On the way to low-emission European buildings: investigating the role of non-ETS CO2 pricing in the residential and tertiary sectors

Şirin Alibaş[1], Tobias Fleiter[1], Pia Manz[1], Rainer Elsland[1]

[1] Fraunhofer Institute for System and Innovation Research ISI, Breslauer Straße 48, 76139 Karlsruhe, Germany. +49 721 6809-578, sirin.alibas@isi.fraunhofer.de, www.isi.fraunhofer.de

Kurzfassung:

The review of the Paris Agreement in December 2020 necessitates that the EU member states reduce their GHG emissions to 55% of 1990 levels by 2030 and become climate-neutral by 2050. According to European Commission's Impact Assessment on Europe's 2030 climate ambition, CO_2 pricing in building sectors can be an effective instrument for the decarbonisation, but it has certain limitations. Here, we make an analysis of where the EU building sectors are heading from the planned perspective and we conduct a CO_2 price sensitivity analysis with the energy demand simulation model FORECAST™. Five different CO_2 price pathways are simulated; starting from an average of 14€/tCO_2eq in 2020 and going up to between 77€/tCO_2eq and 350€/tCO_2eq in 2050. The projections show that EU buildings could achieve 85% direct emission reduction in 2050 at the current pace of the measures. However, CO_2 pricing alone, even if it is very high, does not carry the overall sector emissions to the target levels of the Paris Agreement. The decarbonisation of the EU building stock would require the implementation of more ambitious accompanying measures that overcome barriers not addressed by the CO_2 price. Looking ahead, the analysis should be extended to include carbon-neutral PtX fuels in the decarbonisation of building heating and the effect of CO_2 pricing in the electricity and district heating supply should be considered.

Keywords: carbon-neutral buildings; non-ETS CO_2 price; decarbonized EU buildings; CO_2-price pathways, impact assessment

1 Introduction

In 2019, the buildings of the EU (EU27+UK) were responsible from 37% of the total final energy demand with approximately 5000 TWh [1]. The space heating demand alone made up almost 65% of the final energy demand of residential buildings [2]. Fossil fuels provided 58% of the final energy demand of buildings in 2019 [1,3]. This makes the residential and tertiary sectors (excluding agriculture) responsible for around 15% of the total CO_2 emissions of the EU [4].

Even though coal is already almost abandoned, natural gas and oil are still used heavily for heating of residential and tertiary sector buildings [5]. On the way to achieve the emission reduction goals of the Paris Agreement, European buildings need to decarbonize their heat consumption. Minimum 55% emission reduction by 2030 compared to 1990 is agreed upon

[6]. Under the planned policies and targets, named baseline, the European Commission expects a GHG reduction of around 48% in 2030 compared to 2015 in the residential and services sectors [7]. At this pace, the emission reductions of the sectors would reach almost 70% in 2050 compared to 2015 [5]. When compared to the sectoral emissions in 1990, the reduction is 55 and 68% on average, respectively. Improving the energy performance of the building envelope, installation of efficient equipment, fuel switch to renewables and smart operation of buildings are important measures envisioned to reduce emissions in the building sectors [5].

Carbon pricing in the non-ETS sectors is another measure to help reduce direct emissions from the buildings. In a 'sustainable development' scenario, fossil fuel prices are expected to stay constant or slightly decrease towards 2050 [8]. In order to make the renewable energy carriers financially attractive, the fossil fuels are discouraged via the CO_2 price. Each EU member state decides the implementation and prices nationally. Some member states currently state their plan on how to implement this measure, some of them already apply it and some member states have not declared any plan of pricing the non-ETS sector for CO_2 emissions, yet [9].

1.1 Motivation

According to EU's short-term vision (until 2030), buildings can achieve 60% reduction of emissions by 2030 compared to 2015 levels under the consideration of carbon pricing (CPRICE), which extends the scope of ETS to buildings and other currently non-ETS sectors, while keeping the energy efficiency and renewable energy policies continued at the currently planned pace [4]. The Commission's study models the CPRICE scenario using a carbon price of €60/tCO_2e [4]. However, this scenario explores the effect of carbon pricing in the building sectors only to a limited extent. It is stated that "the short term price sensitivity in the buildings and transport sector is relatively low, hence prices either cannot overcome all barriers or might need to be very high to achieve the outcome, a risk which modelling and the resulting carbon price of €60/tCO_2 in CPRICE can only reflect to a certain extent." [4]. Therefore, it is worth to explore the role and sufficiency of different CO_2 prices applied in the building sectors, taking the applied regulations on building transformation and constraints of the energy carrier availability into account. The following research questions are investigated systematically:

- Can the EU building sectors manage to decarbonize by 2050 with the implementation of currently stated policies, including non-ETS CO_2 pricing?
- What is the effective non-ETS CO_2 price in the building sectors when applied simultaneously with the other planned policy instruments?

1.2 Literature Review

The EU did not establish CO_2 pricing in the non-ETS sectors (includes buildings) as a mandatory measure to be implemented. Member states decide within their national policies to include it or not. Scandinavian states were among the first ones to start applying the CO_2 pricing in non-ETS sectors; Finland, Sweden and Denmark have the carbon tax since 1990s. Sweden takes the lead with the highest current CO_2 price of 119 US$/t$CO_2$e, while Finland and France follow with 58 and 49 US$/t$CO_2$e [9]. While other states including Germany, Austria and Luxembourg have announced their plans to start implementing it as early as 2021 at a price of around 25 US$/t$CO_2$e [9].

