Exogeneous framework conditions for Entranze scenarios

D4.2 of WP4 from Entranze Project

Internal working paper

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ENTRANZE Project

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Project consortium:

EEG	Energy Economics Group Institute of Power Systems and Energy Economics Vienna University of Technology
NCRC	National Consumer Research Centre
Fraunhofer	Fraunhofer Society for the advancement of applied research
CENER	National Renewable Energy Centre
eERG	end use Efficiency Research Group, Politecnico di Milano
Oeko	Öko-Institut
SOFENA	Sofia Energy Agency
BPIE	Buildings Performance Institute Europe
Enerdata	Enerdata
SEVEn	SEVEn, The Energy Efficiency Center

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The ENTRANZE project

The objective of the ENTRANZE project is to actively support policy making by providing the required data, analysis and guidelines to achieve a fast and strong penetration of nZEB and RES-H/C within the existing national building stocks. The project intends to connect building experts from European research and academia to national decision makers and key stakeholders with a view to build ambitious, but reality proof, policies and roadmaps.

The core part of the project is the dialogue with policy makers and experts and will focus on nine countries, covering >60% of the EU-27 building stock. Data, scenarios and recommendations will also be provided for EU-27 (+ Croatia and Serbia).

This internal report provides the main framework conditions for Invert/EE-Lab scenario development. It clearly defines the related values for internal purposes within the consortium and serves as a documentation for the policy group members and other interested persons.

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Executive Summary

This internal report provides the main framework conditions for the projections used in the two models used in Entranze, Invert/EE-Lab and EnergyPlus. It clearly defines the related values for internal purposes within the consortium and serves as a documentation for the policy group members and other interested persons.

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1. Scenarios description

The models used in Entranze, Invert/EE-Lab and EnergyPlus, require the projection of end-user energy prices and of the power mix, so as to derive the average primary energy and emission factors of power generation in each country (respectively, toe/kWh and gCO2/kWh). To do so the project decided to rely on the POLES model of Enerdata that enables to make harmonised projections for each EU country in a global context, taking into account energy prices on the international markets and the intensity of carbon commitments and policies.

Price and power mix projections are derived from two scenarios of the world energy systems simulated with the POLES model, using historical data up to 2011: a "Reference" scenario and an "Ambitious Climate" scenario. The two scenarios have the same macroeconomic context. They mainly differ on the carbon policies. Carbon policy takes into account public support and commitments in the field of energy efficiency and renewable policies.

The **"Reference"** scenario[1] assumes that, once the global recession is over, business as usual behaviour is resumed rather quickly. Sustained growth of China and other emerging countries is a powerful driver of energy demand at world level. Only on-going and already planned climate policies are taken into account, including the 20% emissions reduction in the European Union by 2020. It is assumed that no consensus is reached at international level. After 2020 it is assumed that, in the EU, additional energy and climate policies are adopted and the EU ETS is strengthened and expanded to more sectors, eventually ensuring that the EU reduces its emissions in 2050 by 50% compared to 1990 levels. Without a global agreement, these low intensity and non-coordinated policies result in soaring CO2 emissions across the world and in emerging economies in particular. The future fuel mix is dominated by fossil fuels. Despite a slow diversification towards other sources of energy, the strong growth in energy consumption translates into significant increase in international fuel prices and in a continued growth of global CO2 emissions.

The **"Ambitious Climate"** scenario explores the implications of more stringent climate policies and reinforced support for renewables in several world regions[2]. This scenario shows a clear transition from the current energy system towards a long-term decarbonisation, with more ambitious efforts on energy efficiency and a real emergence of renewable technologies. Negotiations between advanced and emerging economies on climate change are eventually successful and an international consensus is progres-

[1] Derived from Enerdata's EnerFuture "Balance" scenario

[2] Derived from Enerdata's EnerFuture "Emergence" scenario

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sively reached. Europe goes beyond its -20% target by 2020, and the OECD and emerging countries meet their Copenhagen objectives. A new international agreement is adopted to reach the 2050 targets currently under discussion at the UN Climate Change Conferences: i.e. a trajectory limiting the global temperature increase at around 2 to 3 °C by the end of the century (IPCC, 2007), which implies reducing world emissions by a factor 2 by 2050 compared to 1990 levels, and by a factor of 4 for developed countries. For the EU, this will mean meeting its announced objectives of the Energy Roadmap 2050, i.e. reducing its emissions by 80% compared to 1990 levels, by a range of policies, including the expansion of carbon pricing (ETS) to all sectors of the economy. International fossil fuel prices respond to the resulting demand shaving by decreasing.

The result of the projections for the 9 target countries[3] and the EU as a whole necessary for Entranze are described below and are available in two excel files (one for each scenario), with a first sheet summarizing the international prices (sheet called "prices") and one sheet per country containing the following information.

2. Key indicators

2.1 Population forecasts

Total population in the EU as a whole is expected to increase by 3.2%[4] in 2030 compared to 2010 (or 0.2%/year), and will reach 514 million people in 2050 (Figure 1) but is expected to peak around 2030-2040 at 518 million.

[3] Austria, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Romania and Spain.

[4] POLES population projections rely on the 2013 median scenario of UN forecasts from the Department of Economic and Social Affairs, Population Division.

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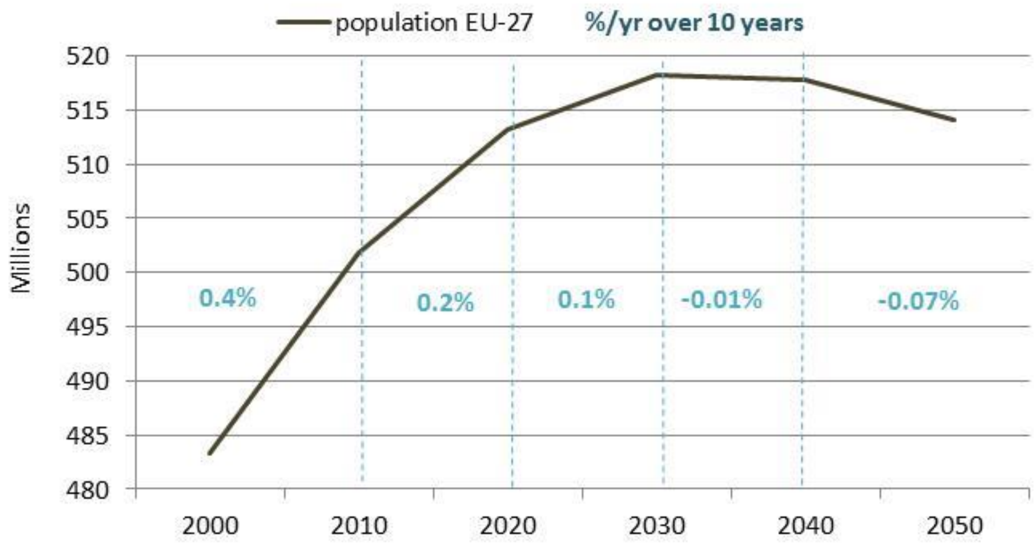

