sEEnergies

QUANTIFICATION OF SYNERGIES BETWEEN ENERGY EFFICIENCY FIRST PRINCIPLE AND RENEWABLE ENERGY SYSTEMS

D3.1 Assessment of reference scenarios for industry

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Acronyms & Abbreviations

Term	Description
EAF	Electric arc furnace
EED	Energy Efficiency Directive
EJ	Exajoule
ESD	Effort Sharing Decision
EU	European Union
EU ETS	European Union Emission Trading System
GJ	Gigajoule
HRE	Heat Roadmap Europe
GJ	Gigajoule
PJ	Petajoule
SEC	Specific energy consumption

1 Introduction

In the sEEnergies project, the detailed analysis of the industrial sector is based on the latest EU projections for the development of energy demand up to 2050 (European Commission, 2016 and 2019). The reference scenario in European Commission (2016) includes final energy demand projections per industrial sub-sector and EU country while capturing current policies and market trends. However, it does not give insights into what extent energy efficiency potentials are already implemented. For this reason, this analysis focuses on constructing a frozen efficiency scenario that considers the same structural changes as the reference scenario in European Commission (2016), but with no energy efficiency improvements. The main aim is to understand the impact of structural changes and energy efficiency in the total final energy projections. To assist the comparison, the final energy demand in the reference scenario is decomposed into volumes (tonnes of product) and energy efficiency.

Two scenarios are analysed:

- Reference scenario: The reference scenario is based on the reference scenario from European Commission (2016). It shows the energy demand projections per industrial sub-sector and EU country. The main assumption is that current policies are continued but not tightened.
- Frozen efficiency scenario: The frozen efficiency scenario assumes that no energy efficiency or technological changes take place in the manufacture of industrial products. It allows however for socio-economic changes (i.e. industrial value added and production volumes). However, the impact of increased material efficiency for primary vs secondary steel and the share of clinker used in cement making is assumed to remain fixed to the 2015 level.

This document summarizes the method and assumptions made to construct the reference and frozen efficiency scenarios. In addition, it compares the final energy demand projections made in these two scenarios with the main purpose to distinguish the impact of socio-economic changes and energy efficiency changes on the energy demand projections.

Note that the data presented in this document is not final. In the next step we will work on energy efficiency potentials and scenarios which entails that we may make improvements to the baseline data sets, when we dive more deeply into the sub-sectors.

Main results:

- **Final energy demand for all EU 28 countries per industrial sub-sector.** Reported energy demand is up to 2050 with 5-year intervals, per fuel type for two scenarios; the reference and the frozen efficiency scenarios.
- **Final energy demand for heating and cooling, for all EU 28 countries per industrial sub-sector.** Reported energy demand is up to 2050 with 5-year intervals, per temperature level and per fuel type for two scenarios; the reference and the frozen efficiency scenarios.
- **Autonomous and policy induced energy efficiency included in the reference scenario.** These are the energy savings already realized in the reference scenario. Autonomous refers to energy efficiency improvement which occurs due to technological developments. Each new generation of capital goods is likely to be more energy efficient than the one before.

2 Overview of the approach

Three main data sources are used to develop the reference scenario:

(1) The EU Reference Scenario 2016 (European Commission, 2016) is used for the final energy development of industries in the period 2015-2050 (data is available for 5-year intervals). It is the most recent scenario for the EU that contains data on a per country and per sector level. Per industrial sub-sector (iron and steel, non-ferrous metal, chemicals, non-metallic minerals, paper and pulp and other) it only includes total final demand. For the industry as a whole, the energy demand is disaggregated into coal, oil, natural gas, electricity and other.
(2) IEA (2016) is used for the breakdown of final energy demand per source (coal, peat, oil, natural gas, electricity, biomass and waste, geothermal, solar, heat and others) per industrial subsector, for the base year 2015. For future fuel mixes the shares are either kept constant or adapted, depending on the development of different production routes (e.g. more electric steel than integrated steel).
(3) Heat Roadmap Europe 4 (HRE4) (2017) is used for estimating the share of final energy demand per industrial sub-sector that is used for heating and cooling at which temperature level.

The resulting final energy demand data for industries includes energy used in blast furnaces and coke ovens but excludes feedstocks (e.g. in the petrochemical industries) and primary energy used to produce purchased electricity. Furthermore, refineries are not included.

The EU Reference 2016 scenario includes policies and measures adopted in the EU in 2014 and Directive amendments made in 2015 (European Commission, 2016). The availability of EU Emissions Trading System (ETS) allowances faces an annual decrease following current Directive provisions and industrial energy efficiency improves reflecting recent policies such as Ecodesign and labelling and the Energy Efficiency Directive (EED). The EU wide greenhouse house gas emission (GHGs) reductions from the Effort Sharing Decision (ESD) are assumed to be achieved in the reference scenario. The industrial GHG emission intensity slightly decreases (2%) in 2020 (compared to 2010) to more drastically decrease in 2030 (27%) and 2050 (51%). This is the result of increased energy efficiency, switch to the production of higher value added industrial products, slow growth of energy intensive industries, and the shift to lower carbon intensive fuels.

Based on the reference scenario a frozen efficiency scenario is developed where the specific energy consumptions (SEC) (in GJ/tonne) remains fixed. The difference between the reference scenario and the frozen efficiency scenario is therefore equal to the (autonomous and policy induced) energy-efficiency improvement in the reference scenario. This provides a good basis for the estimation of the energy efficiency improvement potentials in comparison to the frozen efficiency and reference scenario.

The frozen efficiency scenario is based on:

- Value added assumptions in EU Reference 2016 scenario (European Commission, 2016).
- Estimated production data (based on European Commission (2016), HRE4 (2017) and other sources (see Table 1 Summary of main assumptions for projections of industrial activity.)).
- SEC data from HRE4 (2017) and other literature.

Table 1 Summary of main assumptions for projections of industrial activity. shows the sources used for the activity developments.

Table 1 Summary of main assumptions for projections of industrial activity.

Parameters	Sources	Main assumptions for projection
Industrial value added	EU Ref 2016 (European Commission, 2016)	same as EU Ref.
Iron and steel	POTEnCIA (Mantzos et al, 2019); Worldsteel, 2018	Reference scenario: growth same as POTENCIA; frozen efficiency scenario: total steel growth same a POTENCIA and Electric Arc Furnace (EAF) share remains fixed to the 2015 level.
Cement	POTEnCIA (Mantzos et al, 2019); GCCA, 2020; ECRA, 2017	Reference scenario: cement growth same as in POTENCIA and clinker growth at a slower pace; frozen efficiency scenario: cement and clinker grow at the same pace.
Chemicals	EU Ref 2016 (European Commission, 2016)	Fertilizers and inorganic chemicals stabilize and slightly decline in later years, methanol and ethylene experience strong growth.
All other industrial products	EU Ref 2016 (European Commission, 2016); HRE4 (2017)	No radical changes.