The discussion on the application of CO_2 pricing in the building sectors is relatively young. So far, renovation of the building stock has been of high importance and a central part of the transition of the building sectors, as nearly 80% of today's buildings will still exist in 2050. The technological development of better performing building components and the low compliance rate of old buildings with the relevant standards at their construction time as well as with those of current time necessitate nearly all buildings built before 2010 to be renovated until 2050 [5]. The European and related national building codes as well as directives provide the path of building renovation. However, challenges remain, as there is difficulty in convincing end-users. Renovation costs are high and up-front, but the rates of return develop over a long period of time [10]. Subsidy requirements are often complicated to evaluate. Moreover, the incentives for renovation of buildings are unevenly distributed to property owners and tenants, and inconveniences can easily occur [5, 11].

Moreover, replacement of less efficient and old technologies with the most up-to-date efficient equipment have an important role in the energy demand reduction of buildings. To incentivize the fast diffusion of efficient technologies, especially more efficient and climate-neutral heating equipment such as heat pumps and biomass boilers, could also be challenging in cases where the inefficient/carbon-intensive stock is relatively young, far from the technical end-of-life, or cheap [12].

Nevertheless, the European Commission's study on building energy renovation confirms that the annual weighted energy renovation rate of the EU buildings is rather stagnant at 1% [13]. Considering the rates of renovation historically, in the case of less ambitious energy demand reduction, the fast diffusion of renewable and CO_2-neutral energy supply to buildings is crucial as well. Renewable heat production capacities should increase and be accessible to European buildings. In addition, the renewable heat carriers should also be economically competitive against the widely used and conveniently priced fossil fuels. Depending on regional conditions, district heating (DH), heat pumps (HP), biomass and hydrogen (H_2) are frequently discussed renewable energy sources to capture the heat demand. However, in terms of biomass and hydrogen there is a competition between the demand side sectors such as the transport sector which leads to limited capacity usage in the buildings sector.

2 Methodology

2.1 Modelling approach

The building stock, renovation and investment decisions are modelled with the bottom-up simulation model FORECAST™, which considers socio-techno-economic factors, policy instruments and energy carrier specific restrictions.

The model uses population, GDP and GVA development, number of dwellings, living area per dwelling and working space per employee in order to simulate the building stock. Cohorts represent the stock of technologies, whereas the age distribution of end-use technologies is captured by a vintage stock design [14]. Climate-corrected average outdoor temperatures, thermal properties of the building envelope and building occupation profiles are used to calculate the final energy demand of the stock.

Energy carrier prices for end consumers are projected per nation and they are considered for the diffusion of technologies and retrofit possibilities. The investment decisions are modeled via a discrete choice model that uses a multinomial logit approach for each agent. Agents represent various different actors of the system individually. Figure 1 shows a simple diagram of the flow of FORECAST™ Buildings.

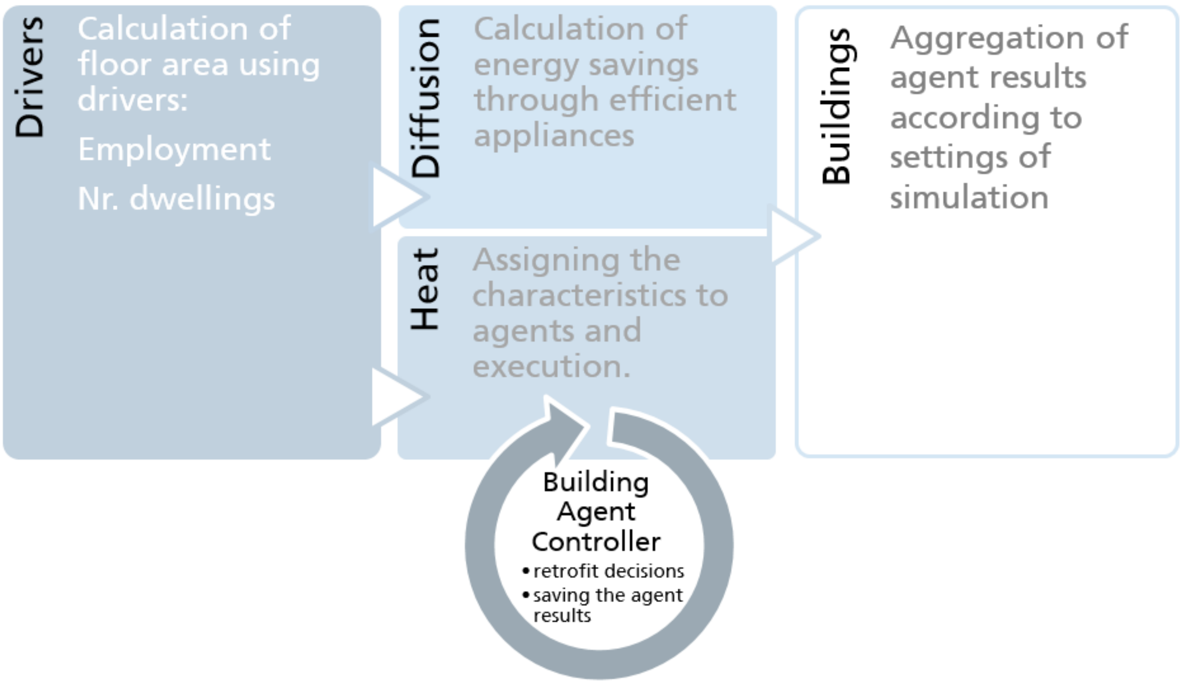

Figure 1: Simple calculation flow of FORECAST™ Buildings

2.2 Scenario analysis

Basic scenario

One basis scenario was designed to represent the evolution of the national building stock under the continuation of declared policies of the member states, based on the declared paths in [15]. Regulations on the efficiency and performance of building components and technological devices are captured within the scenario.