Fig. 1: EU-27 population forecasts until 2050

Source: POLES- Enerdata from UN Population division, 2013

France is expected to have the highest population growth rate among Entranze target countries which is estimated at more than 0.4%/year until 2030 (Figure 2 and Figure 3) and with a total estimated population closed to 75 million in 2050. According to these forecasts, France is likely to be the most populated country in Europe in 2050. On the contrary, in other countries, population is expected to decrease, such as in Germany (4% and 9% decrease resp. in 2030 and 2050) or Bulgaria (14% and 27% decrease resp. in 2030 and 2050) bringing the EU growth average down after 2030. The issue of ageing population will be a major factor with countries such as Germany having a population made up of 32% over 60 years and 13% over 80 years according to Eurostat[5] forecasts in 2060.

[5] Population projection 2010-2060, 80/2011, Eurostat, 8 June 2011

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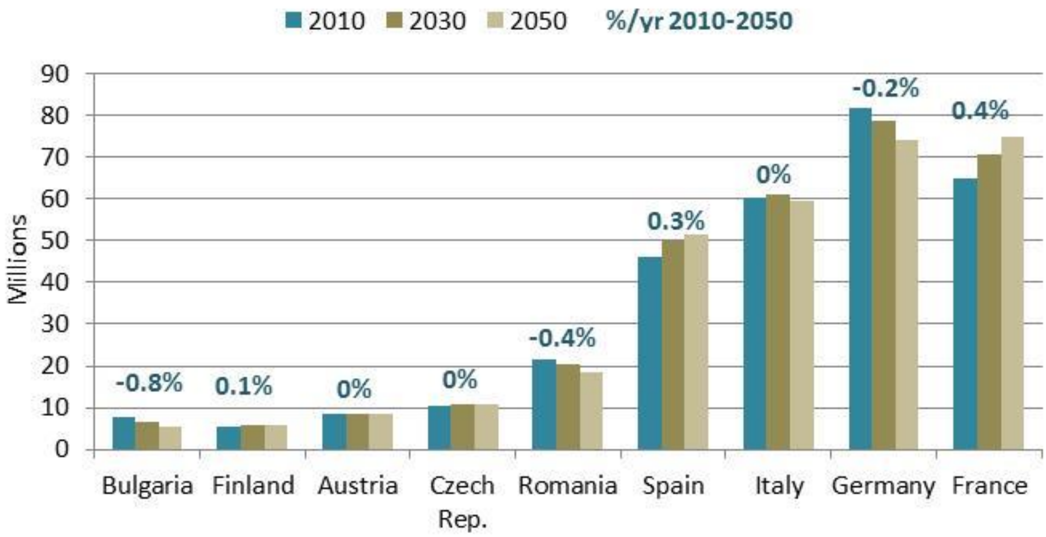

Fig. 2: Population trends until 2050

Source: POLES-Enerdata from UN Population division, 2013

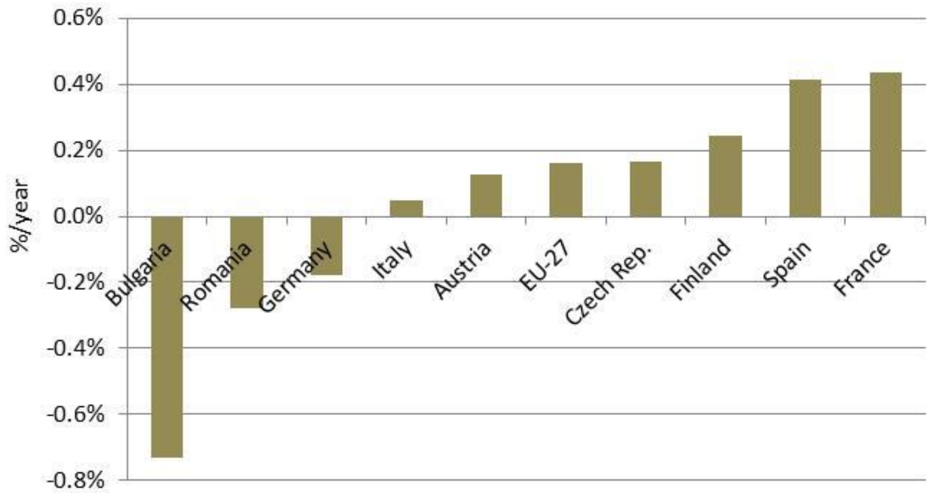

Fig. 3: Annual population growth rates over 2010-2030

Source: POLES-Enerdata from UN Population division, 2013

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2.2 Economic growth

GDP projections come from International Monetary Fund (IMF) in the short-term analysis (until 2018), then long-term projections are coming from CEPII (French research center in international economics) . GDP data are expressed at purchasing power parities to reflect differences in general price levels. Using purchasing power parities rates ("ppp" in short) instead of exchange rates increases the value of GDP in countries and regions with a lower cost of living. The EU GDP at ppp is expected to grow on average by a steady pace of 1.6%/year until 2050 (Figure 4).