The outcome is for the reference and the frozen efficiency scenario for the years 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050 per EU country:

-total final energy demand per industrial sub-sector (split into coal, peat, oil, natural gas, electricity, biomass and waste, geothermal, solar, heat and others),

-final energy demand for heating and cooling per industrial sub-sector (per temperature category).

3 Input data per industrial sub-sector

Figure 1 shows how the industrial value added changes in the 2015-2050 period in the reference scenario in the different EU countries. The data are taken from the EU Reference scenario that reports industrial value added projections per country and per main industrial sub-sector (European Commission, 2016). The twelve countries in Figure 1 were responsible for 90% of the 2015 industrial value added. Only five countries, Germany, Italy, France, UK and Spain were responsible for 70% of the EU28 value added in 2015, a share that is projected to drop to 65% by 2050. Overall, in the 2015-2050 the industrial value added in the EU is projected to grow by 45%. In most countries, industrial value added grows stronger in the 2015-3030 period (see Table 2).

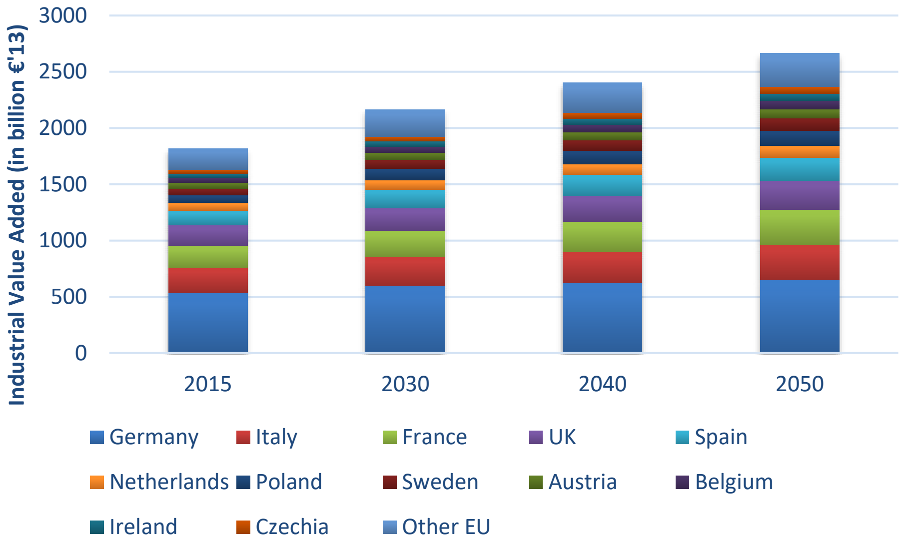

Figure 1 Industrial value added per EU country (European Commission, 2016)

Table 2 Industrial value added per country and associated growth rates (European Commission, 2016). (unit: billion €'13)

Countries:	2015	2030	% 15-30	2040	% 30-40	2050	% 40-50
Germany	535	602	13%	624	4%	653	5%
Italy	227	254	12%	280	10%	313	11%
France	194	230	19%	266	16%	310	16%
UK	180	203	13%	230	13%	256	11%
Spain	130	165	27%	187	14%	207	11%
Netherlands	70	83	19%	92	10%	104	13%
Poland	66	102	54%	122	19%	135	11%
Sweden	61	78	30%	94	19%	112	19%
Austria	52	63	20%	70	12%	78	11%
Belgium	46	55	20%	66	20%	78	18%
Ireland	36	47	32%	54	15%	62	15%
Czechia	34	43	29%	51	17%	59	17%
Other EU	189	238	26%	270	13%	299	11%
EU28	1,818	2,164	19%	2,405	11%	2,665	11%

In Figure 2, the industrial value added in the EU28 is broken down per industrial sub-sector. The main contributor both in 2015 and 2050 is Engineering, responsible for 36% and 45% of total value added, respectively. The most energy intensive industries, pulp and paper, non-ferrous metals, non-metallic minerals and iron steel are responsible for 12% of the value added in 2015, much lower than 16% in 1995, and their share is projected to further decrease to 11% by 2050.

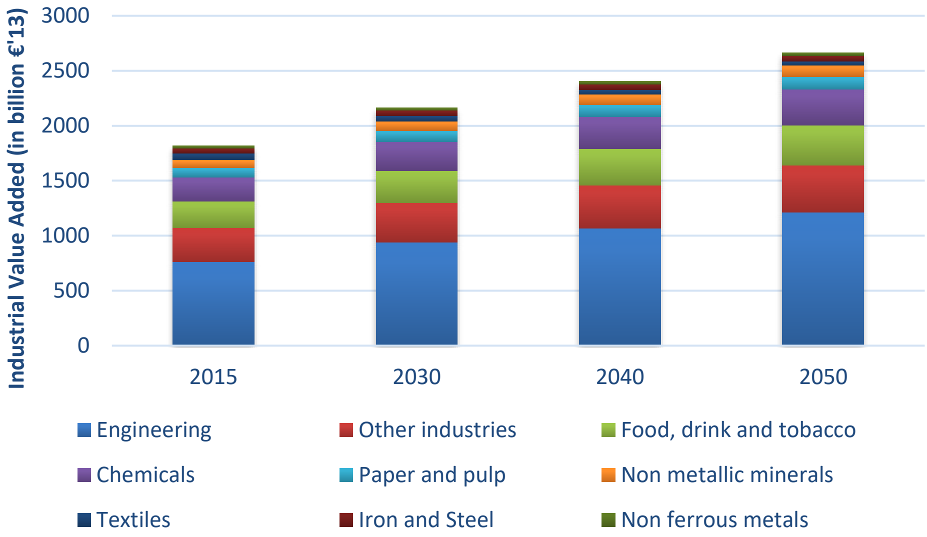

Figure 2 Industrial value added per industrial sub-sector (European Commission, 2016)

Table 3. Production developments in the EU28 in the Reference scenario (in ktonnes). shows the production developments of important industrial products in the Reference scenario. Most products experience an increase in production in the 2015-2030 period while in the 2030-2050 period the bulk seem to stabilize. A significant part of energy intensive products remains in the EU area (European Commission, 2016), so there is no expected significant decrease in production.

Table 3. Production developments in the EU28 in the Reference scenario (in ktonnes).