CO_2-Price modifications

Building on the basis scenario, five different non-ETS CO_2-price pathways were designed. The first path, *VAR0*, includes the prices that were announced by the states, and introduces the prices of neighboring states with similar economies to those countries who did not announce implementation of non-ETS CO_2-pricing (see Table A-1). The development of the prices until 2050 were continued at the pace of the development that is announced by the states.

The second pathway, *VAR1*, sets EU-wide intermediate price goals of 100 and 180 EUR/tCO_2e. Member states reach the price goal of 2030 at their own pace, according to the price that they started with.

Table 1: CO_2 price averages of the EU27+UK in the price pathways investigated in this study

Pathway	Unit	2030	2040	2050
VAR0	EUR/tCO_2e	47	63	77
VAR1	EUR/tCO_2e	102	142	181
VAR2	EUR/tCO_2e	131	166	201
VAR3	EUR/tCO_2e	180	240	300
VAR4	EUR/tCO_2e	200	275	350

(Note that price projection of Sweden already reaches higher than the intermediate goals of VAR1 and VAR2, and consequently, raises the average of EU states to slightly above the intermediate price goals.)

For the rest of the pathways, the same approach is taken to set intermediate goals of 130 and 200, 180 and 300, and 200 and 350 EUR/tCO_2e in *VAR2*, *VAR3* and *VAR4*, respectively. Table 1 summarizes the price pathways.

3 Results and Discussion

The FORECAST™ simulation results of the modeled pathways show that under the planned non-ETS CO_2 price and other policy measures, the direct emissions of the EU buildings would decrease to 309 MtCO_2 in 2030 and to 80,6 MtCO_2 in 2050. This corresponds to a reduction of 42% by 2030 and 85% by 2050 compared to 1990 levels. The reduction in the residential stock steps up after 2030, while the reductions in the commercial stock are relatively constant towards 2050.

Figure 2 displays the CO_2 emissions of the building stock under the five different pricing pathways. If the applied non-ETS CO_2 price doubles on average, in the VAR1 path, direct emissions of the EU building stock drop down to 66,6 MtCO_2 in 2050. This is 88% reduction compared to 1990. Another doubling of the applied non-ETS CO_2 price, in the VAR4 path, leads to around 2% higher reduction than VAR1, resulting in 288,1 MtCO_2 in 2030 and 51,5 MtCO_2 in 2050.

The red horizontal line in Figure 2 marks the level of emissions that needs to be achieved in order to comply with the Paris Agreement. Even the most ambitious VAR4 pricing path reaches almost twice the target level in 2050. The achieved emission reductions are also below the red point that highlights the target reduction level. This shows indeed the limitations of the CO_2 pricing in the buildings sector, even if significantly high CO_2 prices are applied. The energy demand of the building stock and the speed of the technological stock change pose greater barriers than the CO_2 pricing can overcome alone. Thereby, the success of the CO_2 price path is dependent on the success of other decarbonization measures in the building sectors.

The emissions of the building stock do not decrease to 60% of the 1990 level by 2030 in any of the modeled pathways. Emission reductions in 2030 are around 40%, or around 45% in the most ambitious cases. As the price of synthetic gas was not integrated in the model, a CO_2-neutral gas option was not modeled in this study.

