2050 Heat Roadmap Europe
A low-carbon heating and cooling strategy

EU28 fuel prices for 2015, 2030 and 2050

Deliverable 6.1: Future fuel price review

Project Number:	695989
Project acronym:	HRE
Project title:	Heat Roadmap Europe: Building the knowledge, skills, and capacity required to enable new policies and encourage new investments in the heating and cooling sector.
Contract type:	H2020-EE-2015-3-MarketUptake

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989.

Deliverable number:	D6.1
Deliverable title:	EU28 fuel prices for 2015, 2030 and 2050
Work package:	WP6
Due date of deliverable:	30th November 2017
Actual submission date:	30th November 2017
Start date of project:	01/03/2016
Duration:	36 months
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Dissemination Level of this Deliverable:	PU
Public	*PU*
Confidential, only for members of the consortium (including the Commission Services)	*C0*

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Deliverable No. D 6.1: Report (Report, confidential report, etc).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989. The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the funding authorities. The funding authorities are not responsible for any use that may be made of the information contained therein.

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1. Introduction

Modern society is greatly shaped by its use of energy which is one of the most important driving forces in its development. This logically leads to humanities dependence on it as well as its many carriers such as fossil fuels and biomass. In order to stem the ever-growing demand, a lot of effort is being put into energy efficiency as well as the move towards renewable energy sources and fossil free technologies. Despite such efforts, fossil fuels and biomass will remain a necessity in a smaller or larger degree for many years to come.

The importance of fuels for the development of future energy systems results in a need to acquire predictions of the development of their prices. This can often pose a significant problem because of their inherent volatility. The prices of both fossil fuels and biomass are influenced by various technical, political and economic factors such as supply and demand balances, technological development, taxation policies, long term strategies, wars, political conflicts and so on. Due to this, future fuel prices can vary greatly, especially in the long term.

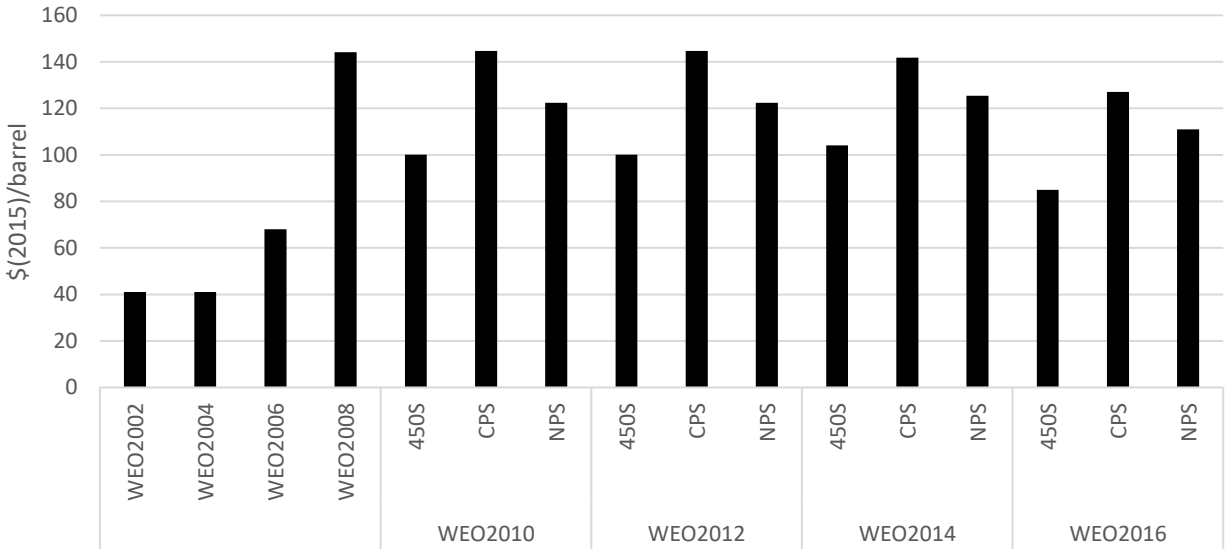

Figure 1 IEA oil price predictions for 2030 adjusted to 2015 level

Some examples of this volatility are presented here. Figure 1 shows the oil predictions available in IEAs World Energy Outlook documents from 2002 until 2016 [1]–[8] for the year 2030 and adjusted for inflation to 2015 levels using inflation data from the OECD [9]. The data available in the New policies, Current policies and 450 scenarios available in the World Energy Outlook 2010 and newer documents are also presented here. The year 2030 was selected for this demonstration it is available in all 8 documents. As it can be seen, the predictions vary greatly from document to document and range from

41 $/barrel in 2002 and 2004 to 144.65 $/barrel in the 2010 and 2012 Current policy scenario prediction. This is an increase by a factor of 3.5 in the span of 10 years. Similar trends can also be observed in the cases of natural gas in Figure 2 and coal in Figure 3. Natural gas prices for the year 2030 vary from 5.37 $/MBtu in the 2002 document to 15.47 $/MBtu in the Current policies scenario from 2010, an increase with a factor of 2.9. Coal prices vary from 62.22 $/tonne in the 2002 and 2004 documents to 132.18 in the Current policies scenario from 2012, an increase with a factor of 2.12.

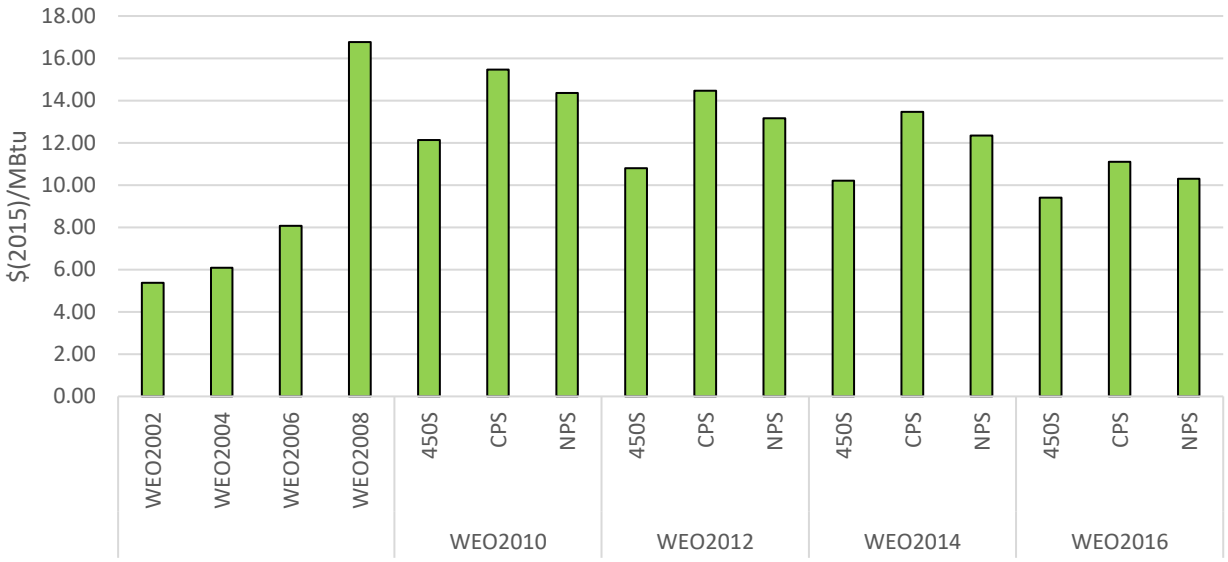

Figure 2 IEA natural gas price predictions for 2030 adjusted to 2015 level

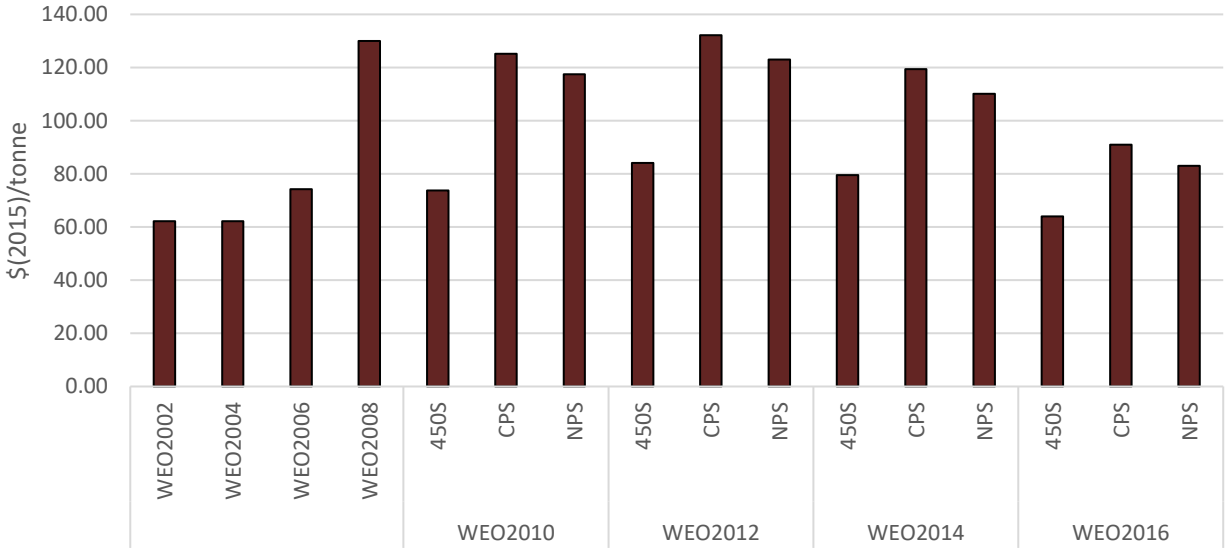

Figure 3 IEA coal price predictions for 2030 adjusted to 2015 level

Figure 4 shows all available oil price predictions from the 8 IEA documents for the period 2015-2040 adjusted for inflation to 2015 levels. As the figure shows, the predictions vary greatly depending on the year, publication and scenario.

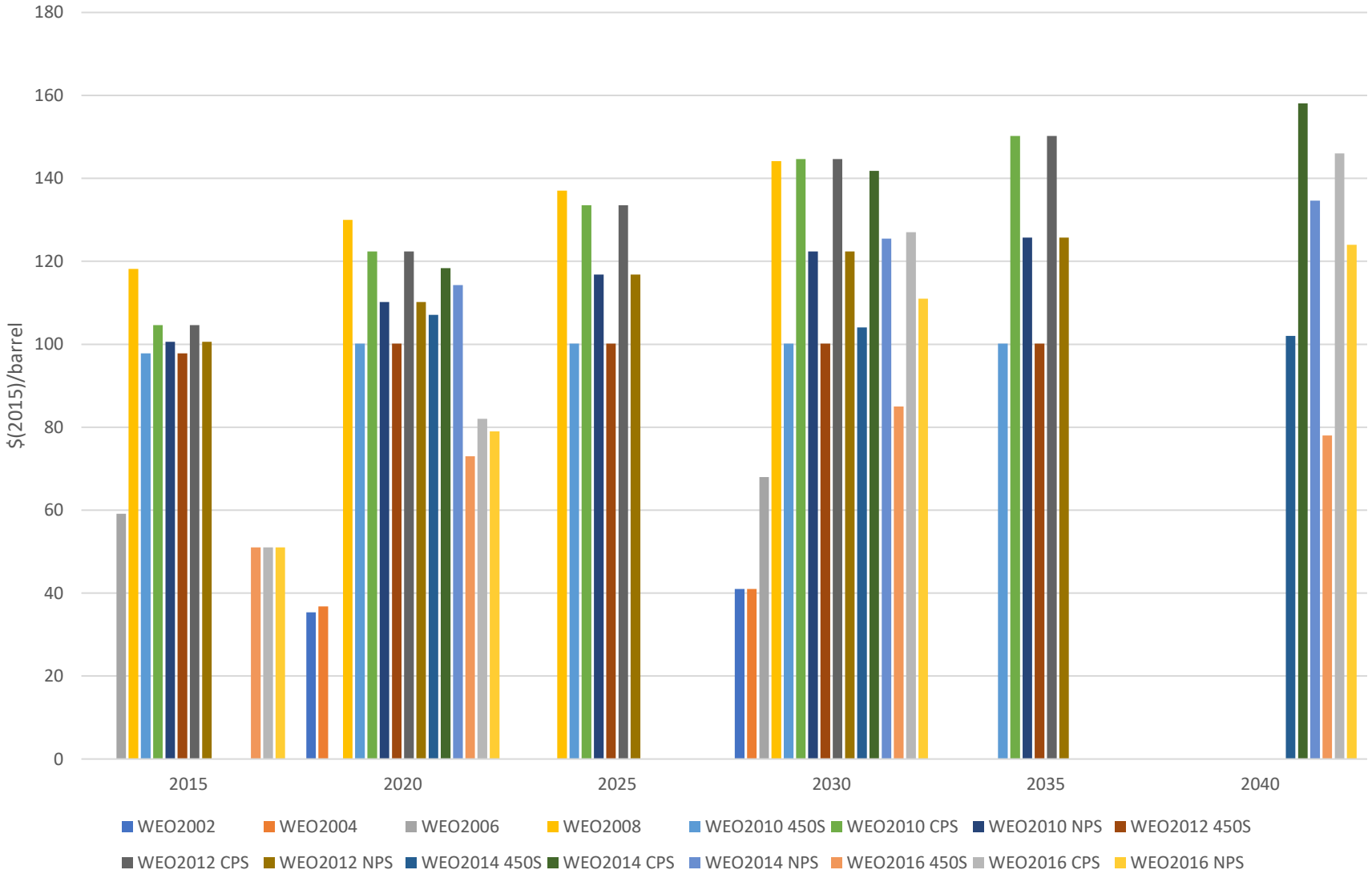

Figure 4 IEA Oil price predictions for the period 2015-2040 adjusted for inflation to 2015 levels

Segregation of fuel prices to a national level is faced with even more issues. Aside from the high volatility, different calculation methods, base years assumptions and scope of the analysis all come into play. It is often impossible to find consistent data and predictions on this scale even if it available for some EU member states in various national plans, strategies and similar documents.