Product	2015	2030	% 15-30	2040	% 30-40	2050	% 40-50
Chemicals							
Carbon black	998	1,138	14.0%	1,151	1.1%	1,172	1.9%
Ethylene	16,810	18,023	7.2%	18,905	4.9%	19,569	3.5%
Methanol	1,438	1,725	20.0%	1,768	2.5%	1,812	2.5%
Ammonia	17,394	17,864	2.7%	17,919	0.3%	17,901	-0.1%
Soda_ash	6,025	6,326	5.0%	6,295	-0.5%	6,263	-0.5%
Toluene	2,273	3,050	34.2%	3,139	2.9%	3,230	2.9%
Iron and steel							
Blast furnace	100,864	105,982	5.1%	103,970	-1.9%	104,093	0.1%
Rolled_steel	150,924	140,652	-6.8%	129,121	-8.2%	118,858	-7.9%
Electric arc furnace	65,429	68,447	4.6%	75,117	9.7%	77,257	2.8%
Food							
Meat	46,621	48,952	5.0%	49,196	0.5%	49,442	0.5%
Dairy	73,262	76,925	5.0%	77,309	0.5%	77,694	0.5%

Non-ferrous metals							
Aluminium_primary	2,242	2,402	7.2%	2,344	-2.4%	2,344	0.0%
Non-metalic minerals							
Cement	168,170	200,794	19.4%	202,154	0.7%	204,665	1.2%
Clinker	127,809	143,660	12.4%	138,908	-3.3%	135,079	-2.8%
Lime	27,674	32,272	16.6%	32,223	-0.2%	32,383	0.5%
Gypsum	17,169	20,227	17.8%	20,328	0.5%	20,430	0.5%
Pulp and paper							
Paper	91,505	99,226	8.4%	100,369	1.2%	101,041	0.7%
Pulp	34,963	37,060	6.0%	37,612	1.5%	38,172	1.5%

The production volumes used in the reference and the frozen efficiency scenarios are the same, except in two cases:

i) **the clinker produced in the cement industry.** In 2015, the average clinker content in the EU was 74% (GCCA, 2020). In the EU Reference scenario, it is assumed that the potentials of using recycled materials is exhausted (European Commission, 2016). We thereby assume that the clinker content in the reference scenario drops to 66%, which the lowest clinker contents used currently in the EU (ECRA, 2017). In the frozen efficiency scenario, the clinker content remains stable at 74% (current level). Figure 3 shows the projected developments in cement and clinker production in the two scenarios.

ii) **the share of steel produced with the electric arc furnace route**. In 2015, the share of the more energy efficient steel production route that uses an electric arc furnace (EAF) was 39% (Worldsteel, 2018). In the reference scenario, the share of EAF steel is projected to account for more than 42% of total steel production (Mantzos et al., 2019). In the frozen efficiency scenario, we assume that the EAF share remains stable at 39% in the whole period analysed. Figure 4 shows the steel production with the different routes under the two scenarios.

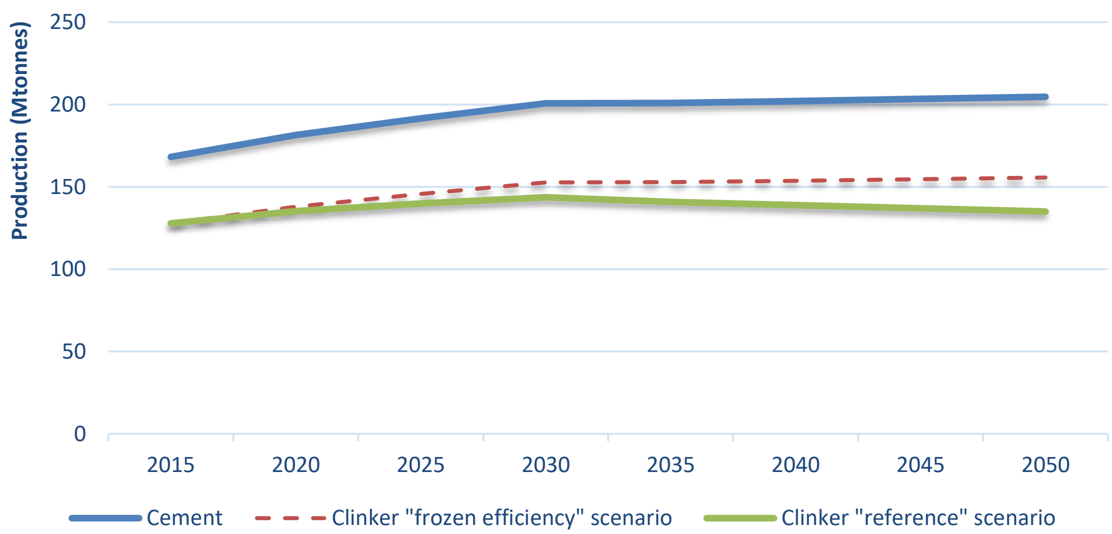

Figure 3 Cement and clinker production in the frozen efficiency and reference scenarios.

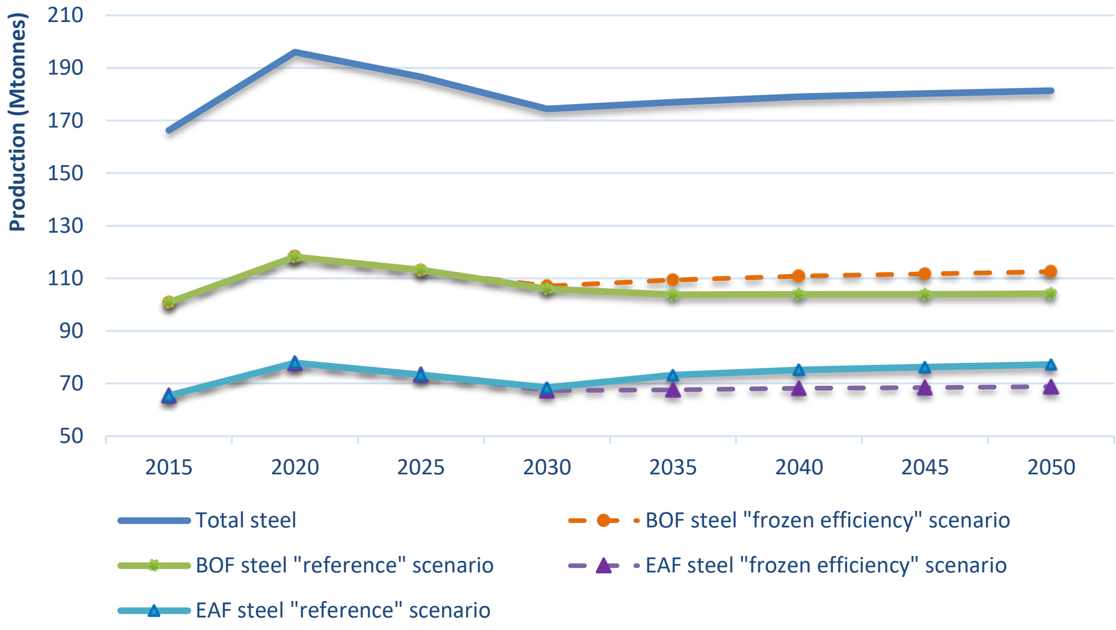

Figure 4 Total steel production and steel production with the BOF and EAF route in the frozen efficiency and the reference scenarios.