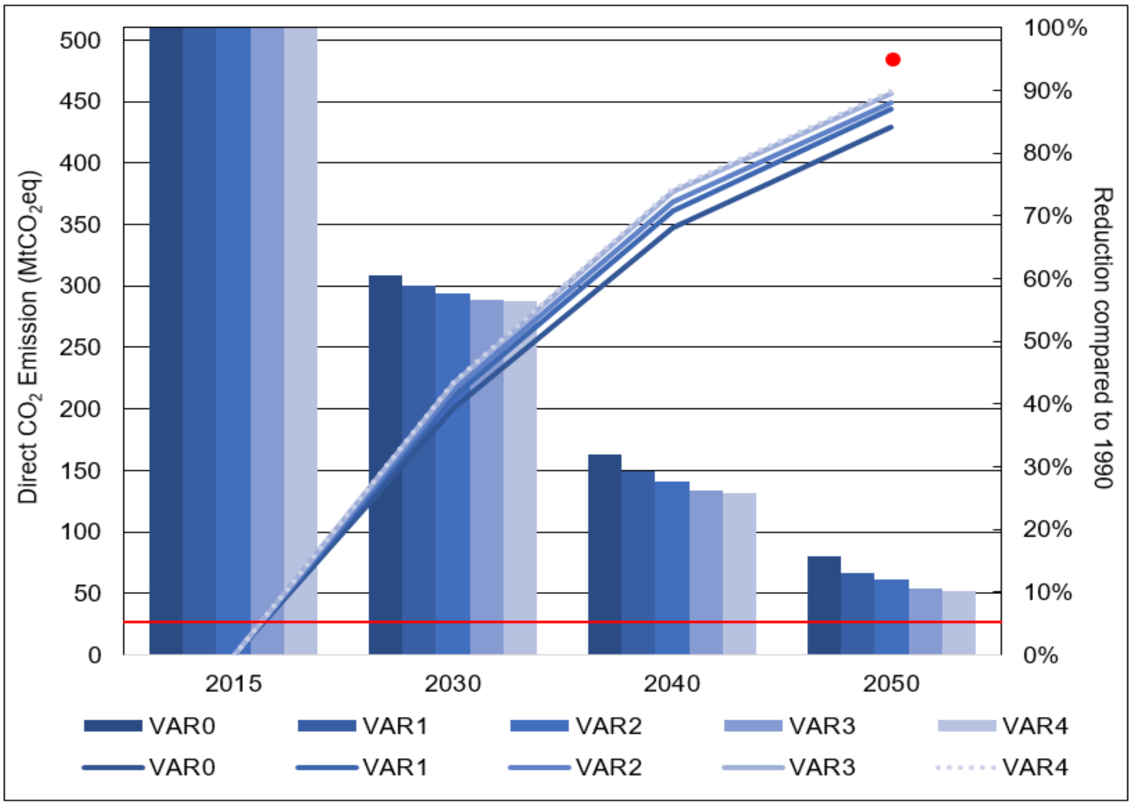

Figure 2: Development of CO_2 emissions of EU buildings under the modeled pathways

Therefore, the CO_2 emissions embedded in the remaining natural gas in the system could not be eliminated. However, it also shows that under the current measures of building stock renovation and fuel switch, the transition to a fossil-free and low-energy building stock is not fast enough and a considerable amount of gas has to stay in the system.

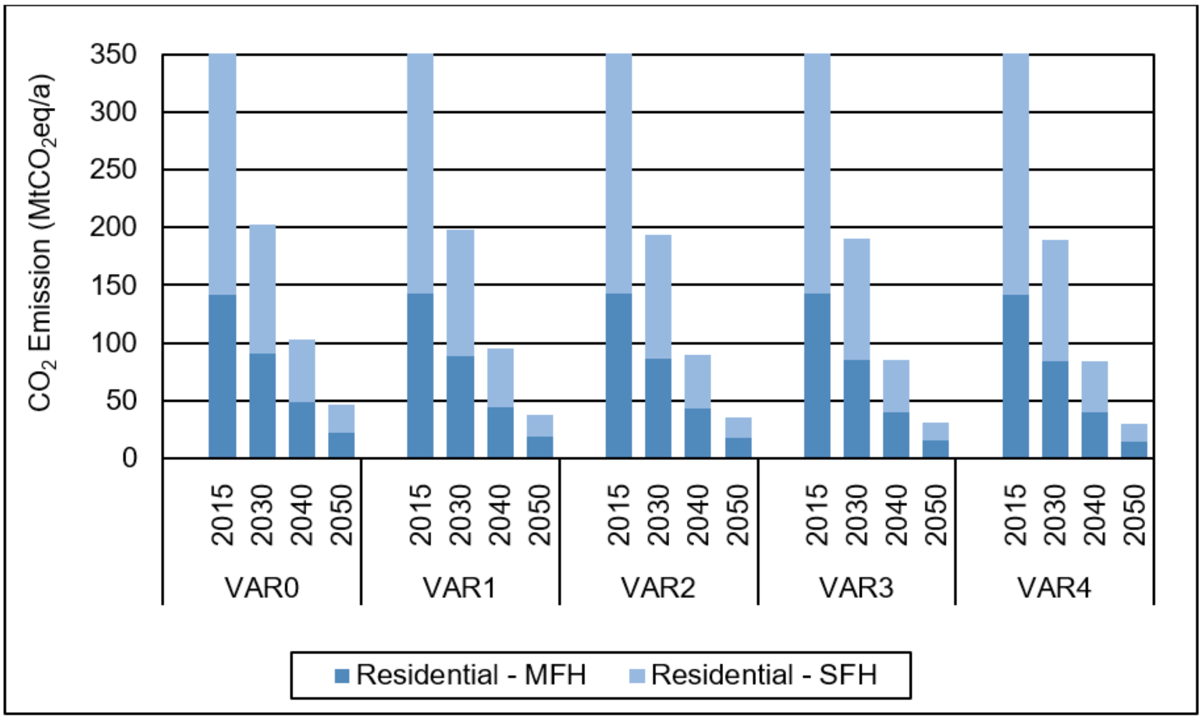

Figure 3: Direct CO_2 emissions of EU residential buildings per subsector

Another assumption of the model is that the heating system technologies are replaced only at the end of technological lifetime. Early replacements due to social factors such as community awareness, incentives and campaigns for mobilization are not captured.

Figure 3 shows the direct CO_2 emissions related to the heating of residential buildings. The increase in the applied CO_2 price pushes the fossil fuels out of the multi-family houses (MFH) and decreases the direct CO_2 emissions of the subsector more than in the single-family houses (SFH). However, single-family houses already experience higher reduction in their direct emissions towards 2050 under the lowest CO_2 price pathway. This is probably due to the higher renovation rates observed in the SFHs.