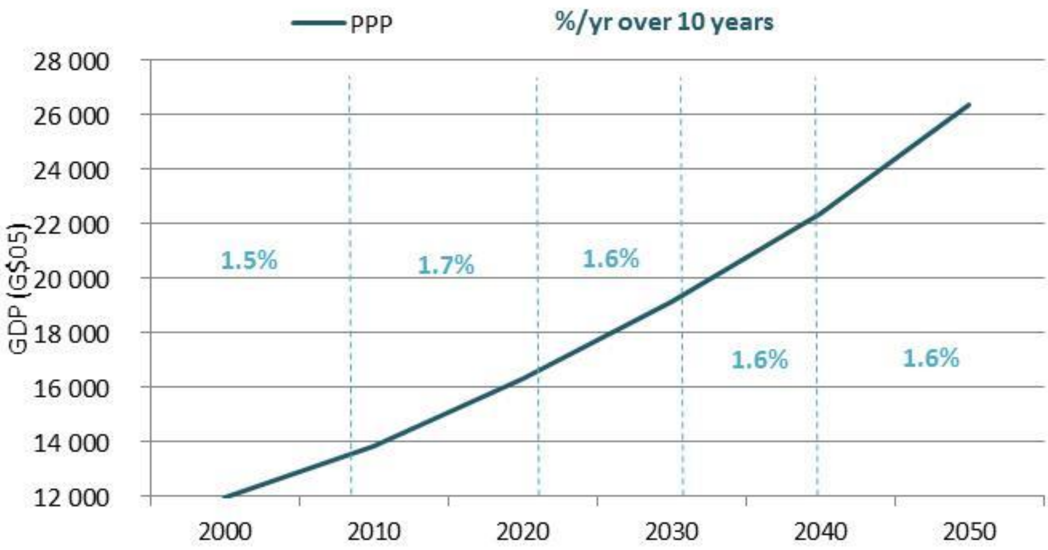

Fig. 4: EU-27 GDP at purchasing power parities forecasts until 2050

Source: POLES-Enerdata, historical data from World Bank and projections from IMF and CEPII,

Trends in economic growth up to 2050 are different across Europe. For instance, in Romania, Bulgaria or the Czech Republic, GDP is expected to increase by at least 2.7%/year until 2030 or 2050, while the increase is expected to be much lower in Italy of Germany for instance (0.6%/year and 0.8%/year respectively, Figure 5). Intermediate trends are expected in France or Spain with an annual GDP growth corresponding to 1.5% or 1.8%/year respectively. As a result, the difference of GDP between France and Germany is reduced across time from 30% in 2010 to 19% in 2030 and 7% in 2050.

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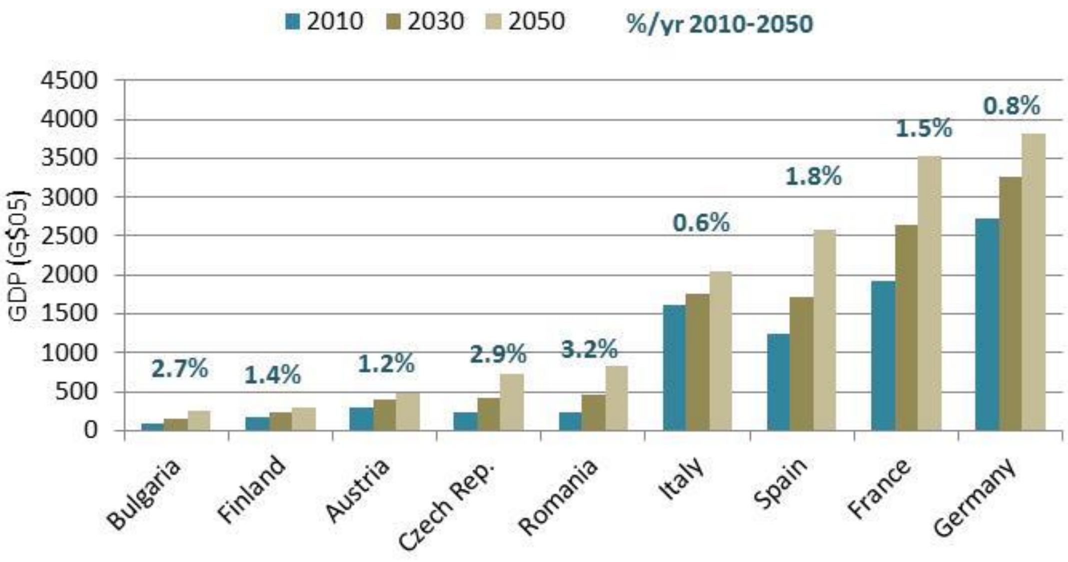

Fig. 5: GDP projections at purchasing power parities

Source: POLES-Enerdata, historical data from World Bank and projections from IMF and CEPII,

3. Domestic prices and carbon prices

Prices of fossil fuels (oil, gas and coal[6]) are final consumer prices (tax included[7]). In Poles, prices are modelled on the basis of changes in international prices and taking into account taxes (excise tax[8], VAT) and a carbon price.

3.1 International prices

Over the period 2010-2030, prices are expected to increase for oil, gas and coal, by up to at least 1.7%/year for oil (Figure 6). Trend variations are significantly stronger in the reference scenario compared to the ambitious one. More details are available below by type of fuel for both scenarios.

[6] The district heating price is not considered in the POLES model. .

[7] Including VAT.

[8] Including existing energy & environmental taxes.

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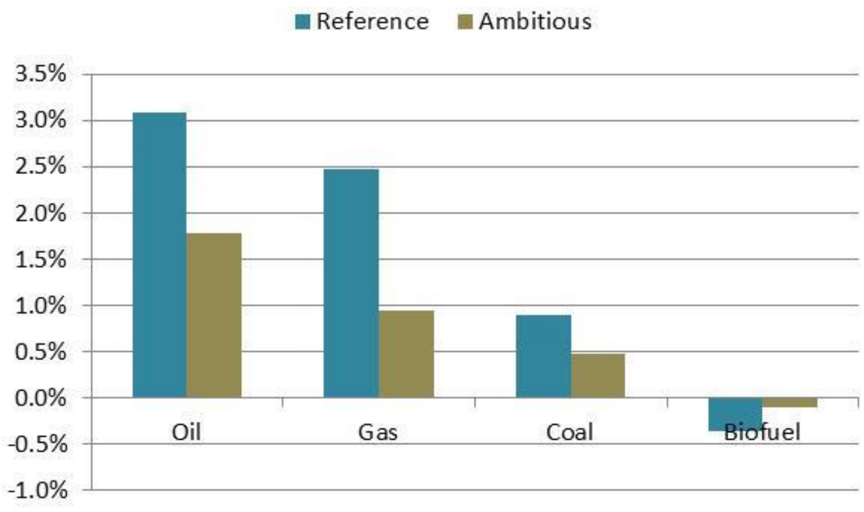