Because of the above mentioned issues, a method has been developed and implemented which is bases on a variety of different EU level datasets which include extraction, import, import dependency and labour costs. Some of this data can be found on a country by country basis in a consistent form. The methodology and results of this process are presented in this report

2. Methodology

The overall methodology for the acquisition of the prices of fossil fuels and biomass as well as fuel handling is presented in this chapter. It is important to note that the prices calculated in this deliverable are presented from a systems perspective and do not necessarily reflect prices for households, commercial or energy entities. This means that they do not include taxes, surcharges, CO_2 prices and additional fees. This can be considered as a technical cost of the energy source. In order to enable the comparison of individual price points from different scenarios, all prices have been adjusted for inflation to 2015 levels using OECD data [9] and are given in €/MWh. Conversion rates from the ECB have been used where necessary [10].

2.1. Fossil fuels

The methodology for the assessment of the current and future fossil fuel prices has been based on three factors:

- Fuel extraction prices,
- Fuel import prices,
- Fuel dependency ratio.

The fuel extraction prices are based on the data available from the JRC-EU-TIMES report [11]. It details the prices for the domestic extraction of fossil fuels in the years 2005 and 2050 for all 28 EU member states. The data for 2015 and 2030 have been obtained through linear interpolation and are adjusted for inflation to 2015 levels using OECD data [9] and exchange rates taken from the ECB [10]. An example of the gathered data can be seen in Table 1.

Table 1 Example of the fossil fuel extraction data

		EU	BULGARIA	CZECH REPUBLIC	GERMANY	FRANCE
N.GAS	Extraction 2015 [EUR/MWh]	7.26	8.06	8.06	8.06	8.06
	Extraction 2030 [EUR/MWh]	7.42	8.14	8.14	8.14	8.14
	Extraction 2050 [EUR/MWh]	7.64	8.24	8.24	8.24	8.24
OIL	Extraction 2015 [EUR/MWh]	11.69	7.70	13.35	13.35	13.35
	Extraction 2030 [EUR/MWh]	11.81	8.10	13.35	13.35	13.35
	Extraction 2050 [EUR/MWh]	11.97	8.64	13.35	13.35	13.35
COAL	Extraction 2015 [EUR/MWh]	5.84	5.29	5.94	6.36	11.80
	Extraction 2030 [EUR/MWh]	6.18	5.89	5.49	7.54	11.80
	Extraction 2050 [EUR/MWh]	6.96	6.68	4.90	9.13	11.80

The second step in the process has been the collection of the EU fuel import prices. To accommodate broad investigation necessary due to large variations in predictions which are elaborated on in the introduction, four data sets deemed most relevant and complete, have been selected. These include the IEA World Energy Outlook 2016 [8]

which contains three price scenarios (new policies, current policies and 450 scenario), JRC-EU-TIMES report [11], which also includes three scenarios (low, reference and high price), the EU Long-term scenarios 2050 [12], and the Background Report for Baseline Projection 2017 [13]. All four mentioned reports include the overall EU energy import prices which are not segregated per country. The data for the three selected years, 2015, 2030 and 2050, were again obtained through linear interpolation and extrapolation where necessary and are all adjusted for inflation to 2015 level using OECD data [9] and exchange rates taken from the ECB [10].

Table 2 shows the fossil fuel import prices in €/MWh adjusted for inflation to 2015 levels for 2015, 2030 and 2050 according to the IEAs World Energy Outlook 2016 report [8]. The future predictions are based on three developed scenarios namely the new policies, existing policies and 450 scenarios. The new policies scenario acts as the main one of the three in the World Energy Outlook 2016 report and it assesses the likely impact of the implementation of announced measures, most notably the climate pledges submitted for COP21. The current policies scenario serves as a benchmark to which other scenarios are compared to and only incorporates enacted measures as of mid-2016. Finally, the 450 scenario demonstrates a potential pathway which could limit the long-term global worming to 2°C above pre-industrial levels [8].

Table 2 EU fuel import data from the IEA World Energy Outlook 2016

EUR/MWH	2015	2030	2050
NEW POLICIES			
N.GAS	29.43	43.30	53.39
OIL	34.21	74.46	91.90
COAL	10.10	13.11	14.17
CURRENT POLICIES			
N.GAS	29.43	46.66	62.63
OIL	34.21	85.19	110.69
COAL	10.10	14.17	17.00
450 SCENARIO			
N.GAS	29.43	39.51	43.72
OIL	34.21	57.02	47.63
COAL	10.10	10.10	7.97

Table 3 shows the fossil fuel import prices in €/MWh adjusted for inflation to 2015 levels for 2015, 2030 and 2050 according to the JRC-EU-TIMES report [11]. The presented prices are in line with the reference case of the European Commission's Energy 2050 Roadmap [14]. Aside from the reference case, the JRC report also contains two additional scenarios, namely the high and low price scenarios.

Table 3 EU fuel import data from the JRC-EU-TIMES report

EUR/MWH	2015	2030	2050
N.GAS			

REFERENCE	26.82	35.55	45.67
HIGH PRICES	32.25	47.11	59.87
LOW PRICES	22.55	23.62	25.11
OIL			
REFERENCE	40.14	49.15	58.85
HIGH PRICES	50.31	69.29	75.32
LOW PRICES	37.92	42.46	38.94
COAL			
REFERENCE	11.90	15.13	15.55
HIGH PRICES	14.36	21.21	18.56
LOW PRICES	10.33	11.05	10.72

Two additional data sources have been considered in the evaluation namely the EU Long-term scenarios 2050 [12], and the Background Report for Baseline Projection 2017 [13], which are presented in Table 4 and Table 5.

Table 4 EU fuel import data from the EU Long-term scenarios 2050 report

EUR/MWH	2015	2030	2050
N.GAS	31.38	35.58	36.72
OIL	56.67	52.18	34.79
COAL	15.37	17.76	21.54

Table 5 EU fuel import data from the Background Report for Baseline Projection 2017

EUR/MWH	2015	2030	2050
N.GAS	29.15	43.16	53.00
OIL	34.88	75.92	93.70
COAL	9.45	12.26	13.26

The final dataset needed for this analysis is the import share of each fuel type for each observed country. This information is available from the Eurostat portal under the Energy dependence tab [15]. Data related to historic dependence on the import of gas, petroleum products and solid fuels for all European countries can be found here. The obtained values have been modified to fit within 0 and 100% (by setting the upper and lower boundary values to 0 and 1) since some countries have a negative value or values of above 100%. This data is presented in Table 6. Since no concrete estimates for the future import shares could be found, the same levels were used until 2050 but additional scenarios have been created to take the possibility of their change into account. The calculation of the final fuel price was done using Equation 1

$$FFP = (1 - ID) \times EP + ID \times IP \qquad \text{Equation 1}$$

- FFP – Fossil fuel price [EUR/MWh]

- ID – Import dependency [-]
- EP – Extraction price [EUR/MWh]
- IP – Import price [EUR/MWh]

Table 6 Import dependency

	N.GAS	OIL	COAL
EU	69.10%	88.80%	42.80%
BELGIUM	99.30%	100.00%	97.20%
BULGARIA	97.00%	99.20%	11.20%
CZECH REPUBLIC	95.10%	97.80%	0.00%
DENMARK	0.00%	5.80%	85.00%
GERMANY	90.10%	96.40%	45.50%
ESTONIA	100.00%	39.40%	0.00%
IRELAND	96.50%	100.00%	66.80%
GREECE	99.90%	100.00%	2.80%
SPAIN	96.90%	100.00%	78.30%
FRANCE	98.70%	98.50%	98.40%
CROATIA	27.10%	79.60%	100.00%
ITALY	90.40%	89.50%	100.00%
CYPRUS	100.00%	100.00%	100.00%
LATVIA	98.60%	100.00%	84.70%
LITHUANIA	99.70%	100.00%	87.10%
LUXEMBOURG	99.40%	99.30%	100.00%
HUNGARY	69.70%	93.20%	34.00%
MALTA	100.00%	97.80%	100.00%
NETHERLANDS	0.00%	100.00%	100.00%
AUSTRIA	72.50%	94.00%	85.20%
POLAND	72.20%	96.80%	0.00%
PORTUGAL	99.80%	99.70%	100.00%
ROMANIA	1.80%	53.50%	17.40%
SLOVENIA	99.60%	99.60%	18.90%
SLOVAKIA	95.10%	89.40%	84.60%
FINLAND	99.70%	100.00%	61.20%
SWEDEN	99.10%	100.00%	92.30%
UNITED KINGDOM	41.80%	36.40%	65.40%

The obtained data sets have been used to create eight sets of results with three sub-scenarios each for the EU28 for 2015, 2030 and 2050. A summary of the scenarios can be seen in Table 7. The extraction price and import shares have been taken from the same sources in all eight scenarios, namely the JRC-EU-TIMES report and Eurostat respectively. The import prices in the first three scenarios have been taken from the IEA World Energy Outlook 2016 [8] which includes the new policy (IEA new policies), current policy (IEA current policies) and 450 scenarios (IEA 450 scenario), the next three are taken from the JRC-EU-TIMES report namely the reference (JRC reference),

low (JRC low) and high (JRC high) prices while the last two correspond to the EU Long-term scenarios 2050 (EU long term) and the Background Report for Baseline Projection 2017 (Background-Report). Finally, three subsets of assumptions have been created for each case modifying the import dependence by -10 and +10% resulting in the three sub-scenarios. This results in 24 datasets for each country and fuel for the years 2015, 2030 and 2050. All prices are presented in €/MWh adjusted for inflation to 2015 levels.

Table 7 List of fossil fuel price scenarios

SCENARIO	EXTRACTION PRICE	IMPORT PRICE	IMPORT SHARE	IMPORT ASSUMPTION
1	JRC	IEA new policies	Eurostat	1 0.9 1.1
2	JRC	IEA current policies	Eurostat	1 0.9 1.1
3	JRC	IEA 450 scenarios	Eurostat	1 0.9 1.1
4	JRC	JRC reference	Eurostat	1 0.9 1.1
5	JRC	JRC low	Eurostat	1 0.9 1.1
6	JRC	JRC high	Eurostat	1 0.9 1.1
7	JRC	EU long term	Eurostat	1 0.9 1.1
8	JRC	Background-Report	Eurostat	1 0.9 1.1

2.2. Biomass

The assessment of the current and future biomass prices has been done using data collected from the Heat Roadmap Europe [16] report from 2012, Analysis of biomass prices for Denmark [17] by the Ea Energy Analyses, labour cost data from Eurostat [18] and the Bioenergy potentials for EU and neighbouring countries report made by the JRC [19].

Initially, the biomass price data available in the Heat Roadmap Europe [16] report has been gathered, converted into €/MWh adjusted to 2015 levels and interpolated to obtain data for 2015, 2030 and 2050. This dataset contains average EU biomass prices and no

data segregated by country and type. In order to distinguish the prices between different EU countries, labour costs have been taken into account. Equation 2 has been used to calculate the baseline biomass price.

$$BMP = (1 - LS) \times BMP_{EU} + LS \times LP \times L \qquad \text{Equation 2}$$

- BMP – Biomass price [EUR/MWh]
- LS – Labour share [-]
- BMP_{EU} – EU average biomass price [EUR/MWh]
- LP – Labour cost [EUR/hour]
- L – Labour intensity [h]

To better evaluate the impact of labour, three scenarios have been created utilizing a share of 5, 15 and 30% of labour costs in the overall average cost of biomass as well as the costs of the individual biomass types. The calculated EU average biomass prices, both for the three subtypes as well as the overall average, were kept constant with respect to the observed year in all cases. This was achieved by modifying the labour intensity values. The labour costs used in the analysis can be seen in Table 8.