On Figure 4, the direct CO_2 emissions resulting from the heating of tertiary sector buildings are visible per subsector and pricing pathway. It is important to note that the least reduction of emissions are achieved in Hotel, café and restaurants in all of the price pathways. Under the currently planned path, they achieve 68% reduction in 2050 compared to 2015. Whereas, public offices and wholesale and retail trade buildings achieve the highest reductions. The pricing of VAR0 reduces their emissions by 85% in 2050 compared to 2015. The highest emitting buildings of the whole sector are of subsectors education, wholesale and retail trade, health and ‘other services’ (buildings outside the list of specified subsectors on Figure 4). Especially buildings of education, health and other services require stricter measures than planned, as they achieve below 80% reduction in the VAR0 pathway.

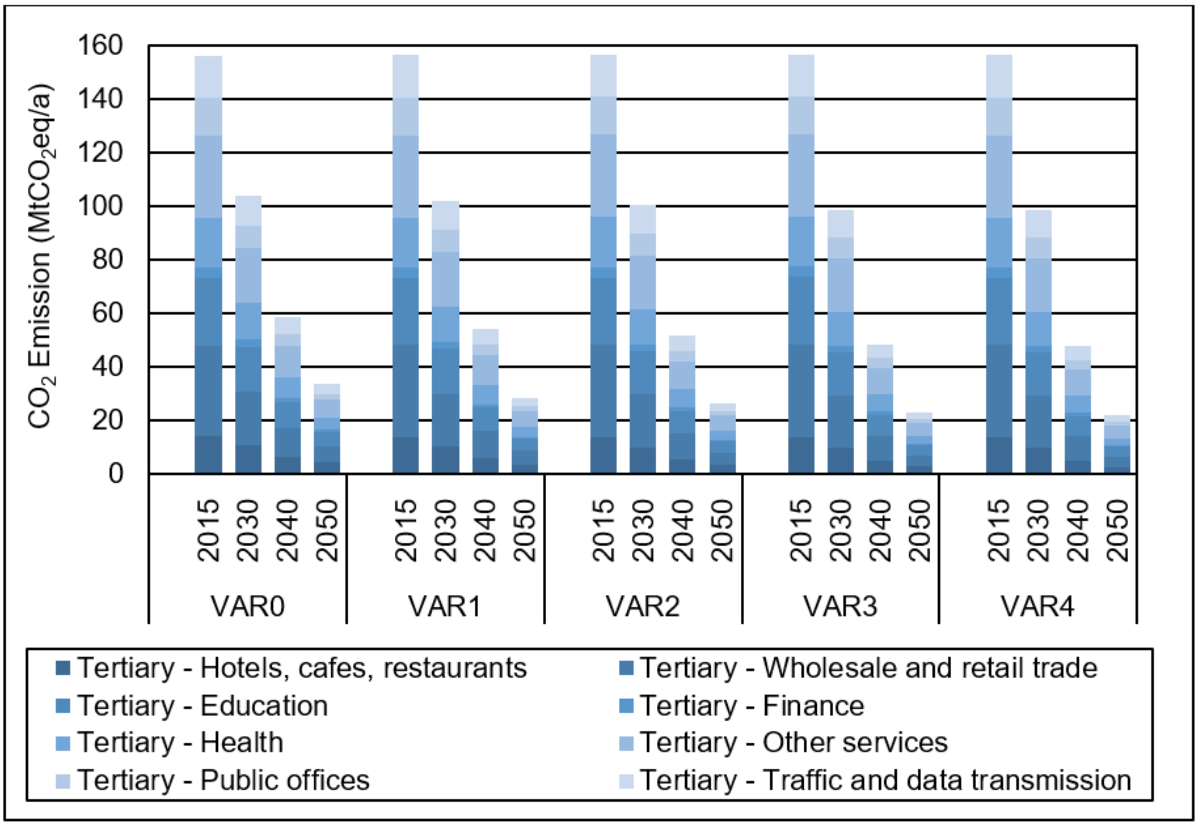

Figure 4: Direct CO_2 emissions of EU service sector buildings per subsector

Figure 5 displays the direct emissions of the buildings in selected EU (EU27+UK) countries. These countries have the highest emitting building sectors among all EU countries in 2015. While most of them achieve above 84% emission reduction with the currently planned non-

ETS CO_2 pricing, Italy and Spain have a lower response to this policy measure. The two countries achieve 82% emission reduction at most in the VAR4 path. Germany, UK and France (the top 3 contributors) already achieve 88% emission reduction on average in 2050 in the planned CO_2 pricing path (VAR0). The substantial increase in the price is not enough to push their reductions above 92% in 2050 (VAR4).