Fig. 6: Annual growth rate of international energy price over 2010-2030

Source: POLES-Enerdata

3.1.1 Oil

In the reference scenario, from 2000 until 2020, oil price is expected to increase at a strong steady pace of 6.5%/year (Figure 7). Then from 2025, oil price will increase less rapidly by 2%/year on average until 2050. In the ambitious scenario, oil price is following a different trend: until 2020, it increases by 3.6%/year and remains quite steady until 2030, at a price level of around 115$/bl, to fall down below 100$/bl in 2050. As the oil demand is decreasing in the ambitious scenario, and as at the same time the resource is becoming less abundant, oil price is maintained at a steady level from 2020.

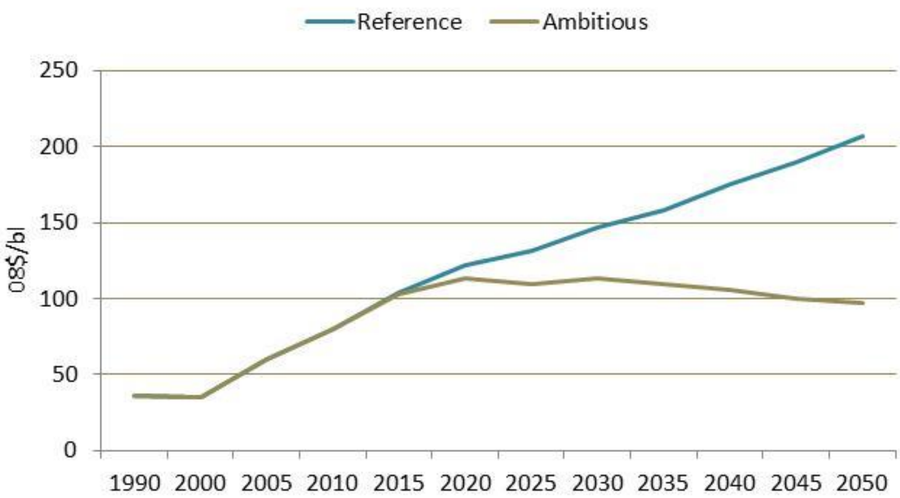

Fig. 7: International oil price forecasts until 2050

Source: POLES-Enerdata

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3.1.2 Gas

Gas price in Europe is expected to increase by 7.6%/year for both scenarios until 2015 (Figure 8). Then it will continue to increase on average until 2030 by 0.8%/year in the reference scenario whilst it is decreasing in the ambitious scenario by 1.2%/year because of decreasing demand.

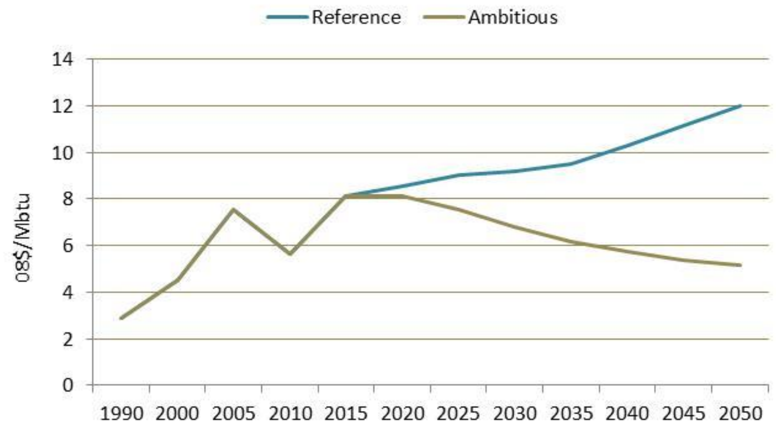

Fig. 8: European market gas price forecasts until 2050

Source: POLES-Enerdata

3.1.3 Coal

Coal prices are expected to increase steadily across time in Europe, with a slightly less rapid trend concerning the ambitious scenario, i.e. 0.5%/year compared to 0.9%/year for the reference scenario (Figure 9). The price is expected to increase in both scenario: the decreasing price effect due to the decrease of demand is counter balanced by the fact that production costs will increase with income in producing regions.

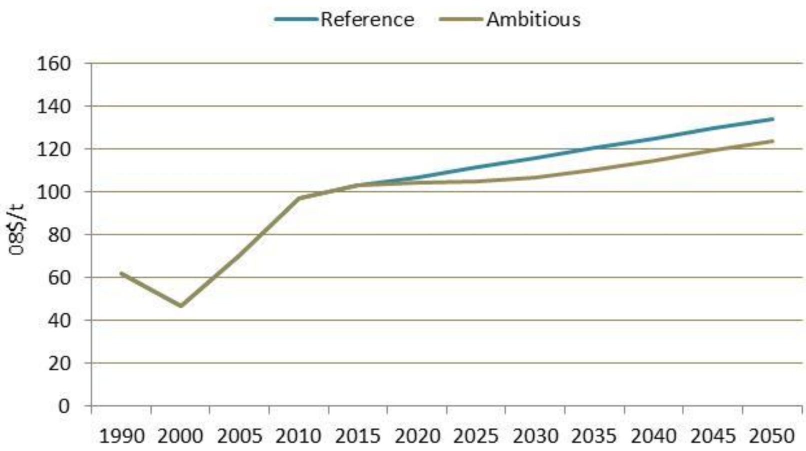

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Fig. 9: European market coal price forecasts until 2050

Source: POLES-Enerdata

3.1.4 Biomass

Until 2015, i.e. in the short-term, the biomass price is expected to increase significantly by 5%/year for both scenarios: there is indeed a strong dynamic in the first coming years in biofuel demand (emerging market in all sectors (energy, transport and domestic uses), Figure 10). Then, thanks to market autoregulation, the price will decrease by roughly 2%/year until 2025. It will remain steady until 2030, and will again increase steadily until 2050 because of a strong substitution towards biofuels that will become the high mitigation option, i.e. low carbon emission.