Table 8 Labour costs used

	LABOUR COSTS [EUR/H]		
EU	25	**LITHUANIA**	6.8
BELGIUM	39.1	**LUXEMBOURG**	36.3
BULGARIA	4.1	**HUNGARY**	7.9
CZECH REPUBLIC	9.8	**MALTA**	13.2
DENMARK	41.2	**NETHERLANDS**	33.2
GERMANY	32.2	**AUSTRIA**	32.4
ESTONIA	10.3	**POLAND**	8.6
IRELAND	30	**PORTUGAL**	13.4
GREECE	14.1	**ROMANIA**	4.9
SPAIN	21.2	**SLOVENIA**	15.8
FRANCE	35.1	**SLOVAKIA**	10
CROATIA	9.6	**FINLAND**	33
ITALY	28.1	**SWEDEN**	37.4
CYPRUS	15.7	**UNITED KINGDOM**	29.7
LATVIA	7.1		

In the second step the individual costs of the following three types of biomass have been collected from the Analysis of biomass prices for Denmark [17] report:

- Straw,
- Wood Chips;
- Wood Pellets.

These three costs have then been averaged and the relation between the cost of the individual biomass type and the average price has been calculated for the years 2015, 2030 and 2050 and adjusted for inflation to 2015 levels. The results of this can be seen in Table 9.

Table 9 Average costs and shares of straw, wood chips and wood pellets in average costs of biomass

YEAR	Average Biomass Price [EUR/MWh]	Share in average price		
		Straw	Wood Chips	Wood Pellets
2015	28.77	0.83	0.92	1.25
2030	30.32	0.86	0.95	1.19
2050	34.89	0.88	0.98	1.14

These values have then been used to calculate the prices of all three types of biomass for the 28 EU member states in the years 2015, 2030 and 2050. An example of the final calculated biomass prices, both average and per type, can be found in Table 10.

Table 10 Example of the resulting biomass prices

TYPE	YEAR	LABOUR SHARE	PRICE [€/MWH]				
			EU	Bulgaria	Czech Republic	Germany	Greece
AVERAGE	2015	5%	28.77	27.60	27.98	29.46	28.26
		15%	28.77	25.27	26.40	30.84	27.25
		30%	28.77	21.76	24.02	32.90	25.73
	2030	5%	30.32	29.09	29.49	31.05	29.79
		15%	30.32	26.63	27.82	32.50	28.72
		30%	30.32	22.94	25.32	34.68	27.11
	2050	5%	34.89	33.47	33.93	35.73	34.28
		15%	34.89	30.64	32.01	37.40	33.05
		30%	34.89	26.39	29.13	39.90	31.20
STRAW	2015	5%	23.93	22.96	23.27	24.50	23.51
		15%	23.93	21.01	21.95	25.65	22.66
		30%	23.93	18.10	19.98	27.37	21.40
	2030	5%	25.99	24.93	25.27	26.61	25.53
		15%	25.99	22.82	23.84	27.86	24.61
		30%	25.99	19.66	21.70	29.72	23.24
	2050	5%	30.74	29.49	29.89	31.47	30.19
		15%	30.74	26.99	28.20	32.94	29.11
		30%	30.74	23.25	25.67	35.15	27.49
WOOD CHIPS	2015	5%	26.49	25.42	25.76	27.13	26.02
		15%	26.49	23.27	24.31	28.39	25.09
		30%	26.49	20.04	22.12	30.30	23.69
	2030	5%	28.83	27.66	28.04	29.52	28.32
		15%	28.83	25.32	26.45	30.90	27.31
		30%	28.83	21.81	24.07	32.97	25.78
	2050	5%	34.06	32.68	33.12	34.87	33.46

		15%	34.06	29.91	31.25	36.51	32.26
		30%	34.06	25.77	28.44	38.95	30.46
WOOD PELLETS	2015	5%	35.89	34.43	34.90	36.75	35.26
		15%	35.89	31.52	32.93	38.47	33.99
		30%	35.89	27.15	29.97	41.05	32.10
	2030	5%	36.14	34.67	35.15	37.01	35.50
		15%	36.14	31.74	33.16	38.74	34.23
		30%	36.14	27.34	30.18	41.33	32.32
	2050	5%	39.87	38.26	38.78	40.83	39.17
		15%	39.87	35.02	36.59	42.74	37.77
		30%	39.87	30.16	33.30	45.60	35.66

Additionally to the above mentioned data, biomass prices have been collected from the Bioenergy potentials for EU and neighbouring countries report made by the JRC [19]. This includes:

- Cost associated with biofuel crops and energy maize;
  - Sugar beet, oil crops, starchy crops.
- Cost associated with dedicated perennials;
  - Dedicated perennials, willow, poplar.
- Cost associated with manure;
- Cost associated with primary agricultural residues;
- Cost associated with forest products and primary forest residues;
  - Roundwood fuelwood, Roundwood chips and pellets, forest residues.
- Costs associated with secondary forest residues;
  - Woodchips, wood dust.
- Costs associated with landscape care wood and road side verge grass;
- Costs associated with biomass waste;
  - Municipal solid waste, sludge.

2.3. Fuel handling prices

Fuel handling prices have been created as a separate distribution for natural gas, oil, coal and biomass in order to allow the users of this document to freely implement it and make separate sensitivity analysis possible for both the fuel and fuel handling prices. The calculation is based on data available in the Prices and Costs of EU Energy Final Report [20], Welfare economic prices of coal, petroleum products and natural gas [21] and the Background Report for Baseline Projection 2017 [13]. Since only the Prices and Costs of EU Energy Final Report [20] includes EU average prices while the other two documents focus only on Denmark, it was used to create an initial validation and calibration. From it, the EU average distribution price for natural gas of 6.6 EUR/MWh has been obtained. Labour costs available at Eurostat [18] have also been considered in the calculation. Three separate distributions have been created assuming three different shares of labour costs in the fuel handling price. Shares of 10, 30 and 50%

were used, while always keeping the average EU price at 6.6 EUR/MWh. The calculated results for Denmark were then compared with the data provided in [20], which has shown a difference of less than 2% in the case of the scenario with a 30% share of labour costs (8.37 compared to 8.51 EUR/MWh). Using the data obtained from [21], the costs of oil and coal handling have been extrapolated from Denmark to the rest of the EU28 using the same method as described above, and again with three labour share scenarios. The calculation follows a similar logic to that of the biomass prices as can be seen in Equation 3.

$$FHP_n = (1 - LS) \times FHP_{EUn} + LS \times LP \times L \qquad \text{Equation 3}$$

- FHP_n – Fuel handling price (per type) [EUR/MWh]
- LS – Labour share [-]
- FHP_{EUn} – EU average fuel handling price (per type) [EUR/MWh]
- LP – Labour price [EUR/hour]
- L – Labour intensity [h]

The handling costs for biomass have been calculated in a similar fashion. The Danish price has been calculated as a difference between the wholesale price and the average price a decentralize plant would pay, excluding taxes and similar levies taken from [13]. These costs have then been extrapolated to the rest of the EU28 using the same method as described above, and again with three labour share scenarios.

Table 11 shows an example of the obtained results.

Table 11 Example of the calculated fuel handling costs

	LABOUR SHARE	EU	BULGARIA	CZECH REPUBLIC	DENMARK	GERMANY
GAS	10%	6.60	6.06	6.24	7.19	6.92
	30%	6.60	4.99	5.51	8.37	7.55
	50%	6.60	3.92	4.79	9.54	8.18
OIL	10%	5.80	5.33	5.48	6.32	6.08
	30%	5.80	4.39	4.84	7.35	6.63
	50%	5.80	3.45	4.21	8.39	7.19
COAL	10%	0.10	0.09	0.09	0.11	0.10
	30%	0.10	0.08	0.08	0.13	0.11
	50%	0.10	0.06	0.07	0.14	0.12
BIOMASS	10%	3.00	2.76	2.84	3.27	3.14
	30%	3.00	2.27	2.51	3.80	3.43
	50%	3.00	1.78	2.18	4.34	3.72

3. Results

The final results of the presented review and analysis can be found below and in the appendices.

Figure 5, Figure 6 and Figure 7 show the natural gas prices for the IEA new, current policies and 450 scenarios, Figure 8, Figure 9 and Figure 10 for the JRC low, reference and high scenarios, Figure 11 for the EU Long Term scenario and Figure 12 for the Background-Report scenario.

Figure 13, Figure 14 and Figure 15 show the oil prices for the IEA new, current policies and 450 scenarios, Figure 16, Figure 17 and Figure 18 for the JRC low, reference and high scenarios, Figure 19 for the EU Long Term scenario and Figure 20 for the Heat-Roadmap scenario.

Figure 21, Figure 22 and Figure 23 show the coal prices for the IEA new, current policies and 450 scenarios, Figure 24, Figure 25 and Figure 26 for the JRC low, reference and high scenarios, Figure 27 for the EU Long Term scenario and Figure 28 for the Heat-Roadmap scenario.

Figure 29 shows the average biomass prices, Figure 30 the prices of straw, Figure 31 for wood chips and Figure 32 for pellets.

Finally, Figure 33 shows the fuel handling price for natural gas, Figure 34 for oil, Figure 35 for coal an Figure 36 for biomass.

All fossil fuel prices are sown for each of the EU28 countries as well as the average EU prices for the years 2015, 2030 and 2050 with the three above described import assumptions (reference, decreased and increased import) in EUR/MWh adjusted for inflation to 2015 levels.

All biomass prices are given separately for each of the EU28 countries as well as the average EU price with the three labour shares described above (5, 15 and 30% shares) for the years 2015, 2030 and 2050 in EUR/MWh adjusted for inflation to 2015 levels.

The fuel handling prices are given for natural gas, oil, coal and biomass for each of the EU28 countries as well as the average EU price with the three labour shares described above (10, 30 and 50% shares).

All of the above mentioned results, as well as the additional biomass prices, are provided in excel files as appendices to the document.