Table 4 Specific energy consumption (in GJ/tonne) and energy shares for heating and cooling for main industrial products (HRE4; 2017). shows the specific energy consumption for the manufacture of important industrial products and the shares of fuel and electricity used for heating and cooling. The SEC values refer to 2015 and remain constant in the frozen efficiency scenario. Table 5 shows the shares of the energy used either for heating or cooling per different temperature level. In this analysis, and due to the lack of data, we have assumed that the shares for cooling and heating remain fixed in both the reference and the frozen efficiency scenarios.

Table 4 Specific energy consumption (in GJ/tonne) and energy shares for heating and cooling for main industrial products (HRE4; 2017).

Products	Specific energy consumption		Share for Heating		Share for Cooling	
	Fuels	Electricity	Fuels	Electricity	Fuels	Electricity
Chemicals						
Carbon black	52.7[1]	1.8	100%	0%	0%	6%
Ethylene	31.8[1]	0	100%	0%	0%	0%
Poly sulfones	24.5	3.1	100%	0%	0%	4%
Methanol	15	0.5	100%	0%	0%	4%
Ammonia	11.3	0.5	100%	0%	0%	6%
Soda ash	11.3	0.3	100%	0%	0%	0%
TDI	26.7	2.8	100%	5%	0%	2%
Oxygen	0	2.5	100%	0%	0%	96%
All rest_chemicals			100%	0%	0%	3%
Iron and Steel						
Blast furnace	11.6	0.6	100%	0%	0%	0%
Rolled_steel	1.8[2]	0.4[2]	100%	10%	0%	0%
Sinter	2.2	0.1	100%	0%	0%	0%
Electric arc furnace	1	2.3	100%	95%	0%	0%
Coke oven	3.2	0.1	100%	0%	0%	0%
All rest_iron and steel			100%	0%	0%	0%
Food						
Meat	2	1.5	100%	5%	0%	61%
Sugar	4.5	0.7	100%	0%	0%	42%
Dairy	1.6	0.5	100%	5%	0%	57%
Bread & bakery	2.4	1.4	100%	45%	0%	44%
Brewing	1	0.4	100%	5%	0%	41%
All rest_food			100%	12%	0%	49%
Non-ferrous metals						
Aluminium_primary	0	55.8	100%	5%	0%	0%
All rest_non-ferrous metals			100%	5%	0%	0%
Non-metallic minerals						
Cement	3.7[3]	0.5[3]	100%	0%	0%	0%
Lime	3.7	0.1	100%	0%	0%	0%
Flat glass	10.9	3.3	100%	0%	0%	6%
Container glass	5.8	1.4	100%	4%	0%	6%
Bricks	1.4	0.2	100%	0%	0%	0%
Gypsum	1	0.2	100%	0%	0%	0%
All rest_non-metallic minerals			100%	0%	0%	2%
Pulp and paper						
Paper	5.5	1.9	100%	1%	0%	1%
Chemical pulp	12.7	2.3	100%	1%	0%	0%
All rest_pulp and paper			100%	1%	0%	0.5%
Others						
All rest_others			100%	5%	0%	15%

[1] Source: Boulamanti and Moya, 2017

[2] Source: IEA, 2007

[3] Gt/tonne clinker. Source: GCCA, 2020

Table 5 Assumptions on the shares of temperature levels for heating and cooling for main industrial products (HRE4, 2018)

	Cooling			Heating			
Products	<-30°C	-30-0°C	0-15°C	<100°C	100-200°C	200-500°C	>500°C
Carbon black	20%	30%	50%	0%	0%	0%	100%
Ethylene	15%	50%	35%	0%	0%	0%	100%
Poly sulfones	0%	40%	60%	0%	100%	0%	0%
Methanol	0%	40%	60%	0%	0%	0%	100%
Ammonia	20%	30%	50%	0%	0%	0%	100%
Soda ash	5%	45%	50%	30%	40%	0%	30%
TDI	0%	30%	70%	0%	100%	0%	0%
Oxygen	80%	10%	10%	0%	0%	0%	0%
All rest_chemicals	18%	34%	48%	0%	30%	0%	70%
Blast furnace	0%	0%	0%	1%	1%	1%	97%
Rolled_steel	0%	0%	0%	0%	0%	0%	100%
Sinter	0%	0%	0%	0%	0%	20%	80%
Electric arc furnace	0%	0%	0%	1%	0%	0%	99%
Coke oven	0%	0%	0%	0%	0%	0%	100%
All rest_iron and steel	0%	0%	0%	0%	0%	4%	95%
Meat	0%	30%	70%	40%	60%	-	-
Sugar	0%	20%	80%	10%	60%	-	30%
Dairy	0%	30%	70%	90%	10%	-	-
Bread & bakery	0%	10%	90%	20%	33%	47%	-
Brewing	0%	35%	65%	55%	45%	-	-
All rest_food	0%	25%	75%	43%	42%	9%	6%
Aluminium_primary	-	-	-	0%	-	-	100%
All rest_non-ferrous metals	0%	0%	0%	0%	0%	0%	100%
Cement	-	-	-	0%	-	10%	90%
Lime	-	-	-	0%	-	-	100%
Flat glass	-	-	100%	2%	21%	43%	34%
Container glass	-	-	100%	2%	19%	19%	60%
Bricks	-	-	-	20%	-	-	80%
Gypsum	-	-	-	0%	50%	30%	20%
All rest_non-metallic minerals	0%	0%	100%	4%	15%	17%	64%
Paper	-	-	100%	5%	88%	5%	2%
Chemical pulp	-	-	-	0%	100%	-	-
All rest_pulp and paper	0%	0%	100%	3%	94%	3%	1%
All rest_others	5%	25%	70%	13%	28%	9%	50%

4 Results

4.1 Final energy demand

The total final industrial energy demand decreases in the reference scenario, according to EU (2016), from 11.9 EJ in 2015 to 10.6 EJ in 2050. After a short increase in the first five years, it decreases annually by 1% in the 2020-2035 period and by 0.1% in the 2030-2050 period (see Figure 5 Final industrial energy demand projections in the reference and the frozen efficiency scenarios.). This is the result of i) energy efficiency improvements and ii) structural changes in the industrial activities which is assumed to move towards less energy intensive and higher value added products (European Commission, 2016). Without any energy efficiency improvements and with industrial structural changes included, as depicted in the frozen efficiency scenario, the final energy demand would increase to 14.8 EJ by 2050 at an annual growth rate of 0.6%. The increase is more prominent in the 2015-2030 period where the production growth is stronger (see Table 3. Production developments in the EU28 in the Reference scenario (in ktonnes).).