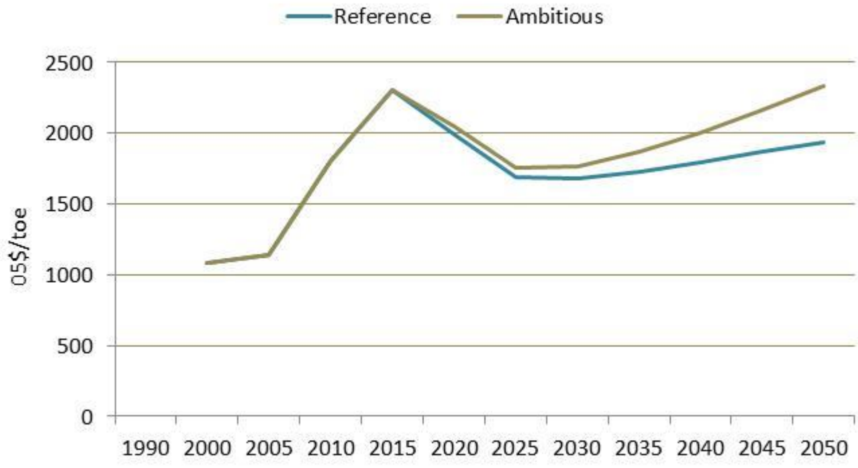

Fig. 10: International biomass price forecasts until 2050

Source: POLES-Enerdata

3.2 Carbon price

Carbon prices are different from EU ETS prices and refer to an aggregate metric in POLES used to characterise the effort necessary to reach climate objectives in 2020 and 2050: they might be seen as “shadow prices” for policies stimulating low-carbon technologies. They may include some carbon tax if they are implemented in a country. In other words, in POLES, the “carbon price” reflects either a carbon tax or the intensity of the climate policy or both.

Trends are drastically different according to scenario: the carbon price will increase up to 800 $05/tCO2 in the ambitious scenario, while it won’t go beyond 150 $05/tCO2 in the reference one (Figure 11).

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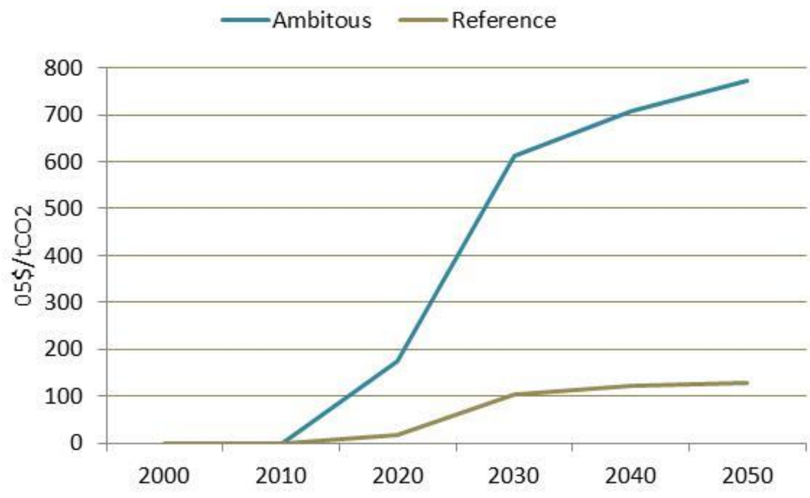

Fig. 11:EU-27 carbon price forecasts until 2050

Source: POLES-Enerdata

3.3 Residential domestic prices[9]

Excise taxes and VAT have been assumed constant in these projections. Historical data for 2010 and 2011 come from Eurostat or IEA. Oil and gas prices are projected to increase by respectively 5.9% and 5.2%/year in the ambitious scenario over the period 2010-2030. In the reference scenario the progression will be lower because of lower carbon tax (2.9% and 1.5%/year respectively for oil and gas) (Figure 12). The coal price will increase rapidly in the ambitious scenario[10], by up to 9%/year, whereas it would decrease in the reference scenario by 2.3%/year.

The electricity price is modelled on the basis of the price of fossil fuels, the power mix and the cost of generation of electricity. It also includes taxes. The average price will increase by 2%/year in the ambitious scenario and by 0.8%/year in the reference one. The electricity price is expected to peak in 2030 at around 3 400 $05/toe (40 000 $05/MWh) in the ambitious scenario and at 2 500 $05/toe (30 000 $05/MWh) in the reference scenario.

[9] Domestic prices are in constant euros (i.e. without inflation), from which you can derive an average variation by period.

[10] Trends are different across target countries, for instance the coal price is increasing by more than 10%/year for Bulgaria, Finland and the Czech Republic and up to 18%/year in Romania over 2010-2030, while it increases by on average 5%/year in the other target countries.

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Prices for biomass refer to modern biomass (i.e. pellets or wood chips). Prices are based on simulation of land use and international biomass trade, and unlike for other fuels they do not take into account historical prices. Thus it is best to use these prices as indexes for the evolution of biomass prices rather than use their absolute value. Biomass prices are slightly decreasing between 2010 and 2030