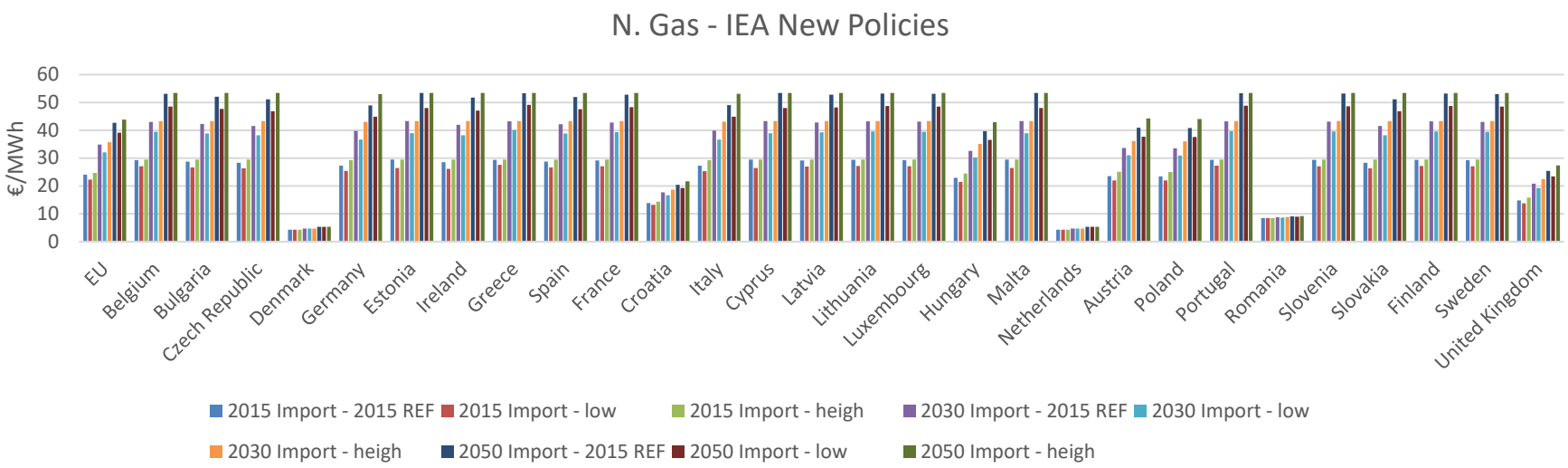

Figure 5 Natural gas prices for the IEA new policies scenario

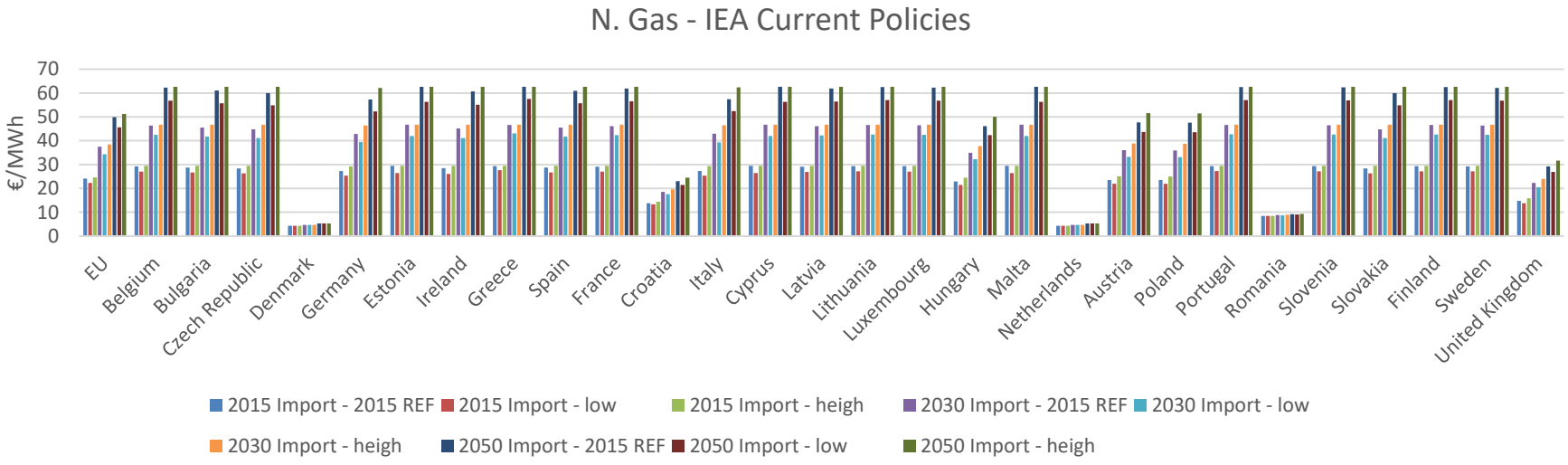

Figure 6 Natural gas prices for the IEA current policies scenario

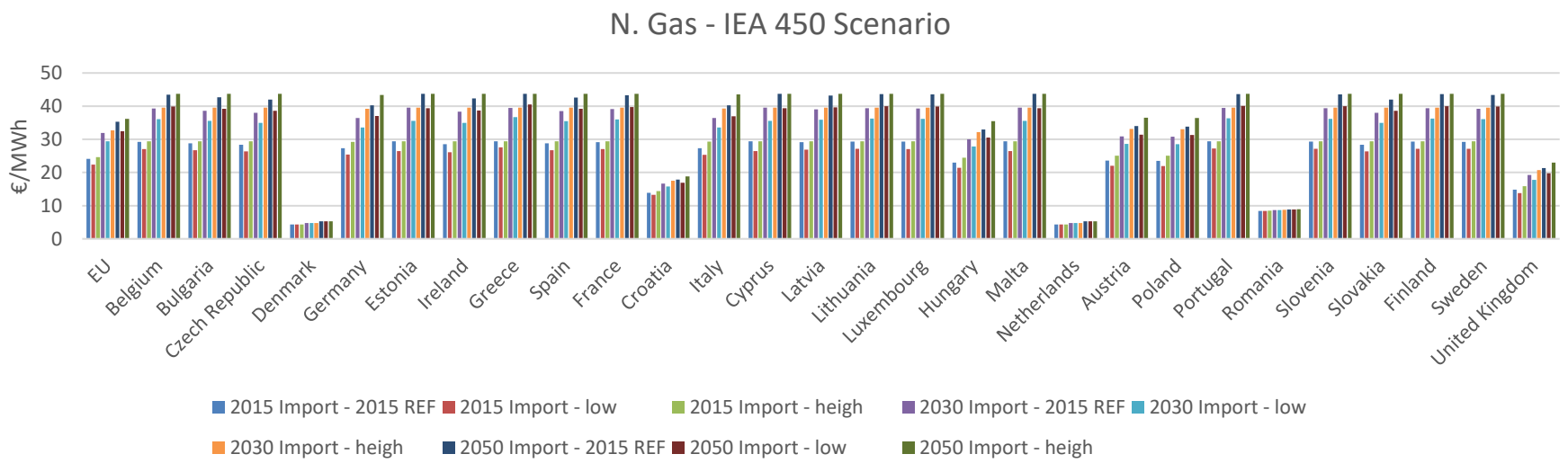

Figure 7 Natural gas prices for the IEA 450 scenario

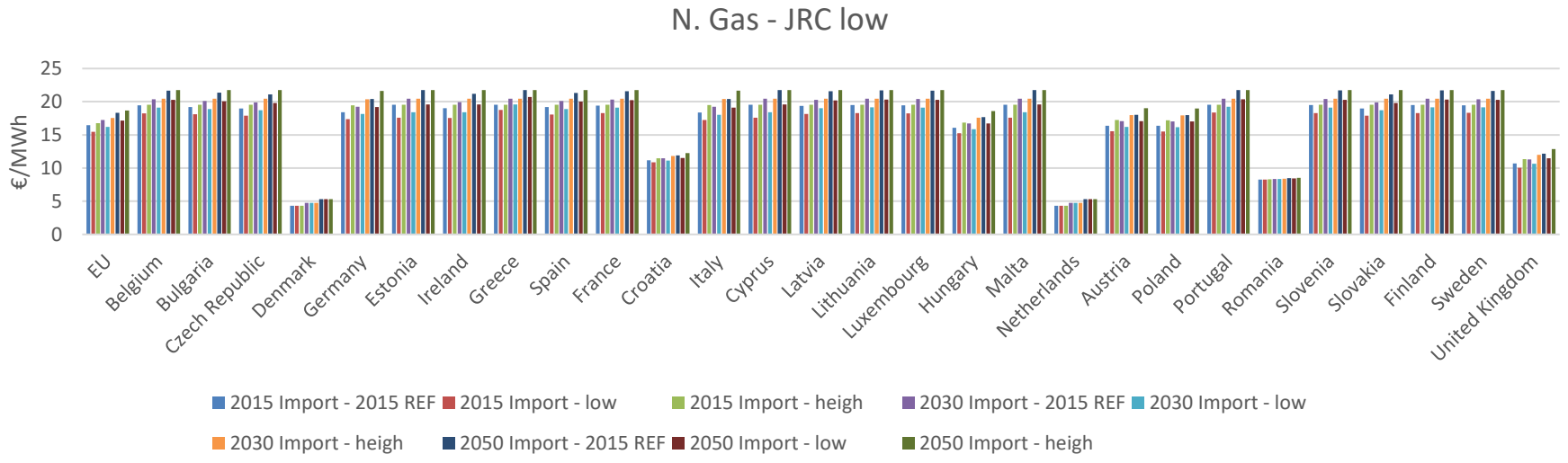

Figure 8 Natural gas prices for the JRS low scenario

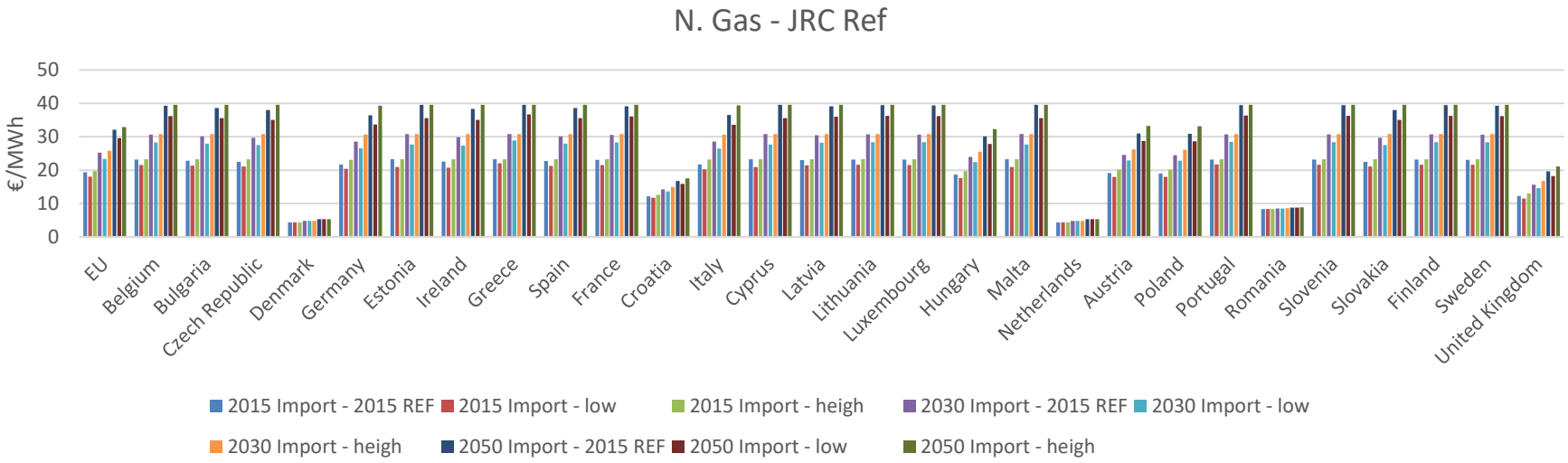

Figure 9 Natural gas prices for the JRS reference scenario

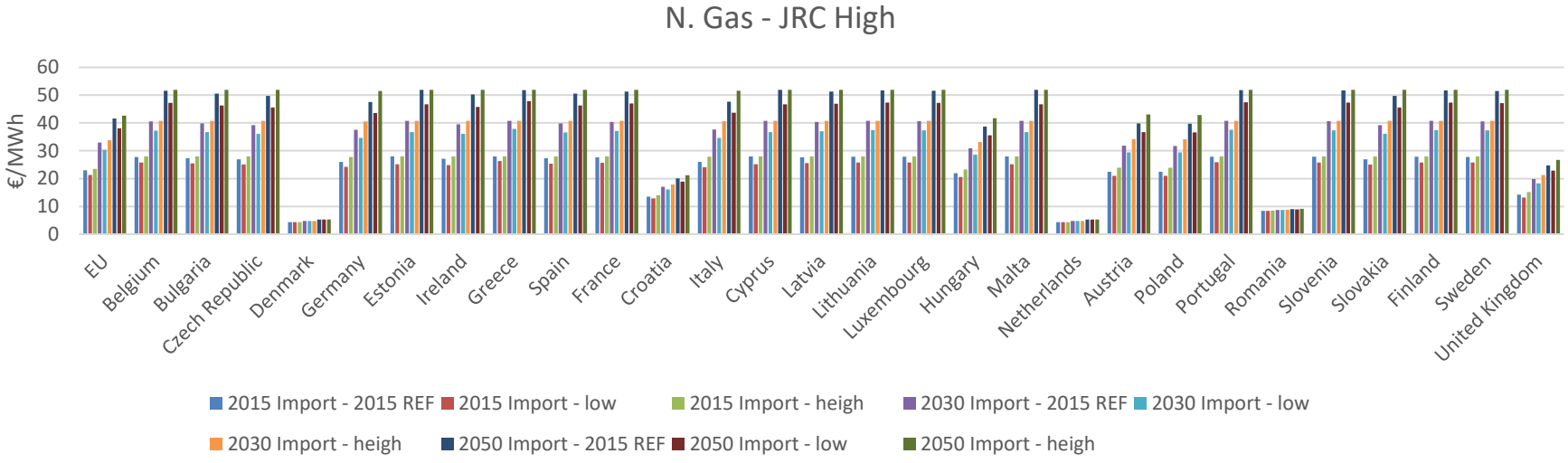