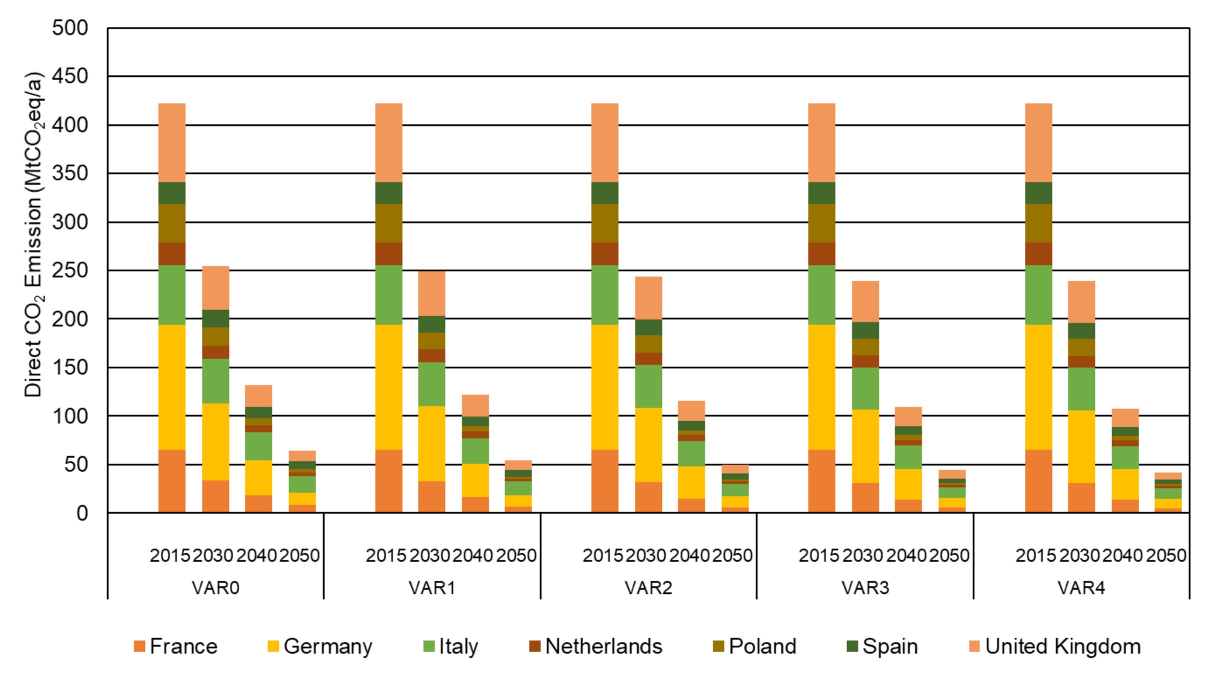

Figure 5: Development of CO_2 emissions of buildings in selected EU countries (incl. UK)

The CO_2 pricing in buildings is the most successful in Poland. Even with a CO_2 price of 15 EUR/t in 2030 and 23 EUR/t in 2050 (VAR0), it is projected to achieve 92% emission reduction by 2050. The relative price of useful energy produced from fossil fuels compared to carbon-free alternative carriers determines the advantageous operating costs of the heating system. In Poland, the price of useful energy coming from a renewable source such as a heat pump operating with carbon-free electricity is close to that coming from natural gas. Therefore, even low CO_2 prices can shift the economic profitability towards renewable heating systems easily. For example, in the UK, this price difference is higher and therefore, a higher price of CO_2 can force the same outcome. This shows the importance of determining the prices specific to each country considering the prices of fossil fuels and its available alternatives, as well as the efficiency of heating technologies.

Figure 6 shows the development of the final heating energy demand of EU buildings. The strong decrease in fossil fuels is immediately visible. In 2050, 248 to 384 TWh of fossil fuels are needed to provide between 10 to 15% of the heat demand of the building stock. The fuel switch is dominantly towards district heating, biomass and ambient heat (i.e. heat pumps). Around 560 TWh of biomass and 615 TWh of district heating in 2050 serve 25 and 27% of the heating demand of buildings. Heat pumps serve 12% of the demand in 2030 and take up after 2030 to supply around 27% of the heating demand in 2050. Hydrogen is not able to diffuse into the market, due to high prices of the fuel and the required investment costs of the heating equipment.