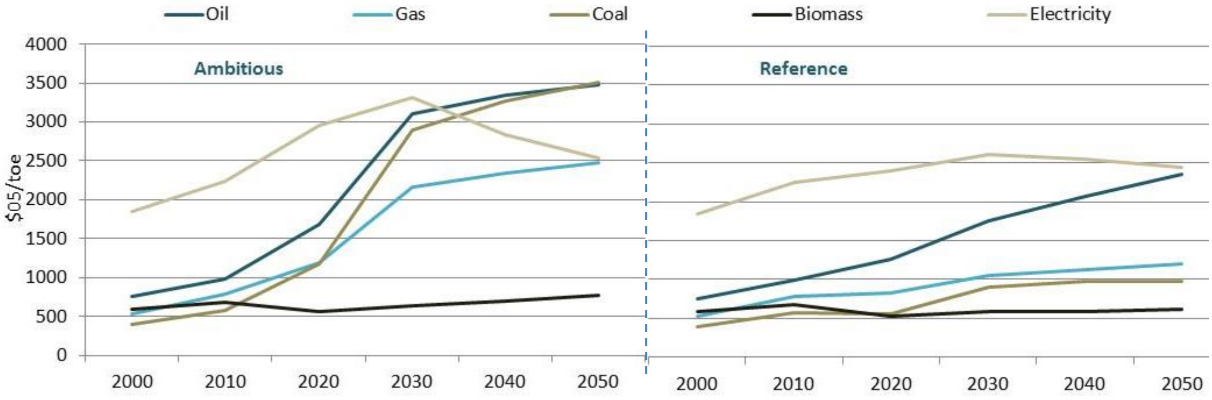

Fig. 12:EU-27 residential domestic prices forecasts by type of energy until 2050

Source: POLES-Enerdata

4. Power mix and power factors

4.1 General trends

The power production is expected to grow at an annual rate of 0.8% over 2010-2030 and 1.7% over 2030-2050 in the ambitious scenario (Figure 13). Trends are smoother in the reference scenario, with an annual growth rate of 1%/year until 2030 and 1.3%/year over 2030-2050. The growth is more rapid after 2030 in the ambitious scenario because of higher carbon prices that will make electricity more competitive than fossil fuels. In the ambitious scenario, fossil heat demand is more and more substituted by electricity.

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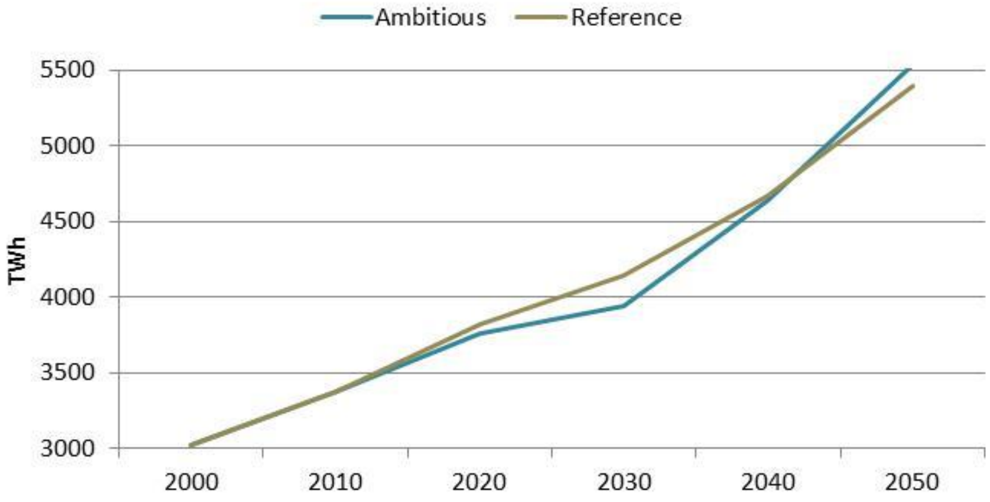

Fig. 13: EU-27 power production forecasts until 2050

Source: POLES-Enerdata

At target country level, power production of Italy, Austria, Finland and Germany will not exceed a 1%/year increase. In Germany, nuclear production is phased out and will drop from 140 TWh in 2010 to 47 TWh in 2020, and no production in 2030; nuclear production is substituted by renewables, whose production will increase from 140 TWh in 2010 up to 390TWh in 2030 and 480 TWh in 2050. On the other hand, Romania and Czech Republic have a stronger increase of their power production, up to 2%/year over the period 2010-2050 (Figure 14) thanks to a deep increase of both nuclear and renewable production.

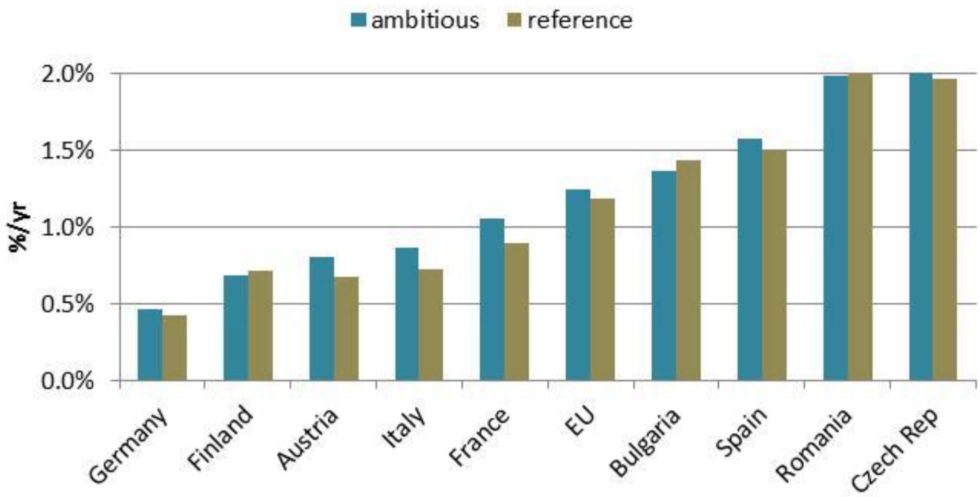

Fig. 14: Annual growth rate of power production over 2010-2050 period

Source: POLES-Enerdata

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This increase in total power production will be led by the development of renewables. Indeed in both scenarios the share of renewable increases: by 18 points in the reference scenario and up to 23 points in the ambitious scenarios between 2010 and 2030 (Figure 15). This trends is common to all target countries, and on average in EU renewable power production is expected to increase by 4.7%/year over 2010-2030. On the opposite there is a decreasing role of fossil fuels: half of the power production came from fossil fuels in 2010, while it may only represent a quarter in the ambitious scenario in 2030. As shown in Figure 16, consumption of fossil fuels in power generation would significantly decrease over the next 20 years.