Figure 10 Natural gas prices for the JRS high scenario

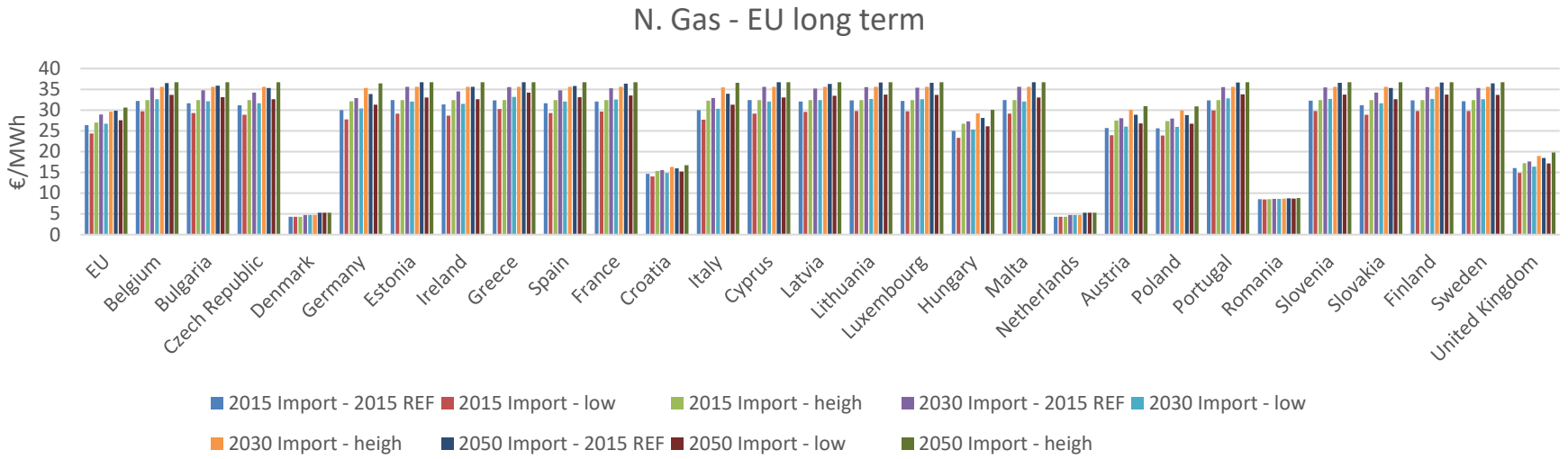

Figure 11 Natural gas prices for the EU long term scenario

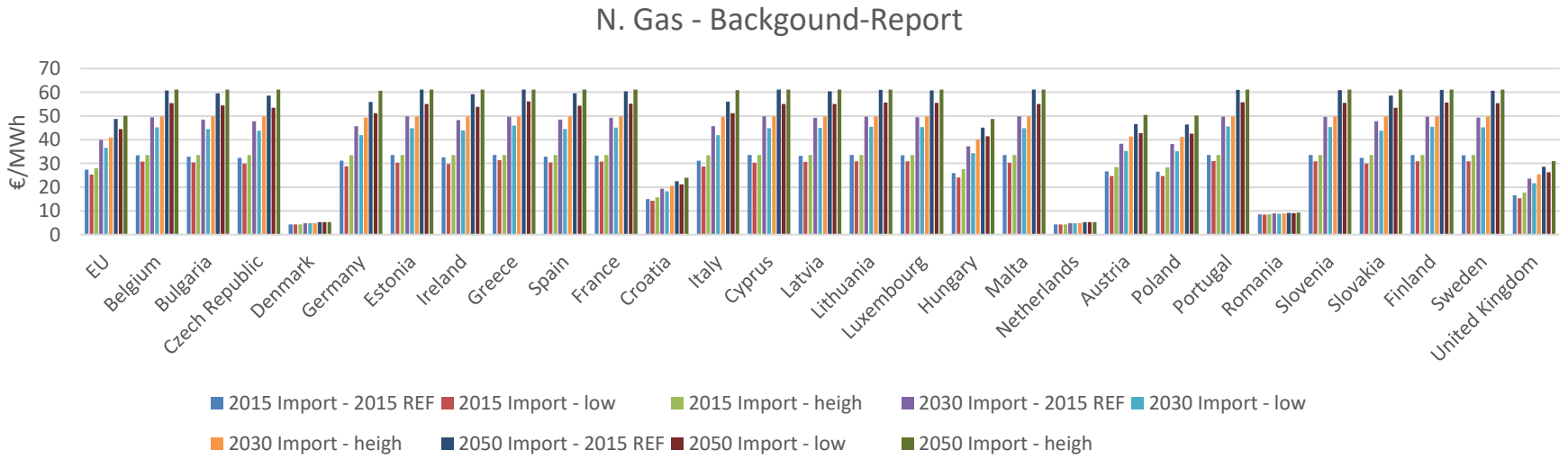

Figure 12 Natural gas prices for the Background-report scenario

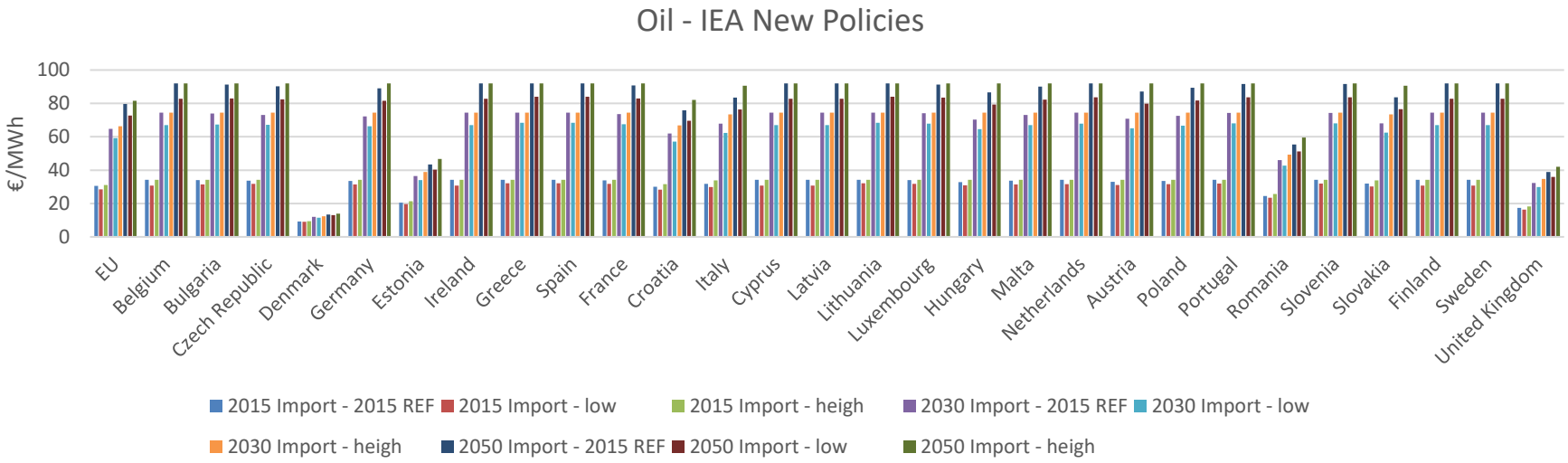

Figure 13 Oil prices for the IEA new policies scenario

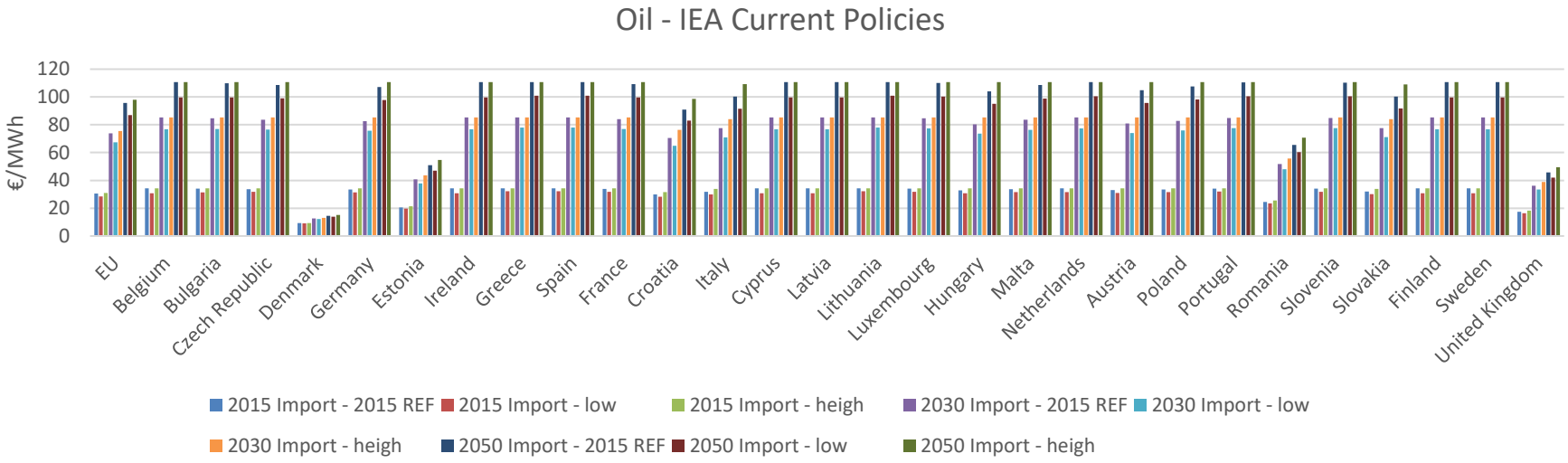

Figure 14 Oil prices for the IEA current policies scenario

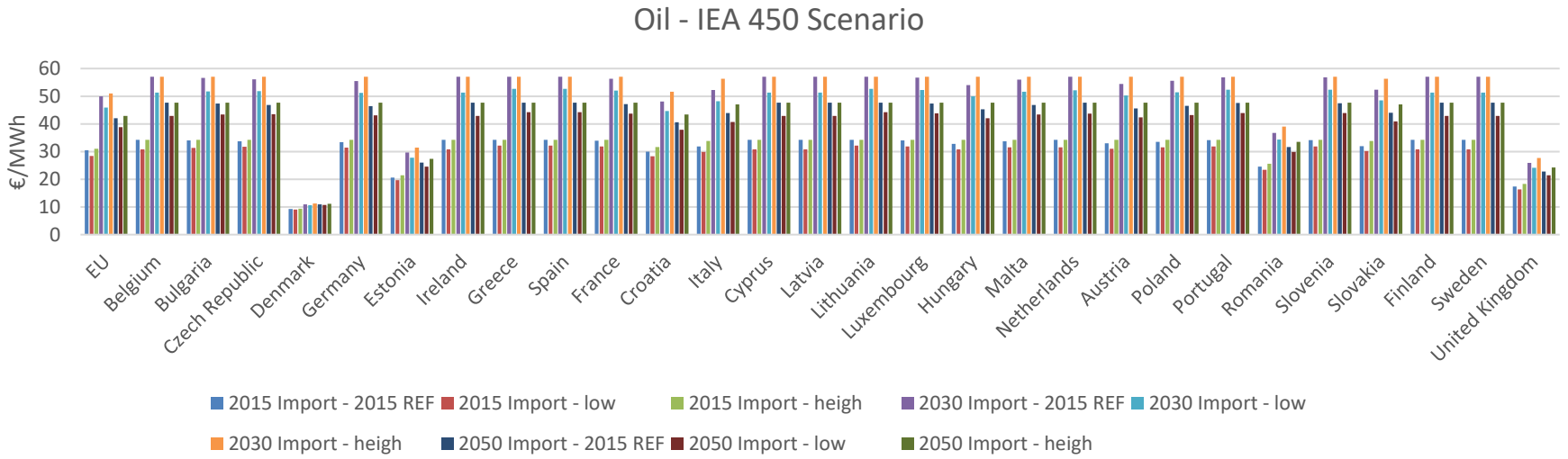

