scenarios.

in comparison to various reference scenarios and Figure 3-14 displays the sectoral impacts on gross output in relation to various reference scenarios. Implementation of the ETS2 (compared to REF-LEE-BA-O) shows slight negative impacts throughout all sectors due to suppressed consumer spending leading to lower demand and lower employment.

Employment takes a further and more significant hit under the effect of inflated energy prices (NZ-LEE-BA-A and NZ-LEE-BA-B compared to REF-LEE-BA-O of Figure 3-13). The sectors hit hardest are those directly related to consumer expenditure in goods and services with higher domestic contents, such as retail and services. This is supported by Figure 3-14.

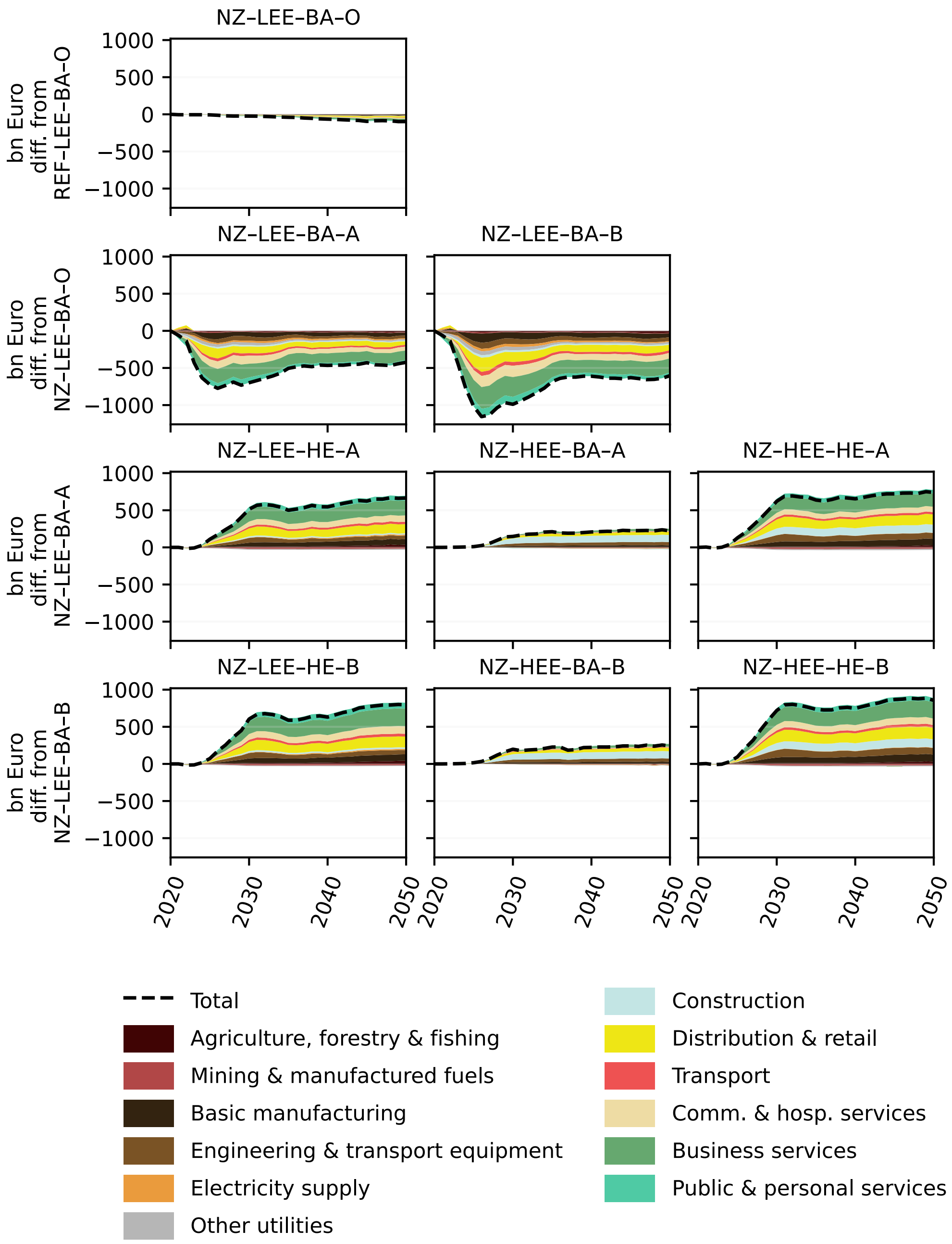

Figure 3-14: Gross output by sector, EU aggregate, 2020-2050, in bn€/y, difference from various reference scenarios.