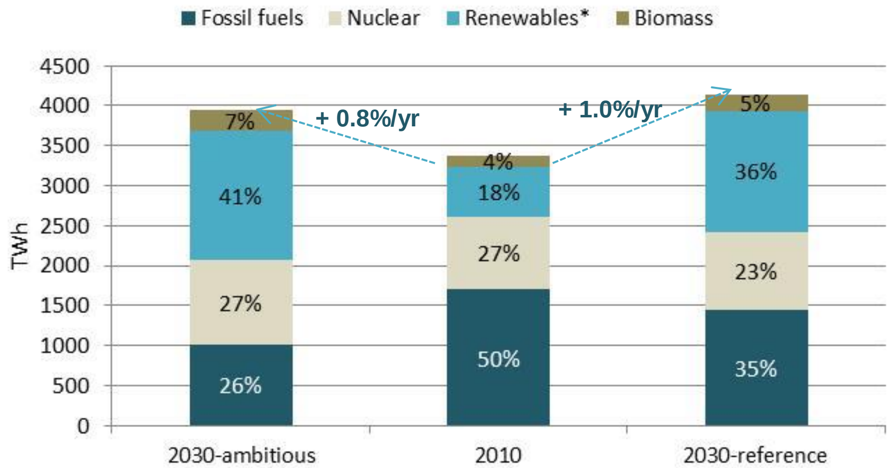

Fig. 15: Decomposition of EU-27 power production

Source: POLES-Enerdata; * including hydro, excluding biomass

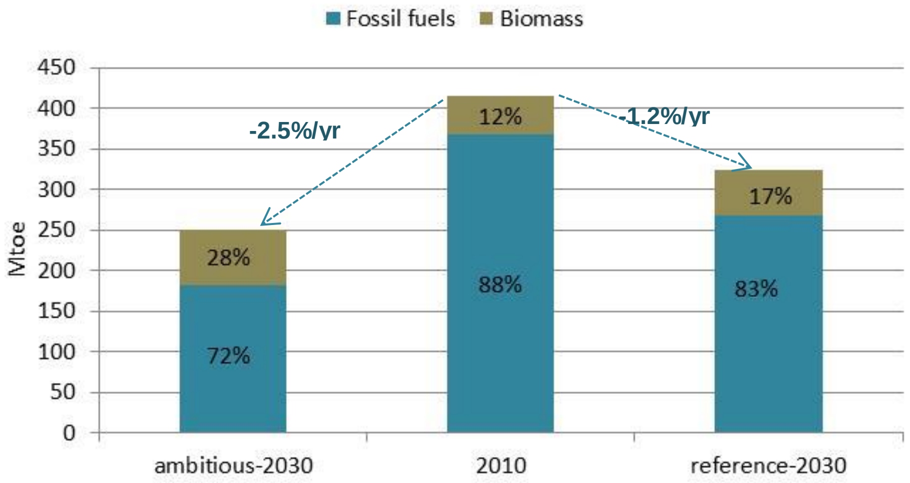

Fig. 16: EU-27 inputs in thermal power production

Source: POLES-Enerdata

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4.2 Primary energy factors[11]

The Primary Energy Factor for electricity (PEF) is provided as the ratio between the average primary energy input in power generation (in toe) per kWh produced.

For primary renewables (wind, solar, geothermal and hydro, i.e. excluding biomass) and nuclear, the Eurostat (or IEA) conversion factors were used. This means a factor of 0.086 ktoe/GWh for wind, solar and hydro to convert the power produced in primary energy inputs. For geothermal (mainly for Italy), an exogenous coefficient of 0.9 ktoe/GWh was used. For nuclear, the “thermal efficiency” factor was used (corresponding to an efficiency of 33%), resulting in 0.26 ktoe/GWh. For fossil fuels, the primary factor corresponds to the actual input of fossil fuels or biomass in power generation. Thus the average primary energy factor for electricity changes with the power mix.

As renewables will play an increasing role in power production, the average PEF of the EU is decreasing over time from 2.6 in 2000 to 1.9 in 2030 for both scenarios (Figure 17). Again this PEF is not decreasing at the same pace among target countries: for instance in Germany, Austria and Italy the PEF might be closed to 1.5 in 2030 thanks to the high share of renewable (and a decrease of nuclear power), compared to Finland or France where PEF will be above 2 because of nuclear importance.

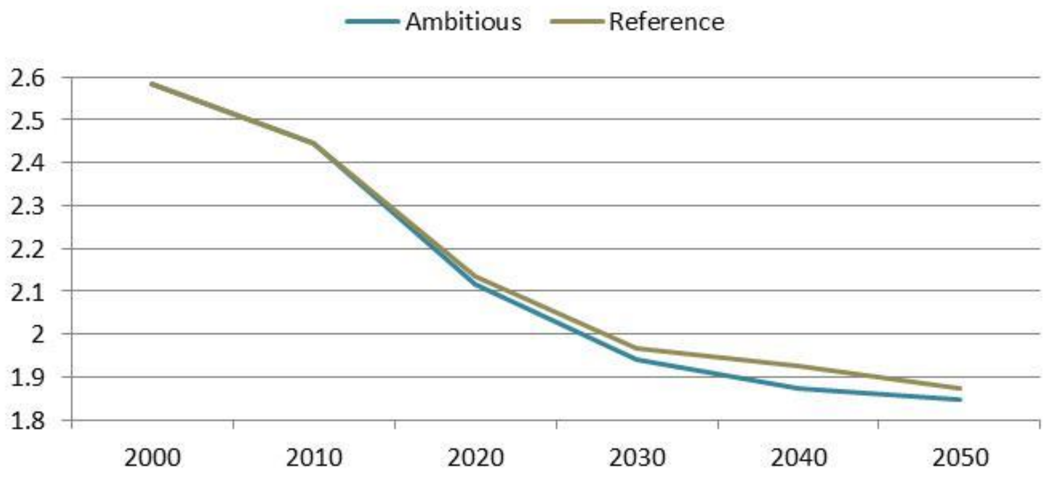

Fig. 17: EU-27 electricity primary energy factors forecast until 2050

Source: POLES-Enerdata

[11] The issue of the primary factor is only meaningful for electricity and district heat. For other fuels (oil and gas), the PEF is usually taken equal to 1.

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4.3 CO2 emission factor for electricity generation

The CO2 emission factor, i.e. the average amount of CO2 emitted per kWh produced in gCO2/KWh, is linked to the production mix of electricity, especially to the share of fossil fuels in the power mix and the efficiency of power plants.