Figure 15 Oil prices for the IEA 450 scenario

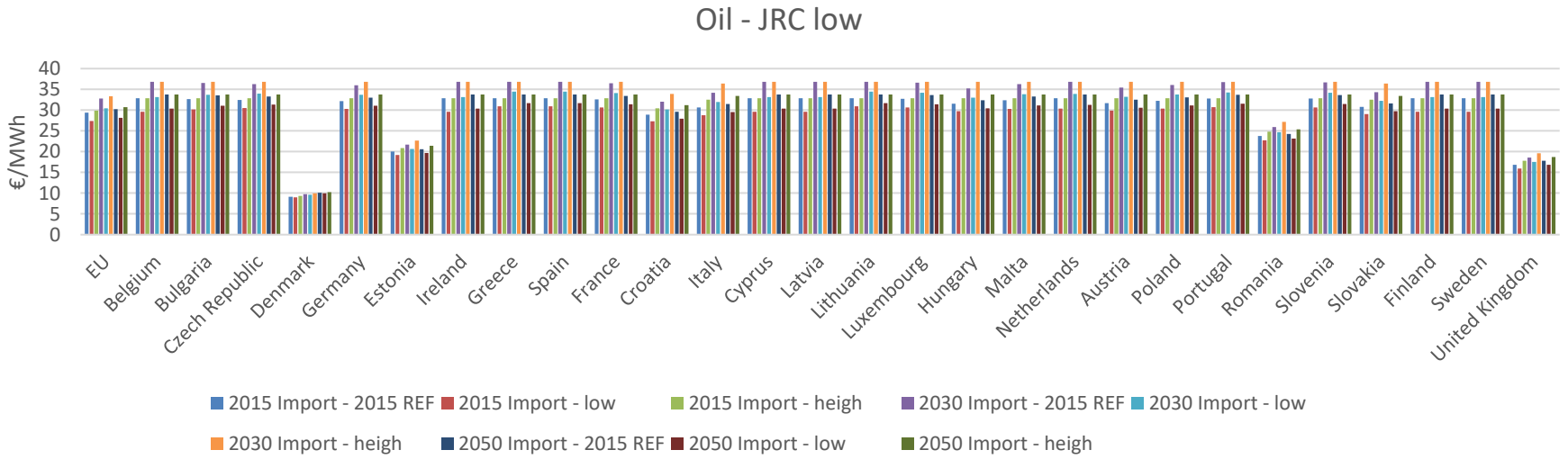

Figure 16 Oil prices for the JRS low scenario

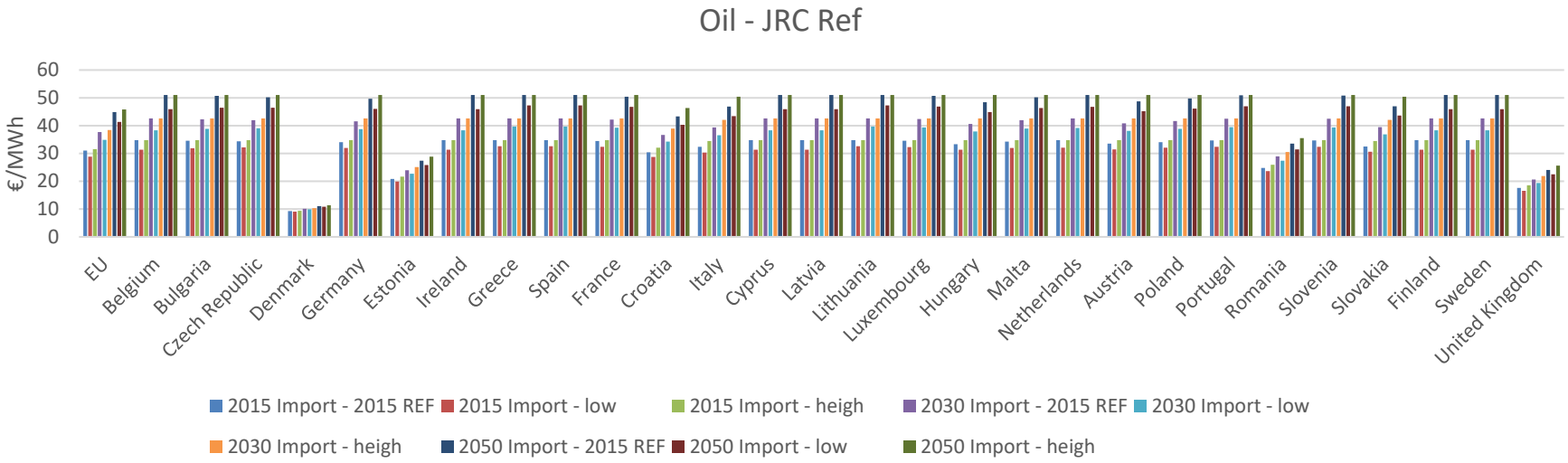

Figure 17 Oil prices for the JRS reference scenario

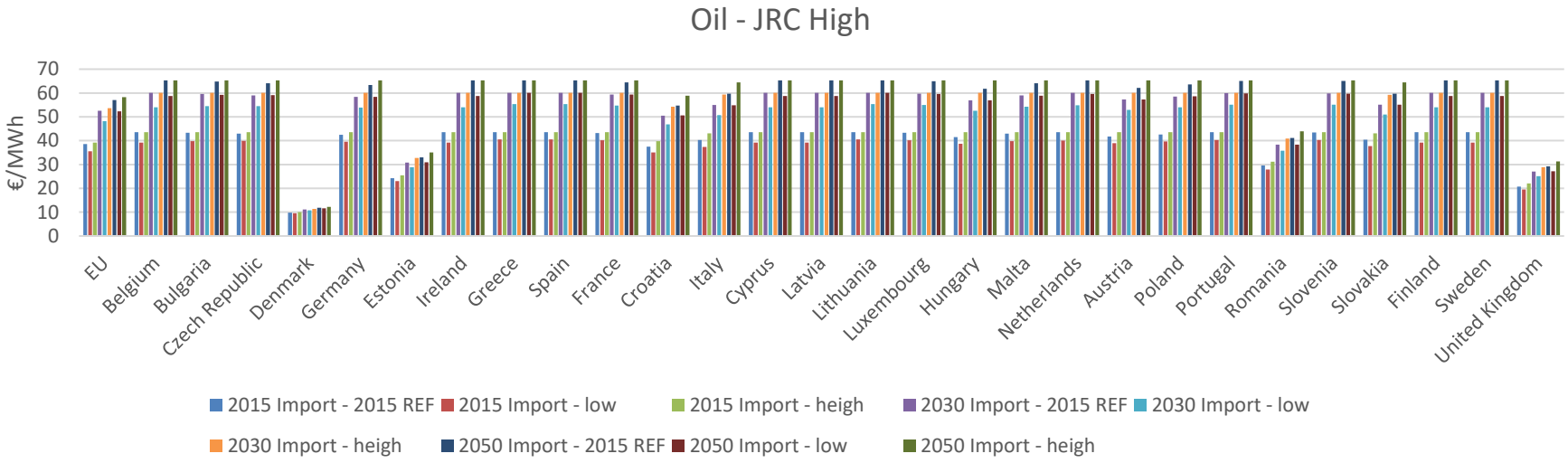

Figure 18 Oil prices for the JRS high scenario

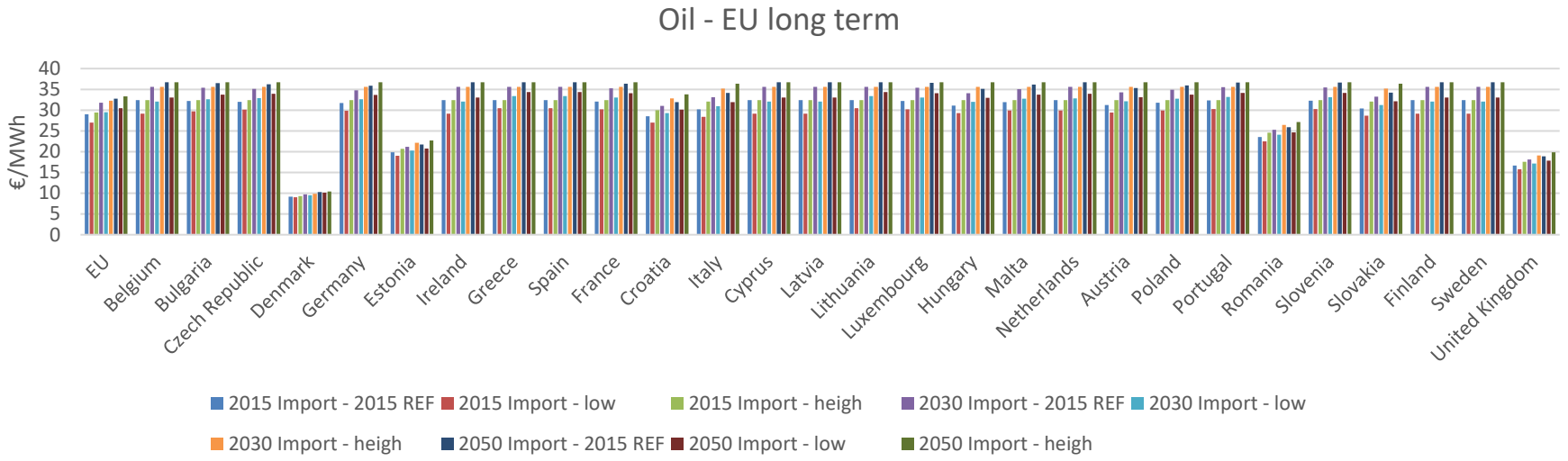

Figure 19 Oil prices for the EU long term scenario

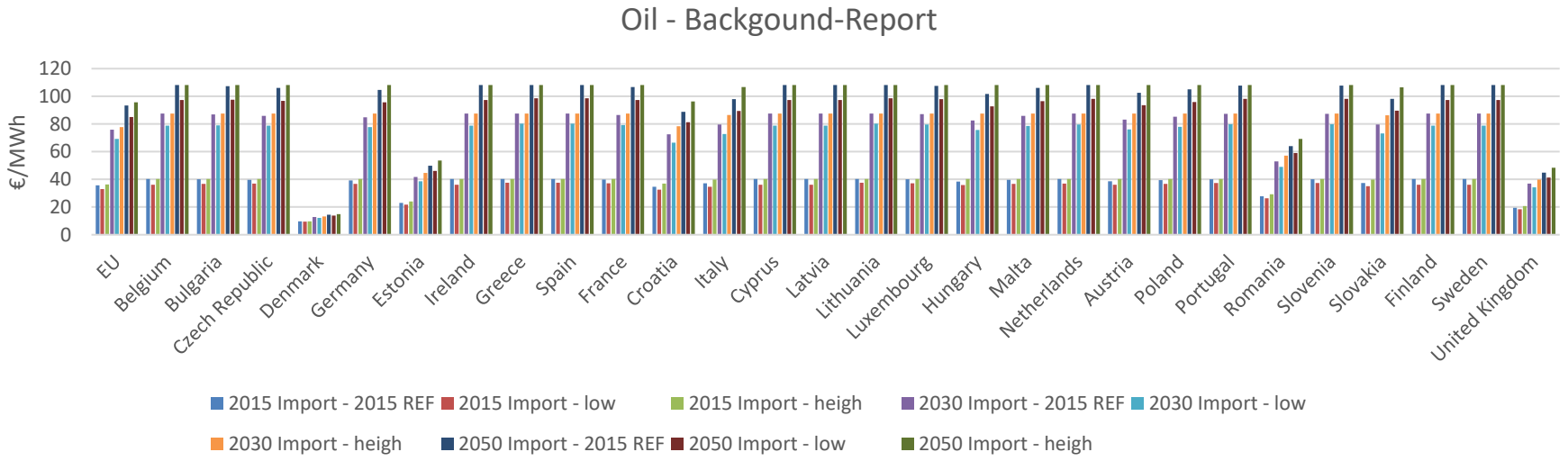

Figure 20 Oil prices for the Background-report scenario