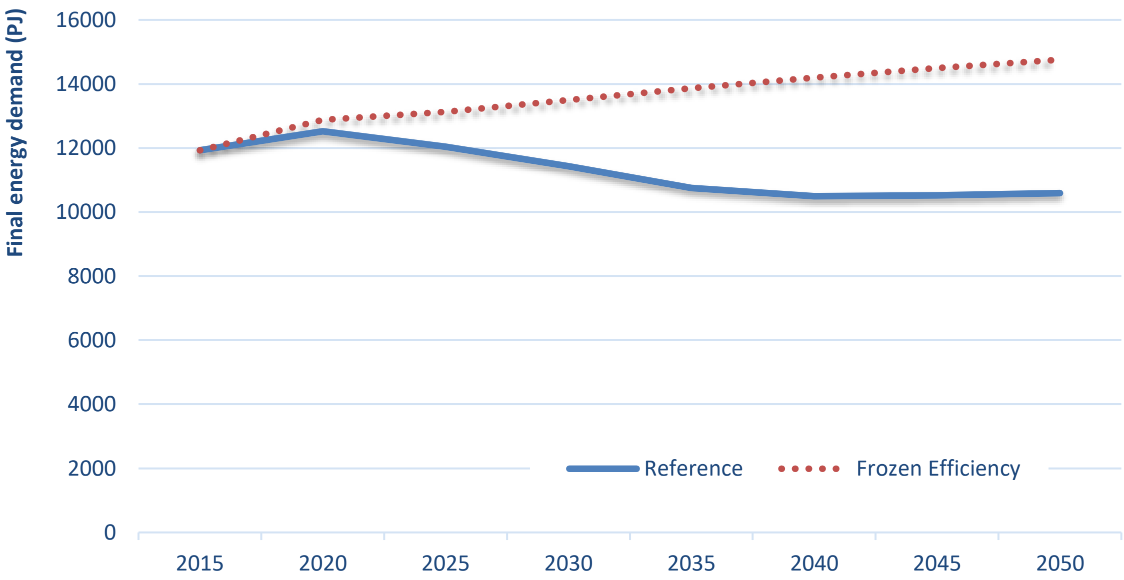

Figure 5 Final industrial energy demand projections in the reference and the frozen efficiency scenarios.

Figure 6 Final industrial energy demand per EU country in the reference and the frozen efficiency scenarios. shows the total final energy demand per country in the two scenarios. In 2015, five countries, Germany, France, Italy, UK and Spain were responsible for 59% of the total industrial energy demand in the EU. The same countries are still projected to account for most of the industrial use in 2050 (share 57%) in the reference scenario while in the frozen efficiency scenario the share is slightly higher (59%).

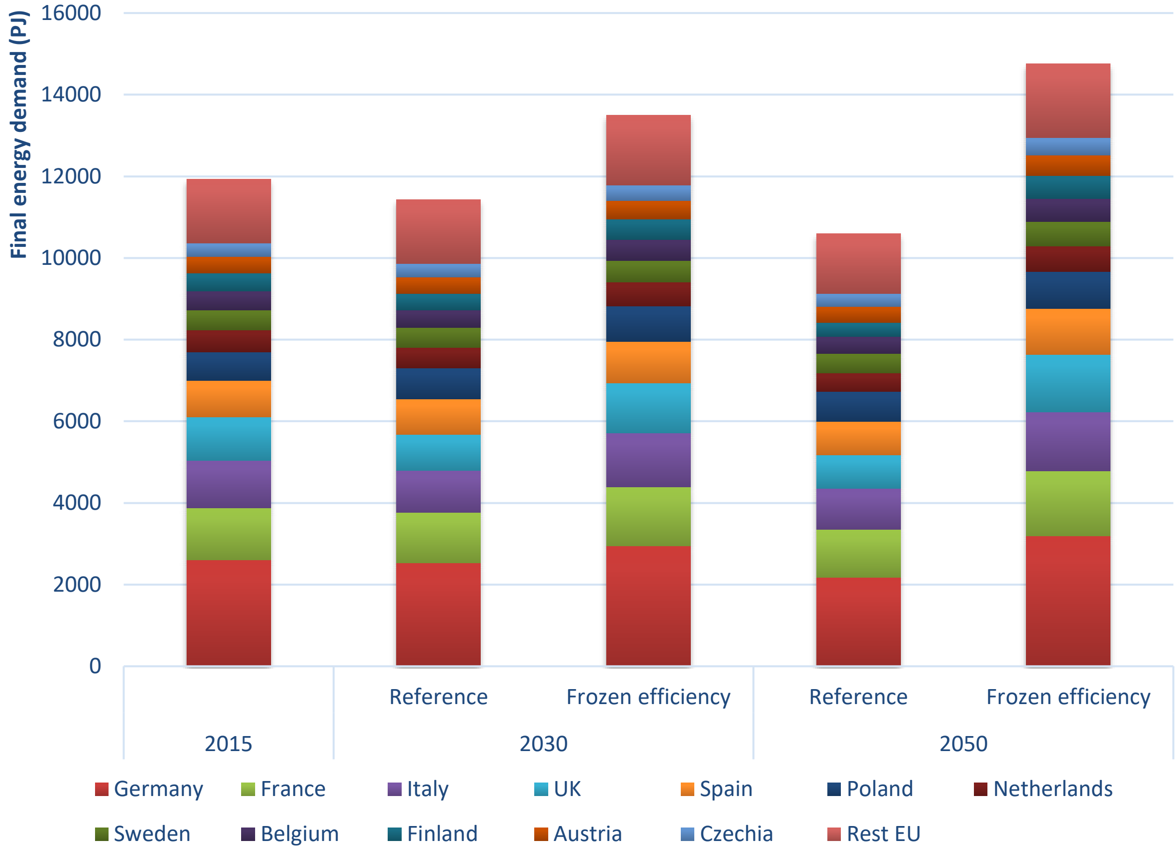

Figure 6 Final industrial energy demand per EU country in the reference and the frozen efficiency scenarios.