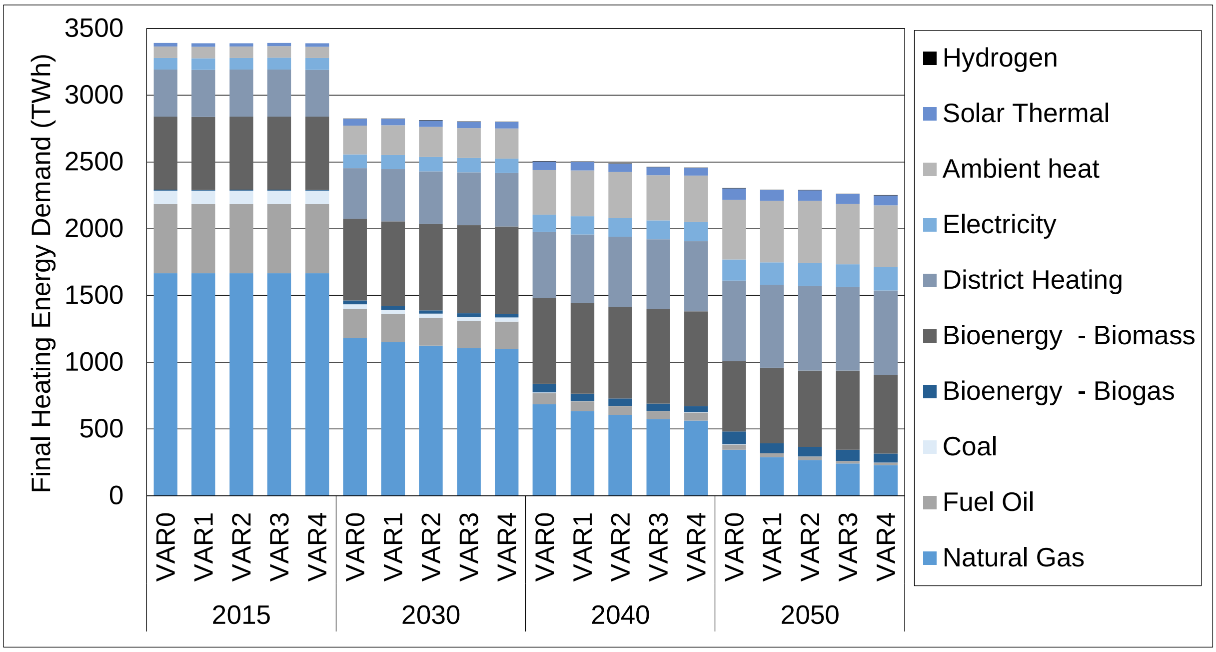

Figure 6: Final energy demand of EU buildings per energy carrier

The total heat demand of the EU buildings differ slightly between the different price pathways. As, the demand reduction depends on the renovation activities, it supports that the CO_2 pricing in buildings, no matter how high, has to be complemented with policy instruments on the renovation of buildings. This way, the fossil fuel demand in building heating could go below 10%, and there is less risk of exceeding the renewable resource capacities.

According to the definition of the Commission's study on building energy renovation, the average energy related renovation rate of the EU building stock for above 'light' depth renovations between 2012-2016 has been 1,3 and 2,6% for residential and commercial buildings, respectively [13]. The outcome of this study shows that the renovation rates increase over the decades towards 2050.

Under the modeled policy efforts, energy related renovation rates in residential building go above 2% after 2030 in all pathways of this study. These rates could be a benchmark for renovation and energy efficiency policies targeting more ambitious energy demand reduction in the EU building stock. Figure 7 summarizes the resulting average rate of above light depth energy related renovations for the EU countries.

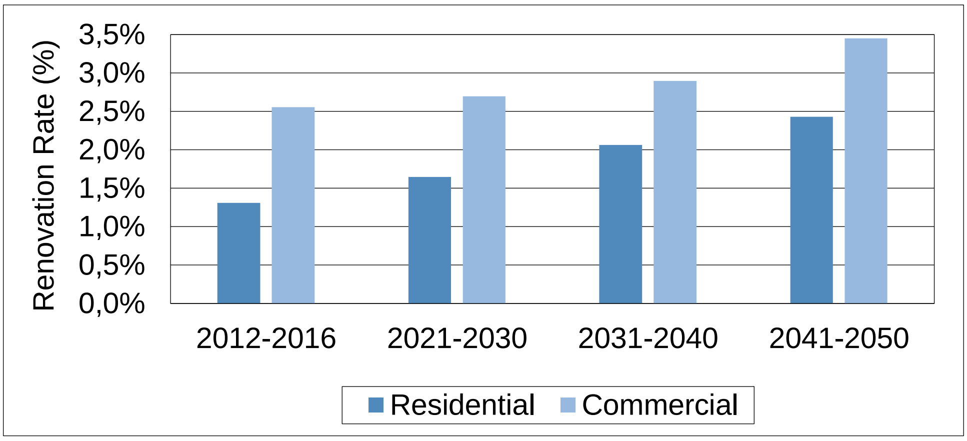

Figure 7: Energy related renovation rate of the EU building stock

4 Conclusions

This study investigated the application of different CO_2 prices on fossil fuels in the heating of buildings of the EU. The EU building stock was modeled and its development was simulated until 2050 via the energy demand simulation model FORECAST™. The objective was to investigate the strengths and limitations of CO_2 pricing in the building sectors, assuming that the other policies are continued in the sectors at the same pace.

The pricing pathway that is currently planned by the member states does not carry the overall sector emissions to the target levels of the Paris Agreement. The energy demand of the building stock and the replacement speed of the technological stock pose greater barriers than the CO_2 pricing can overcome alone. The success of the CO_2 price is linked to the success of other decarbonization measures in the building sector.

The impact that the CO_2 price makes on the fuel switch to renewables is also strongly linked to the relative price of energy carriers. Therefore, this study comes to the conclusion that it is not necessary to establish one common CO_2 price for the whole EU. The impact of the CO_2 price in the building sectors does not necessarily get stronger as the price increases. Rather, it is smart to thoroughly calculate and optimize the price specific to each nation.

Residential buildings are forecasted to cut their emissions faster than the commercial buildings, even though the modeled renovation rates are higher in the commercial sector. It shows the potential of the CO_2 pricing in the residential sector, as well as the potential of fuel switch to renewables in the residential sector. The main renewable heat sources considered in this study are biomass, district heating and electricity (and ambient heat) via heat pumps. The service sector buildings of education and health require stricter measures to reduce their direct emissions, as they achieve below 80% reduction under the planned pathway.

It is important to analyze and evaluate the non-ETS CO_2 pricing in EU building sectors further, with a model that includes the carbon-neutral synthetic fuels in the system. It is also worth to investigate how the CO_2 pricing in the electricity and district heating supply affects the energy carrier prices and overall choice of heating technology in buildings. Moreover, considering social factors such as community awareness, incentives and campaigns for mobilization in modeling the turnover of the heating technology stock would add high value to this investigation in the future.