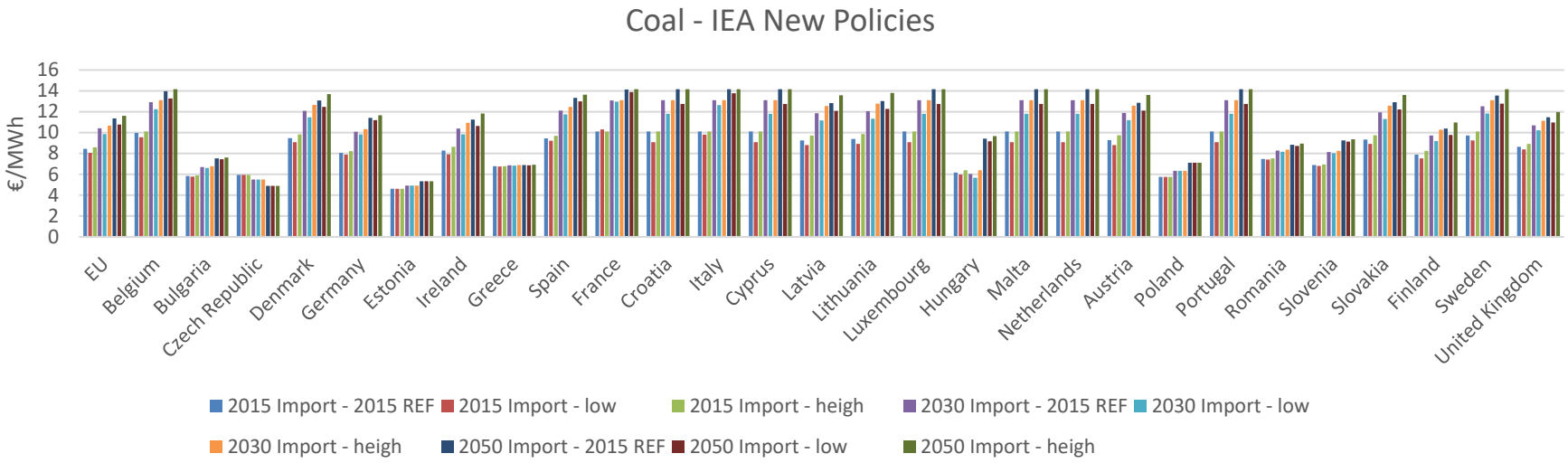

Figure 21 Coal prices for the IEA new policies scenario

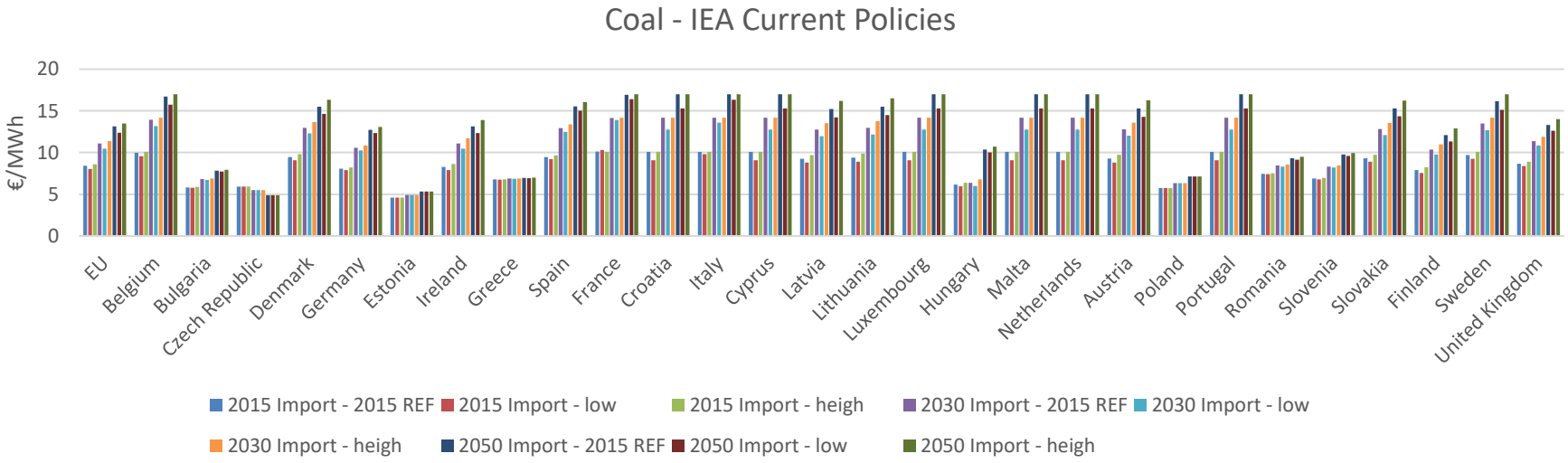

Figure 22 Coal prices for the IEA current policies scenario

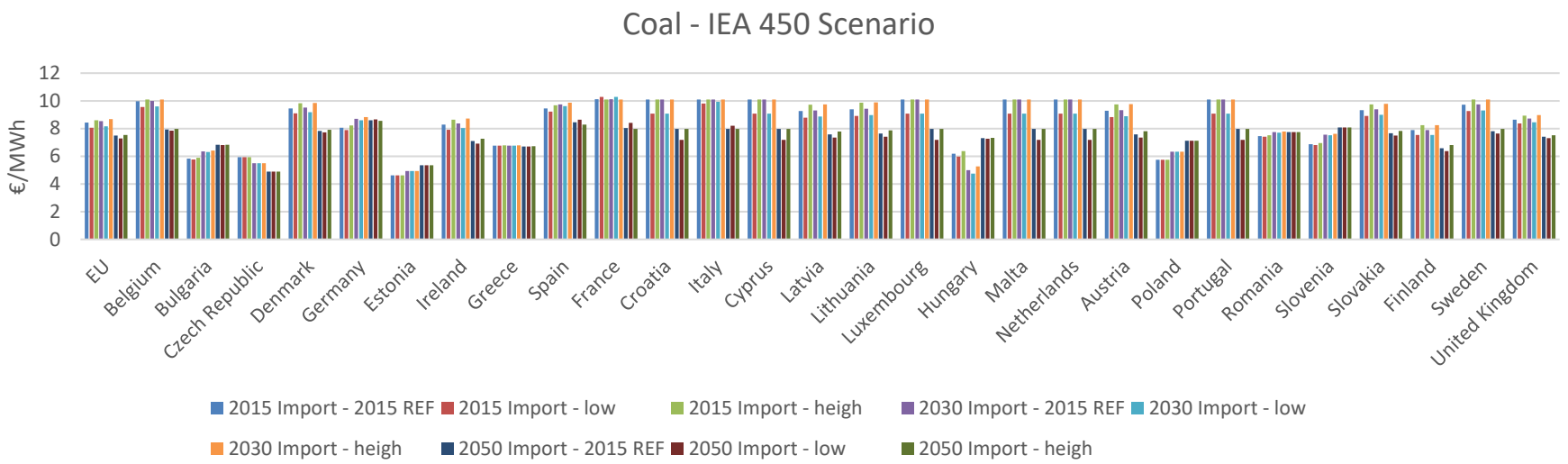

Figure 23 Coal prices for the IEA 450 scenario

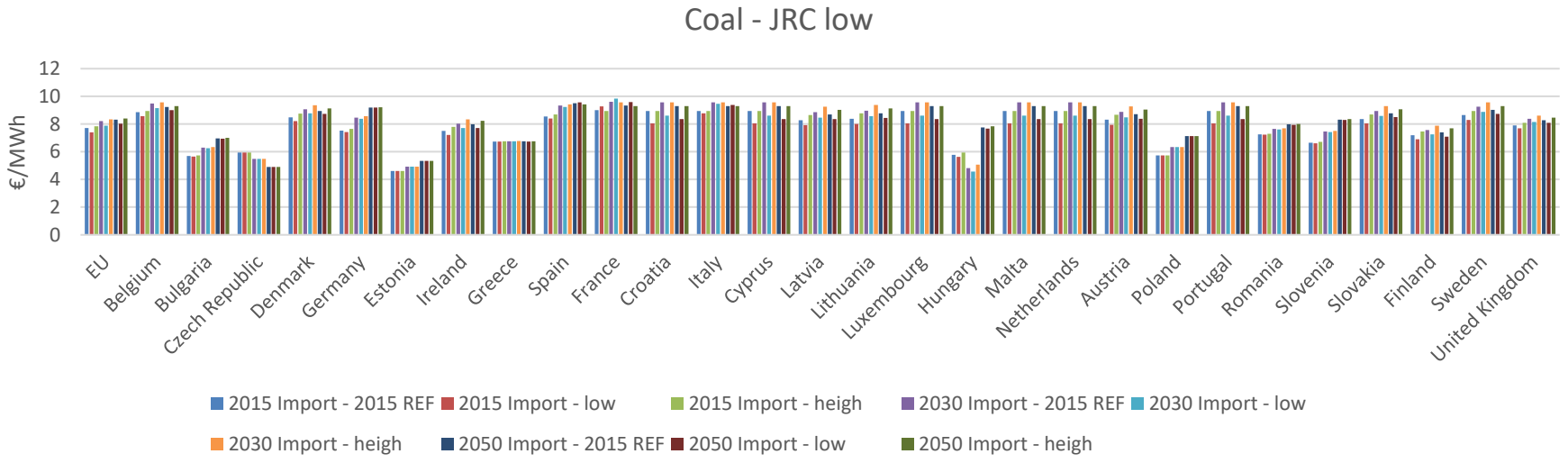

Figure 24 Coal prices for the JRS low scenario

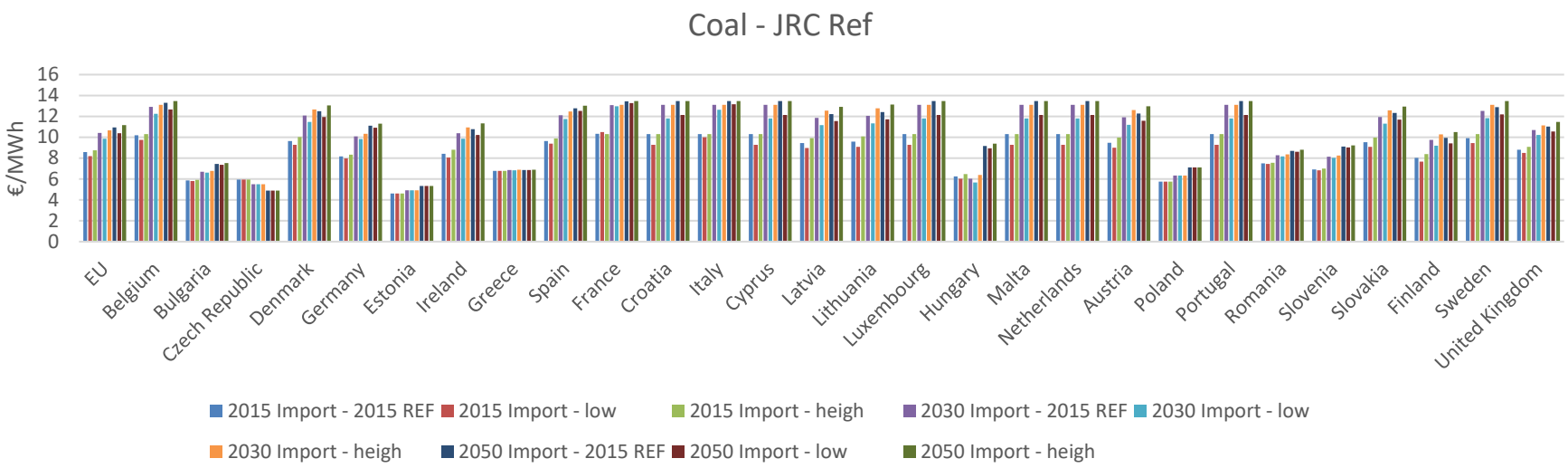

Figure 25 Coal prices for the JRS reference scenario

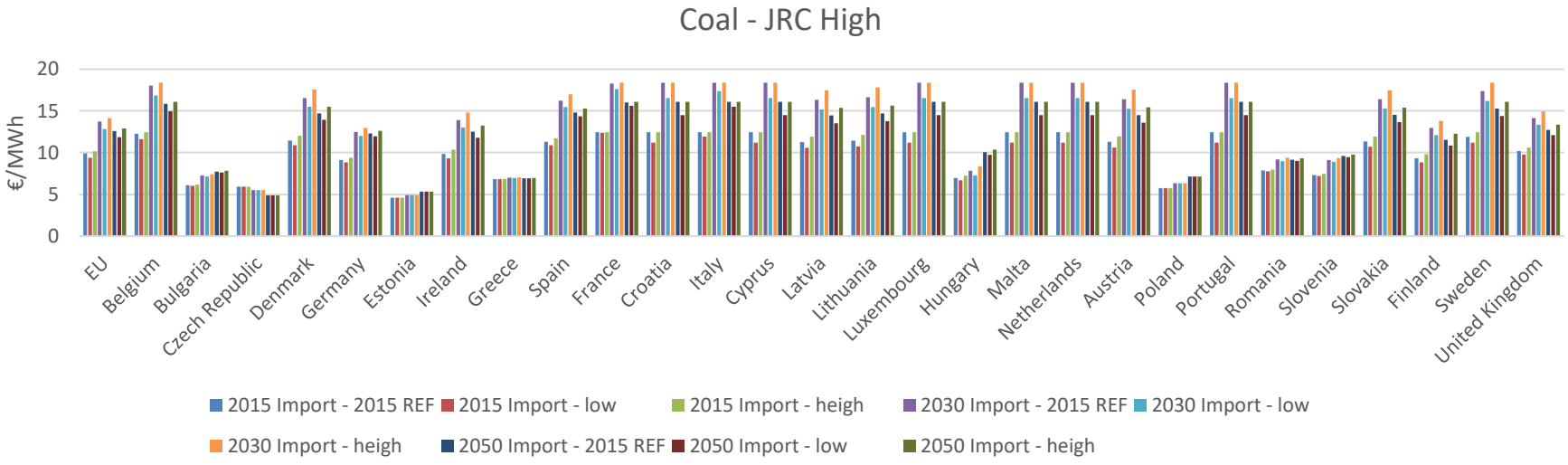

Figure 26 Coal prices for the JRS high scenario