As shown in Figure 18, the average CO2 emission factor of the power sector will improve significantly over time: in the ambitious scenarios, it is expected to decrease by 7%/year over the period 2010-2030 and by 4%/year in the reference scenario. This decarbonisation is obtained thanks to the increasing use of renewables, the increasing use of carbon capture storage (CCS), and of course thanks to the decreasing use of fossil fuels.

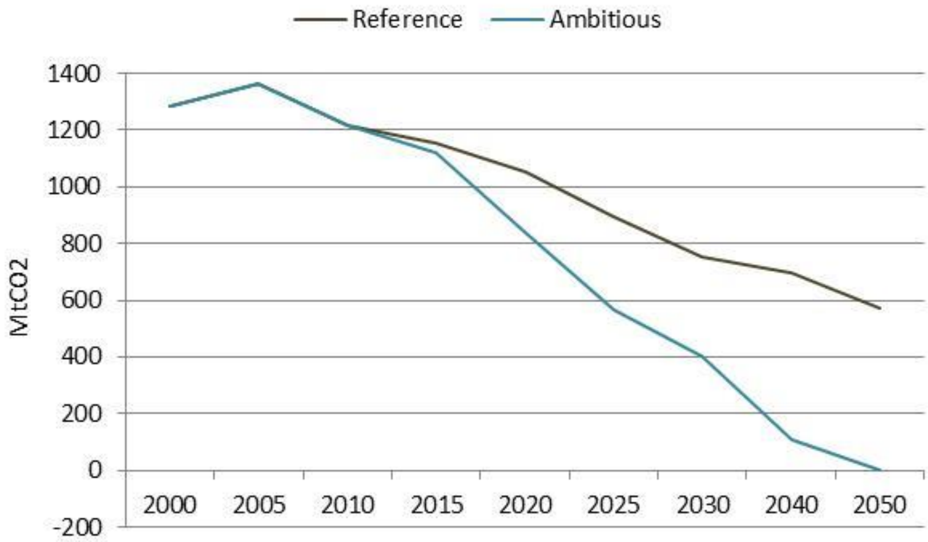

Fig. 18: EU-27 CO2 emission content in power production until 2050

Source: POLES-Enerdata

Even if the average carbon emission factor in power production is decreasing in all target countries, there are different trends (Figure 19 and Figure 20). In the ambitious scenario, the decrease over 2010-2030 is going from almost 4%/year in France and Italy to more than 10%/year in The Czech Republic, Romania, Bulgaria or Finland.

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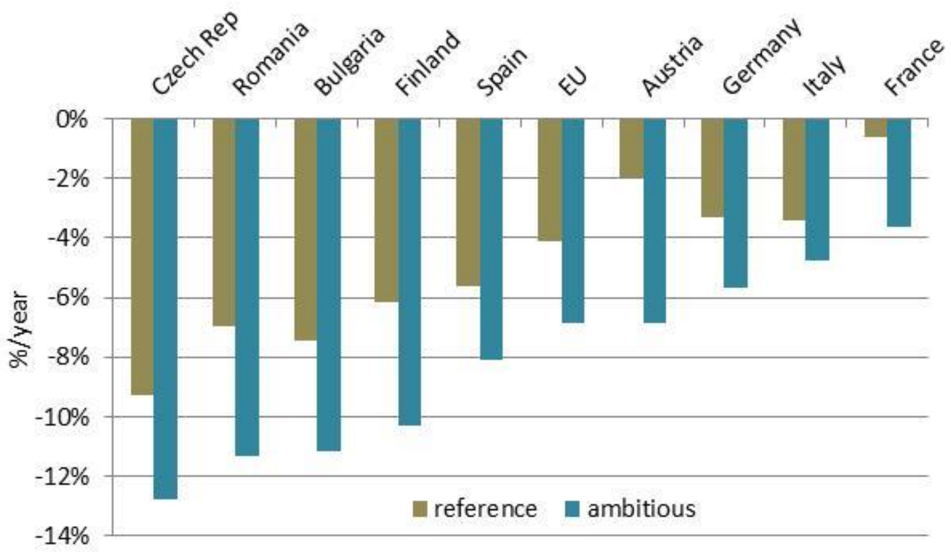

Fig. 19: Annual growth rate of carbon emission content in power production over 2010-2030

Source: POLES-Enerdata

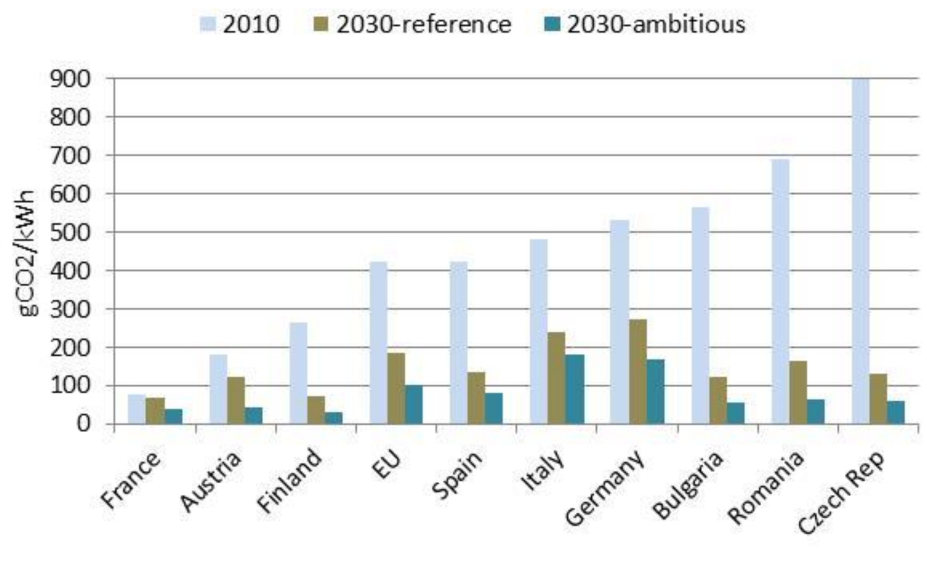

Fig. 20: carbon emission content in power production in 2010 and 2030

Source: POLES-Enerdata

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