Figure 7 shows the developments of main industrial sub-sectors in the EU28 in the period 2015-2050 in the two scenarios. In the reference scenario (0.1% annual decrease in 2015-2050) the sub-sectors that decrease their energy demand are the chemicals (25%), iron and steel (14%), paper and pulp (29%), non-ferrous metals (17%) and non-metallic minerals (15%). The others sector is the only sector increasing its energy demand by about 6%. In the frozen efficiency scenario, where the same structural changes take place as in the reference scenario but no energy efficiency improvements, all sectors increase their energy demand: chemicals (16%), iron and steel (5%), paper and pulp (10%), non-ferrous metals (8%) and non-metallic minerals (23%) and others (43%).

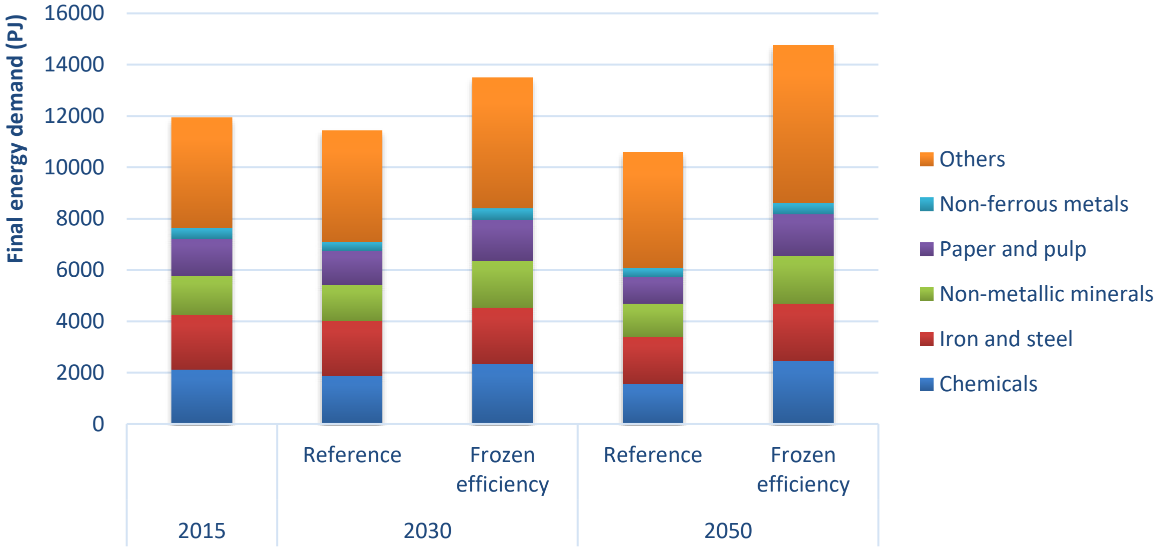

Figure 7 Final industrial energy demand per main industrial sub-sector in the reference and the frozen efficiency scenarios.

The frozen efficiency scenario allows for structural changes (i.e. the switch to higher value added products) but in the iron steel industry it does not allow for i) higher rates of the EAF route than in the base year (2015), and ii) for higher clinker to cement ratios than in the base year. Figure 8 shows the industrial energy demand in the whole industry, and in the iron and steel and the non-metallic minerals industrial sub-sectors when these structural changes are allowed and they are on the same level with the reference scenario. When these changes are allowed the total final energy demand in the frozen efficiency scenario increases from 11.9 TJ in 2050 to 14.3 TJ in 2050 instead of 14.8 TJ when these changes are not allowed.

Increasing the EAF share from 39% (EU 28 average in 2015) to 43% will reduce the energy demand by approximately 75 PJ in the iron and steel industry. Decreasing the clinker to cement ratio from about 74% (EU 28 average in 2015) to 66% will reduce the 2050 energy demand in the non-metallics minerals sector by about 210 PJ (see Figure 8).

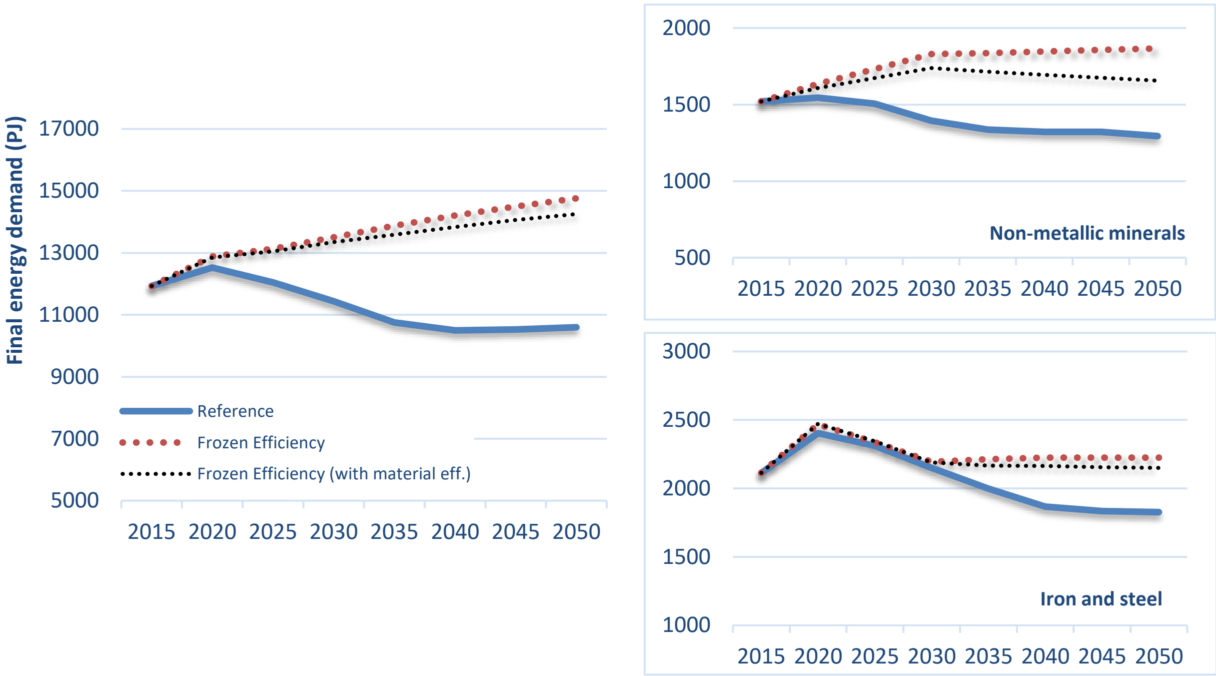

Figure 8 Final energy demand in the EU28 iron and steel and non-metallic minerals industry in the reference and the frozen efficiency scenarios.