After embedding the ETS2 and the higher price projections into the reference scenario, we can look at the isolated impacts of heat electrification and increased energy efficiency. Electrification leads to the greatest job impacts and somewhat reverses the negative impacts of the energy price inflation. Due to prevented energy costs, more spending returns into retail and services, leading to higher output and therefore job creation which are maintained over the timeline.

Greater efforts to renovate the housing stock leads to small positive impacts. Renovations increase demand for the construction sector to perform the renovations and we note an increase in job impacts there. The timing of increased renovations is not as steep as the uptake of HPs, so the prevented energy costs are lower compared to the effect of electrification. Therefore, consumer spending is affected by the elevated prices, more so than in the scenarios that include electrification.

Overall, the combination of energy efficiency and electrification of the heat supply leads to the highest job levels of job creation and retention through increased sectoral output, mainly in the retail, services, and construction sectors.

Implied energy trade impacts

The EU has for a long time been reliant on fossil fuel imports from other regions, yet recent events have illustrated the risks of energy imports. Decarbonising the heat supply and/or suppressing the demand for heating through renovations leads to lower final energy demand for residential heating and therefore reduces energy import dependency.

Figure 3-15 shows the implied cumulative energy import differences in terms of energy and in terms of value. The High Electrification scenarios show a swift uptake of HPs and heating and cooling is completely decarbonised by 2050. Therefore, energy import savings are greatest for this scenario. Renovations without addressing the heat supply will have a minor effect on imports, but a combination with High Electrification reduces the import dependency slightly compared to High Electrification without High Efficiency. Under energy price projection B, the avoided import value is higher due to the higher wholesale fossil fuel prices.

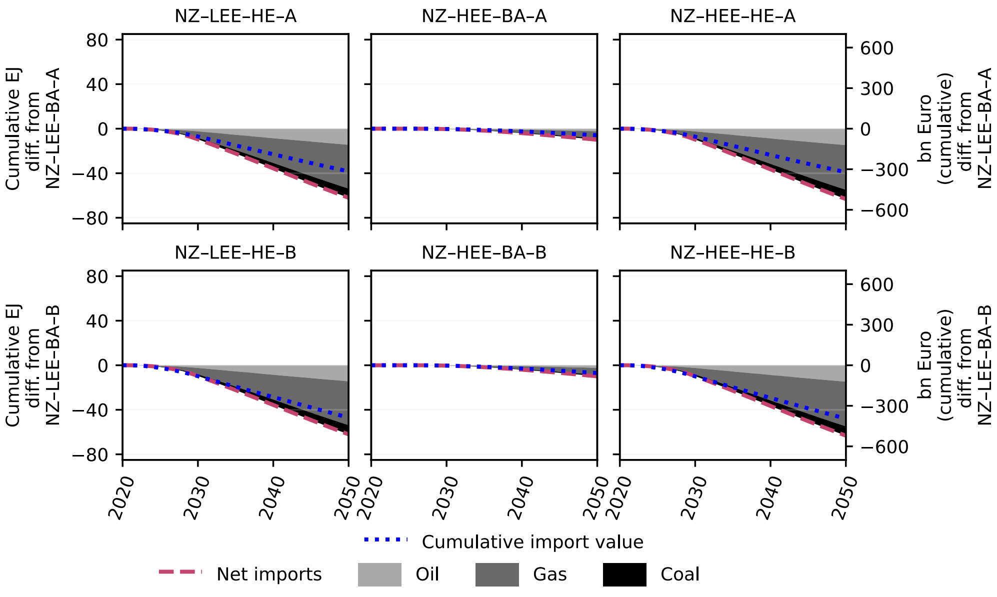

Figure 3-15: Implied energy trade in terms of energy and value, EU aggregate, 2020-2050, in EJ (cumulative) on the left axis and bn€ (cumulative) on the right axis, difference from respective reference.

4 References

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