Appendix A - Assumptions

Table A-1: Development of CO_2 price in buildings in VAR0 path (continuation of planned prices)

Country		**2021**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Austria	EUR/t	20	40	65	79	90	101	111
Belgium	EUR/t	20	40	65	79	90	101	111
Cyprus	EUR/t	2	7	15	17	19	21	23
Czech Rep.	EUR/t	2	7	15	17	19	21	23
Denmark	EUR/t	25	36	42	47	51	55	59
Estonia	EUR/t	3	7	11	14	16	17	19
Finland	EUR/t	55	68	81	93	103	113	122
France	EUR/t	47	54	63	70	77	83	89
Germany	EUR/t	25	55	65	84	93	103	112
Greece	EUR/t	22	39	51	60	67	74	80
Hungary	EUR/t	2	7	15	17	19	21	23
Ireland	EUR/t	26	50	80	97	111	124	136
Italy	EUR/t	15	35	50	58	66	72	79
Latvia	EUR/t	12	24	39	54	69	84	99
Lithuania	EUR/t	12	24	39	54	69	84	99
Luxembourg	EUR/t	20	40	65	79	90	101	111
Malta	EUR/t	22	39	51	60	67	74	80
Netherlands	EUR/t	22	39	51	60	67	74	80
Poland	EUR/t	2	7	15	17	19	21	23
Portugal	EUR/t	25	36	42	47	51	55	59
Slovakia	EUR/t	2	7	15	17	19	21	23
Slovenia	EUR/t	21	32	38	43	47	51	55
Spain	EUR/t	22	39	51	60	67	74	80
Sweden	EUR/t	114	132	152	169	186	201	215
UK	EUR/t	26	50	80	97	111	124	136
Romania	EUR/t	2	7	15	17	19	21	23
Bulgaria	EUR/t	2	7	15	17	19	21	23
Croatia	EUR/t	21	32	38	43	47	51	55
Average		***21***	***34***	***47***	***56***	***63***	***70***	***77***

Appendix B - Results

Table B-1: Development of CO_2 emissions and the reduction in the emissions per building sector

		CO_2 Emission | Reduction with respect to 1990								
		1990	**2015**		**2030**		**2040**		**2050**	
Residential	*VAR0*	343,4	353,2	-3%	204,7	40%	104,3	70%	47,0	86%
	VAR1	343,4	353,2	-3%	198,2	42%	94,8	72%	38,2	89%
	VAR2	343,4	353,2	-3%	193,8	44%	89,9	74%	35,0	90%
	VAR3	343,4	353,2	-3%	190,4	45%	84,8	75%	31,2	91%
	VAR4	343,4	353,2	-3%	189,3	45%	83,6	76%	29,7	91%
Commercial	*VAR0*	193,1	156,6	19%	104,1	46%	58,8	70%	33,6	83%
	VAR1	193,1	156,6	19%	102,0	47%	54,2	72%	28,3	85%
	VAR2	193,1	156,6	19%	100,4	48%	51,5	73%	26,3	86%
	VAR3	193,1	156,6	19%	98,7	49%	48,4	75%	22,7	88%
	VAR4	193,1	156,6	19%	98,7	49%	47,6	75%	21,8	89%

Literature

[1] Eurostat, 2019. Complete energy balances (Accessed in April 2021)

[2] Eurostat, 2018. Disaggregated final energy consumption in households – quantities (Accessed in April 2021)

[3] Eurostat, 2019. Share of fuels in final energy consumption (Accessed in April 2021)

[4] European Commission (2020): Impact assessment Part 2/2 accompanying the document: Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions COM (2020) 562 - Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people. European Commission, Brussels.

[6] European Union (2019): "Paris Agreement." Climate Action - European Commission, European Commission, https://ec.europa.eu/clima/policies/international/negotiations/paris_en (Accessed in August 2021).

[5] European Commission (2018): In-depth analysis in support of the Commission Communication COM (2018) 773: a Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. Brussels.

[7] European Commission (2020): Impact assessment Part 1/2 accompanying the document: Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions COM (2020) 562 - Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people. European Commission, Brussels.

[8] IEA (International Energy Agency) (2020): World Energy Outlook-2020, IEA, Paris, https://www.iea.org/reports/world-energy-outlook-2020.

[9] World Bank (2020): "State and Trends of Carbon Pricing 2020" (May), World Bank, Washington, DC. Doi: 10.1596/978-1-4648-1586-7. License: Creative Commons Attribution CC BY 3.0 IGO

[10] Petran, H.; Geissler, S.; and Vlachos, S. (2017): EPC/retrofitting actions -stakeholders÷ perspective: needs, barriers and general acceptance Deliverable 2.3: Report on analysis of the results – Survey at retrofitting companies, energy efficiency programs stakeholders and final users.

[11] Möst, Dominik; Schreiber, Steffi; Herbst, Andrea; Jakob, Martin; Martino, Angelo; Poganietz, Witold-Roger (2021): The Future European Energy System. Cham: Springer International Publishing.

[12] Hartner, M.; Forthuber, S.; Kranzl, L.; Fritz, S.; Aichinger, E.; Müller, A.; Herbst, A.; Fleiter, T.; Rehfeldt, M.; Heitel, S.; Krail, M.; Köhler, J.; Bernath, C.; and Sensfuß, F. (2019): Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation D.5.8: WP5 Summary report - Energy Systems: Demand perspective. Technische Universität Wien, Wien.

[13] Ipsos Belgium and Navigant (2019): Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. Final report. Commissioned by the EUROPEAN COMMISSION.

[14] Elsland, Rainer (2015): Development of an integrated modelling concept to capture technological myopia - Analysing long-term energy demand in the German residential sector. Dissertation. Karlsruhe Institute of Technology (KIT), Karlsruhe.

[15] European Commission (2020): Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions COM (2020) 564 - An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning. European Commission, Brussels.