Table 6 Annual autonomous and policy induced energy efficiency improvement compared to the base year (2015) shows the annual autonomous and policy induced energy efficiency improvement compared to the base year (2015). It is calculated by annualising the difference in the final energy demand (fuel or electricity) between the reference scenario and the frozen efficiency scenario for each industrial sub-sector for the EU28. The highest fuel efficiency improvements in the 2015-2050 period are observed in the pulp and paper (1.64%) and the chemicals industry (1.59%). It is also observed that the highest rates of improvement are in the period 2020-2035 ranging from 0.00-2.15%. The improvements are lower in the case of electricity, but still the same is observed, i.e. the improvement is stronger in the 2015-2035 period.

Table 6 Annual autonomous and policy induced energy efficiency improvement compared to the base year (2015)

	2020	2025	2030	2035	2040	2045	2050
			Fuel use				
Non-metallic minerals	-0.42%	-0.95%	-1.25%	-1.51%	-1.48%	-1.33%	-1.19%
Iron and steel	-0.45%	-0.29%	-0.32%	-0.66%	-0.88%	-0.82%	-0.73%
Non-ferrous metals	-0.31%	-1.51%	-2.08%	-1.85%	-1.66%	-1.50%	-1.36%
Chemicals	0.00%	-1.09%	-1.62%	-2.15%	-1.98%	-1.77%	-1.59%
Paper and pulp	-0.59%	-1.43%	-1.48%	-1.83%	-1.93%	-1.81%	-1.64%
Others	-0.41%	-0.96%	-1.31%	-1.56%	-1.51%	-1.35%	-1.20%
			Electricity use				
Non-metallic minerals	-0.7%	-0.5%	-0.5%	-0.4%	-0.3%	-0.3%	-0.2%
Iron and steel	-1.0%	0.5%	0.7%	0.6%	0.4%	0.4%	0.4%
Non-ferrous metals	-0.4%	-0.6%	-1.0%	-0.6%	-0.5%	-0.4%	-0.4%
Chemicals	-0.6%	-1.0%	-1.2%	-1.3%	-1.0%	-0.8%	-0.7%
Paper and pulp	-0.6%	-0.5%	-0.4%	-0.5%	-0.5%	-0.5%	-0.4%
Others	-0.6%	-0.5%	-0.5%	-0.4%	-0.3%	-0.3%	-0.2%

Figure 9 Final industrial energy demand per energy carrier. shows how the different energy carriers develop in the two scenarios during the 2015-2050 period. In the reference scenario, the share of coal products on the overall energy use decreases from 15% in 2015 to 9% in 2050, for natural gas from 29% to 22%, and for oil from 10% to 6%. The shares of electricity, biofuels and heat increase in the same period from 30%, 9% and 6% to 39%, 15%, and 9%, respectively. Since in the frozen efficiency scenario the shares of the different energy carriers remain stable per sector throughout the analysed period, the energy mix in 2050 is much different than in the reference scenario. Coal accounts for 30%, natural gas for 30%, oil for 11%, biofuels for 9% and electricity for 30%. The shares of biofuel and heat also remain to the 2015 levels.

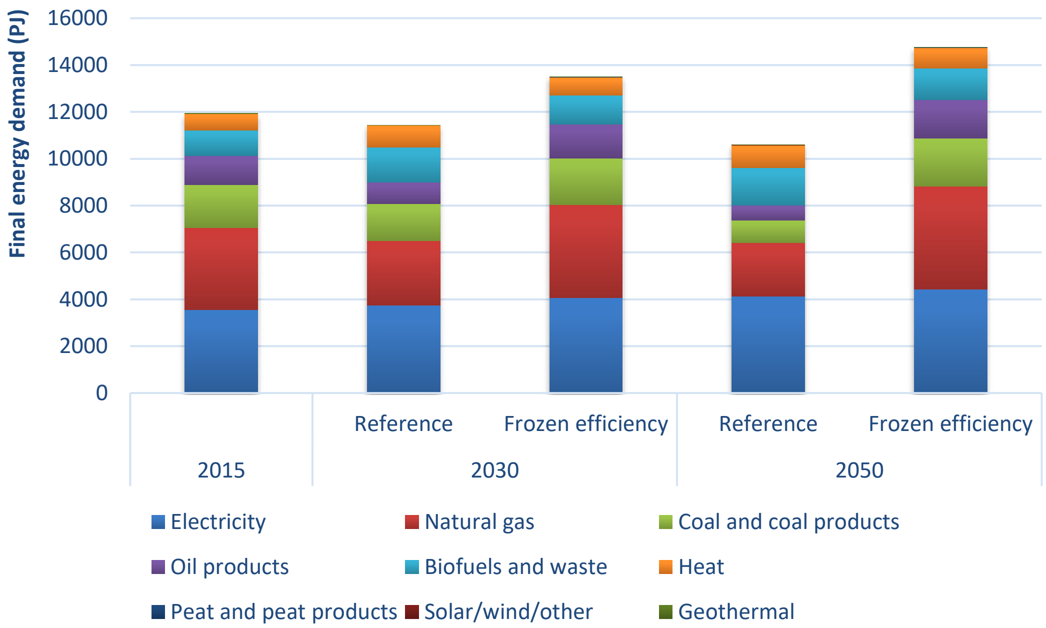

Figure 9 Final industrial energy demand per energy carrier.

4.2 Demand for process heating and cooling

Compared to 2015, the demand for heating and cooling in the baseline scenario decreases from 8.9 EJ to 7.1 PJ. The shares in total energy demand are reduced from 75% in 2015 to 67% in 2050 in the reference scenario with heat demand being dominant (see Figure 10 Final energy demand for process heating and cooling and for other purposes (e.g. machine drive) in the reference and the frozen efficiency scenarios.). Within the 2015-2050 period, the demand for cooling increases by 25% and the demand for heating decreases by 21%. In the frozen efficiency scenario, the demand for cooling increases by 37% and the demand for heating by 27%.

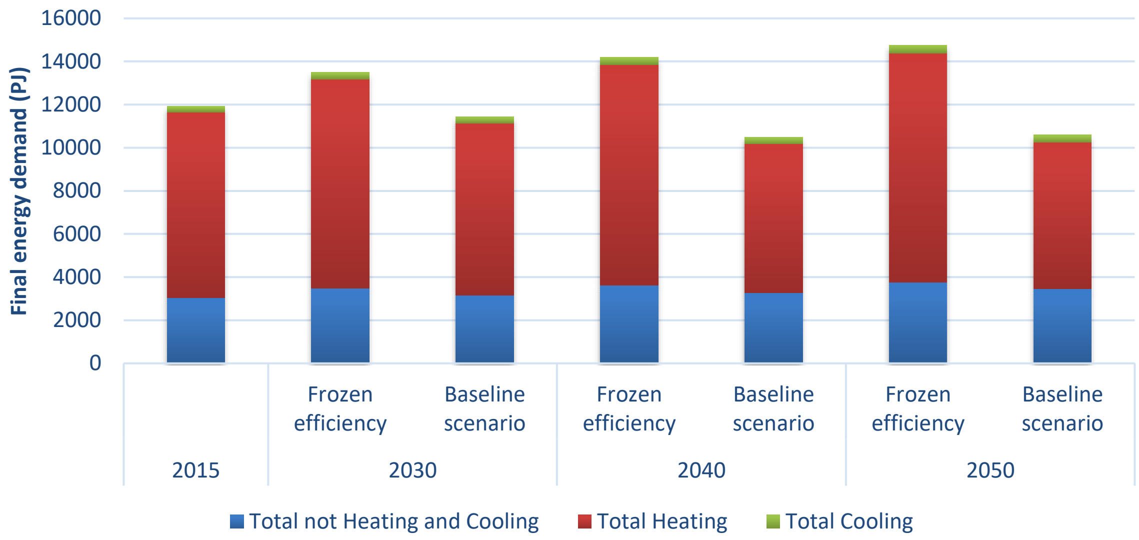

Figure 10 Final energy demand for process heating and cooling and for other purposes (e.g. machine drive) in the reference and the frozen efficiency scenarios.

Most of the heat used is higher temperature heat (>500°C), see Figure 11 Final energy demand for process heating and cooling per temperature level in the reference and the frozen efficiency scenarios.. One shortcoming of the analysis is that the shares of heating and cooling and the temperatures levels at which these are required, because of the limited data available, are assumed to remain fixed. Figure 12 Development of heating and cooling demand in the EU28 by temperature and country in the reference scenario. shows the heating and cooling demand for the countries with the highest industrial energy demand. The demand for heating is shown to decrease in all countries while the demand for cooling increases.

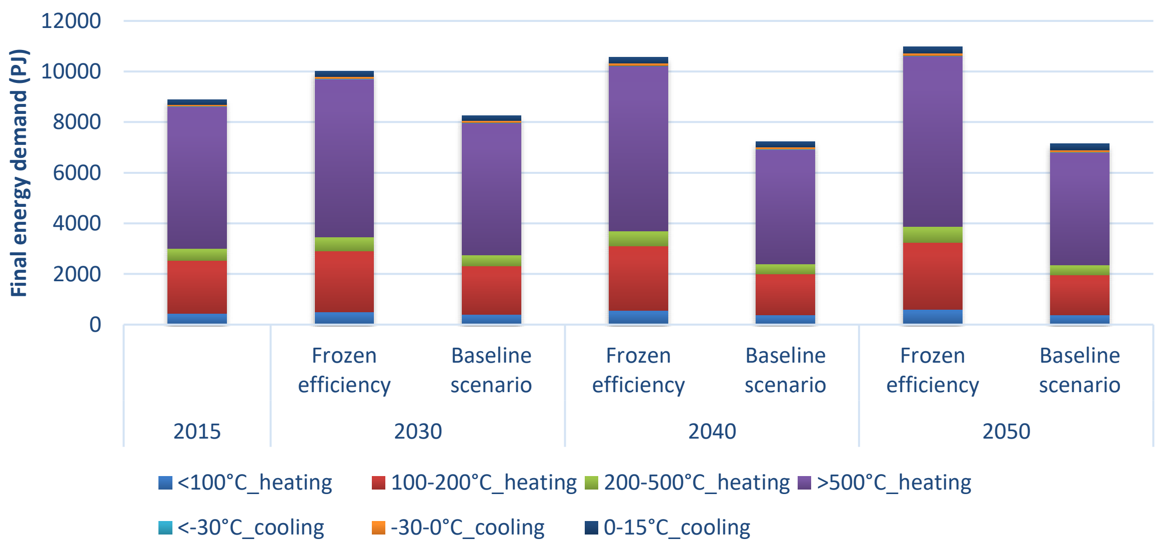

Figure 11 Final energy demand for process heating and cooling per temperature level in the reference and the frozen efficiency scenarios.

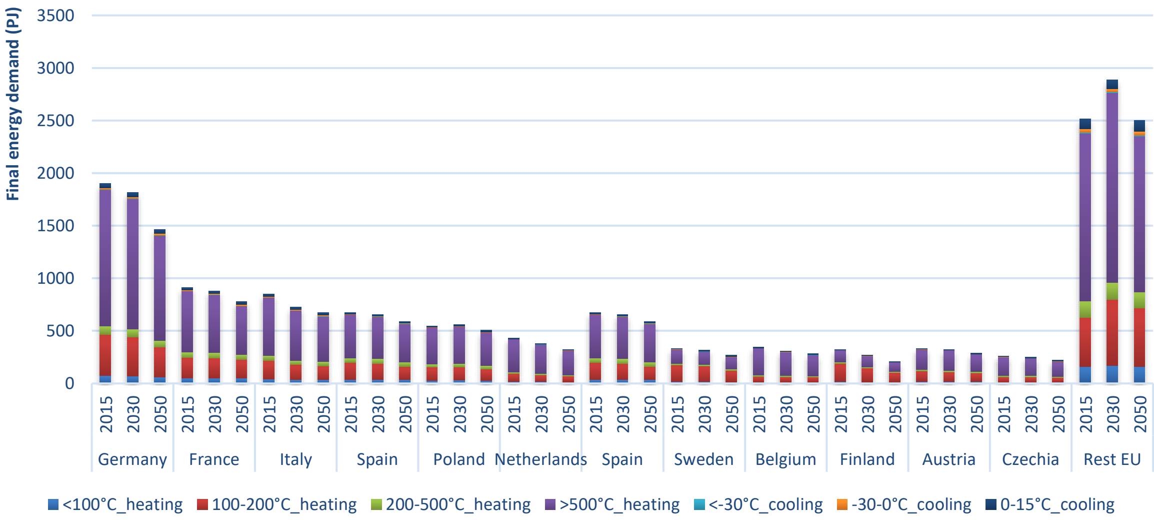

Figure 12 Development of heating and cooling demand in the EU28 by temperature and country in the reference scenario.

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