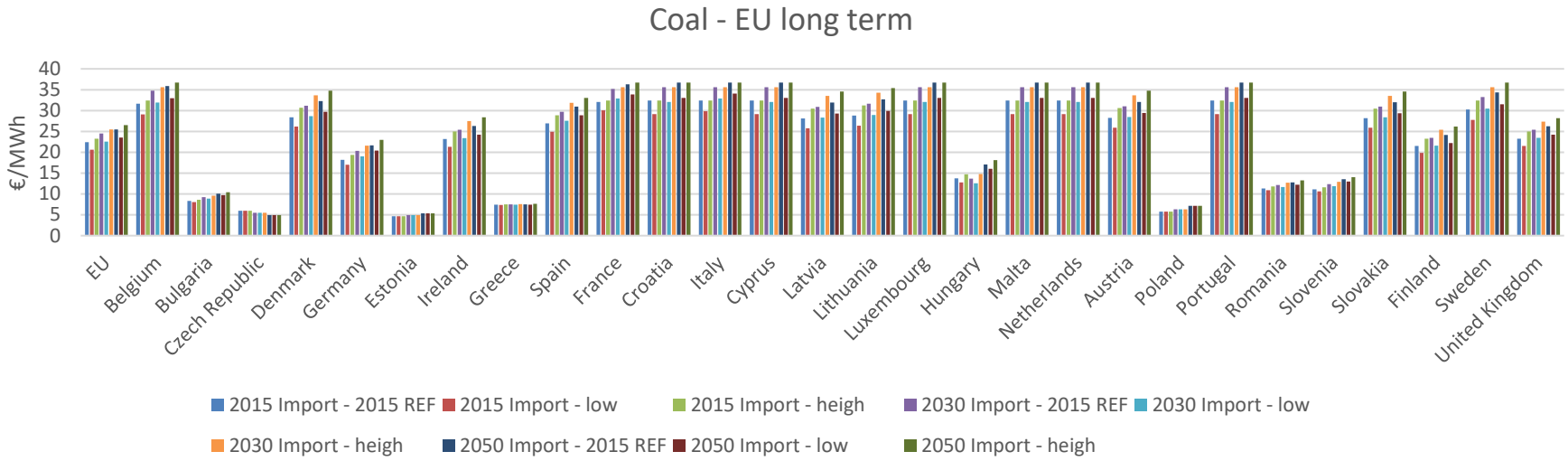

Figure 27 Coal prices for the EU long term scenario

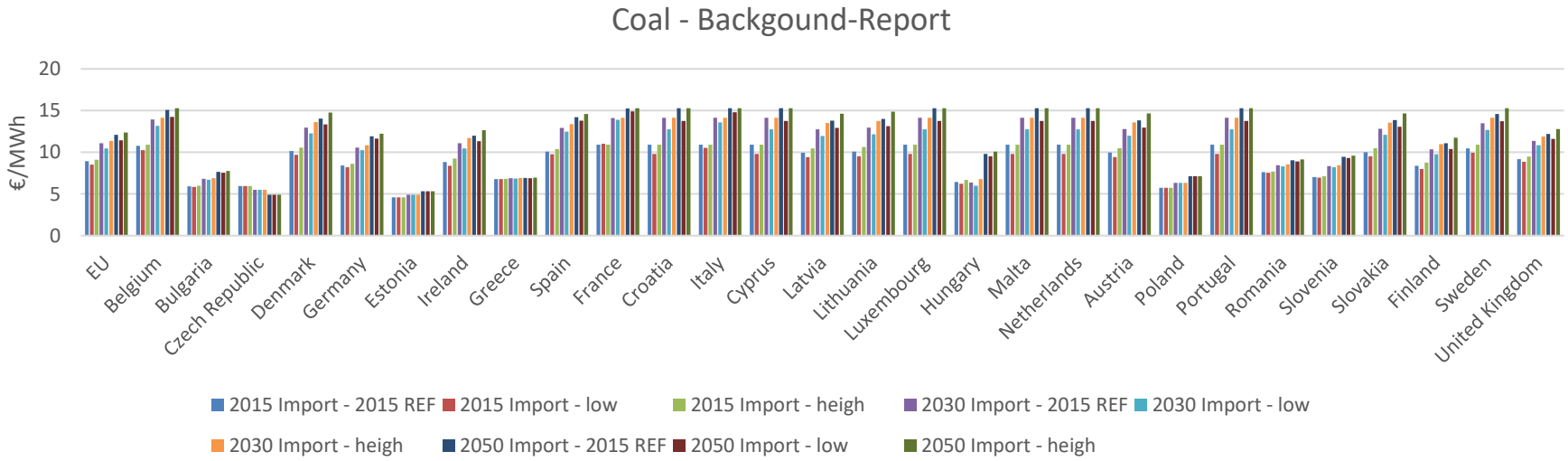

Figure 28 Coal prices for the Background-report scenario

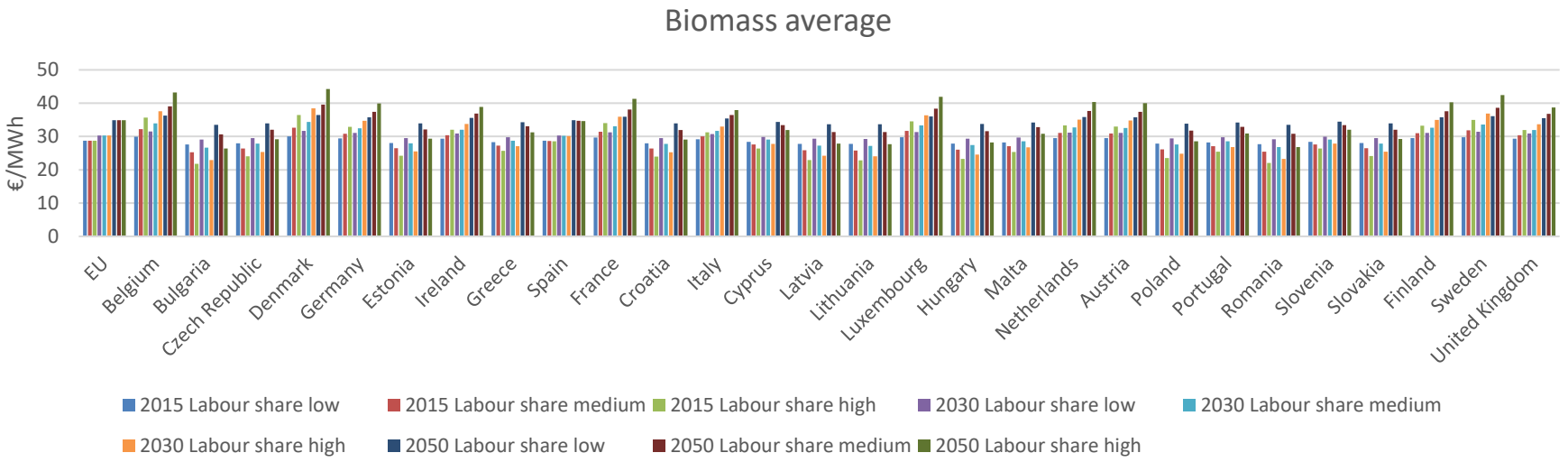

Figure 29 Average biomass prices

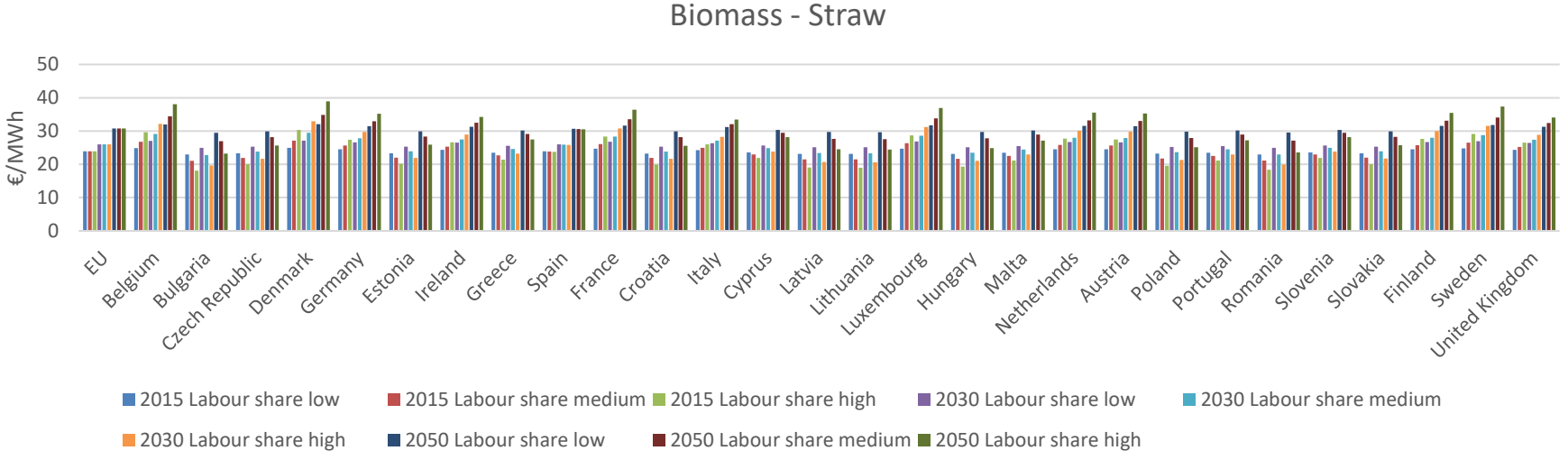

Figure 30 Biomass – straw prices

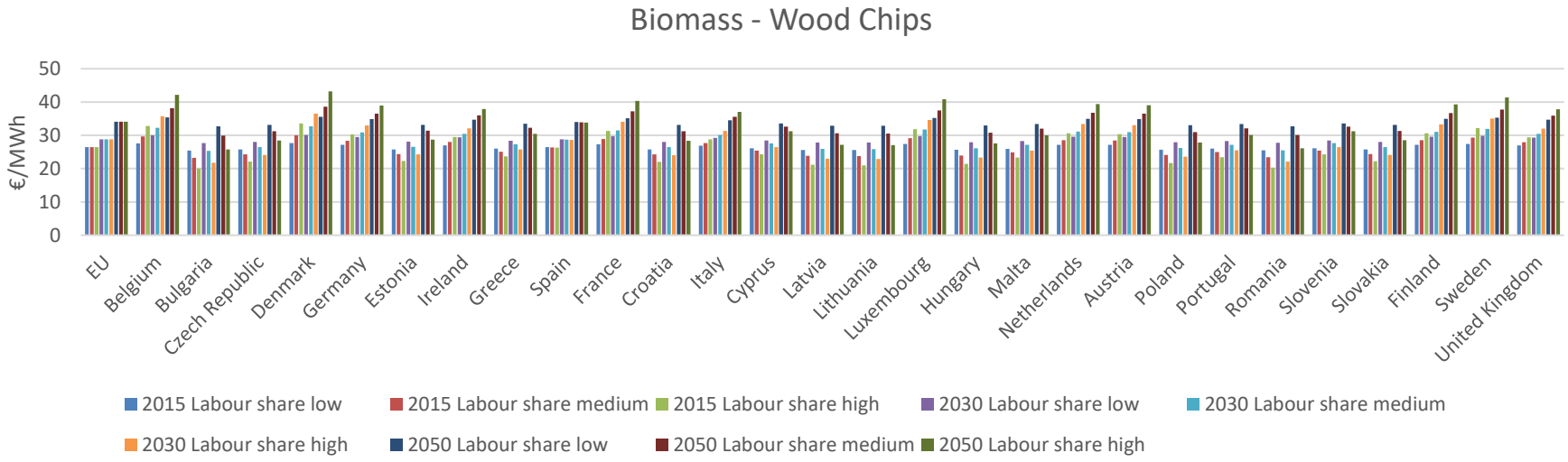

Figure 31 Biomass – wood chips prices

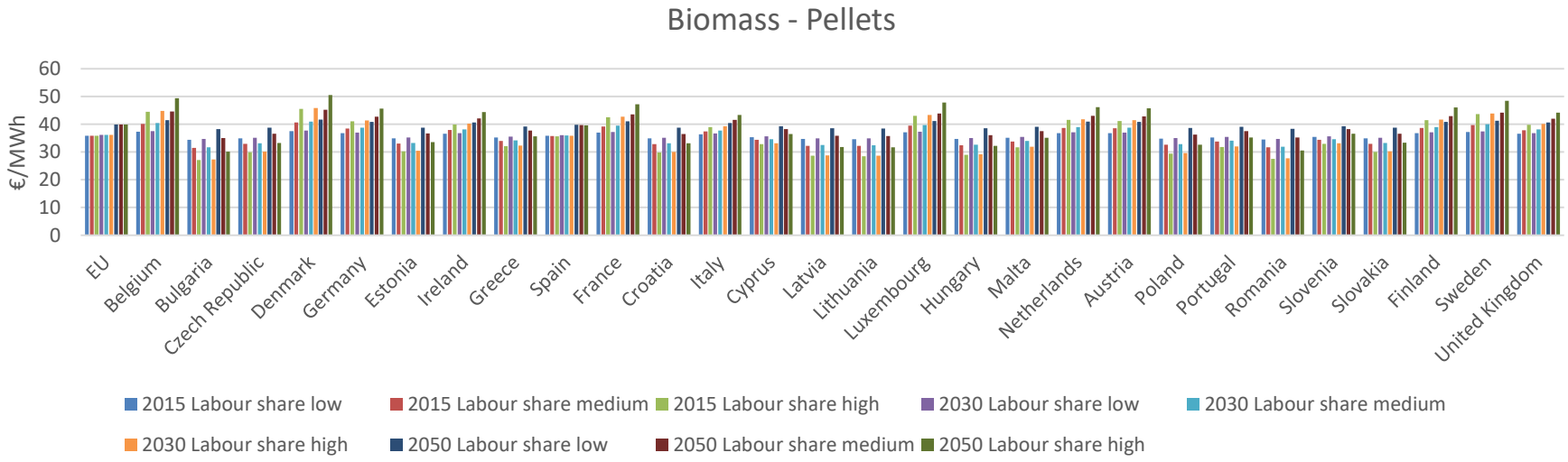

Figure 32 Biomass – pellets prices

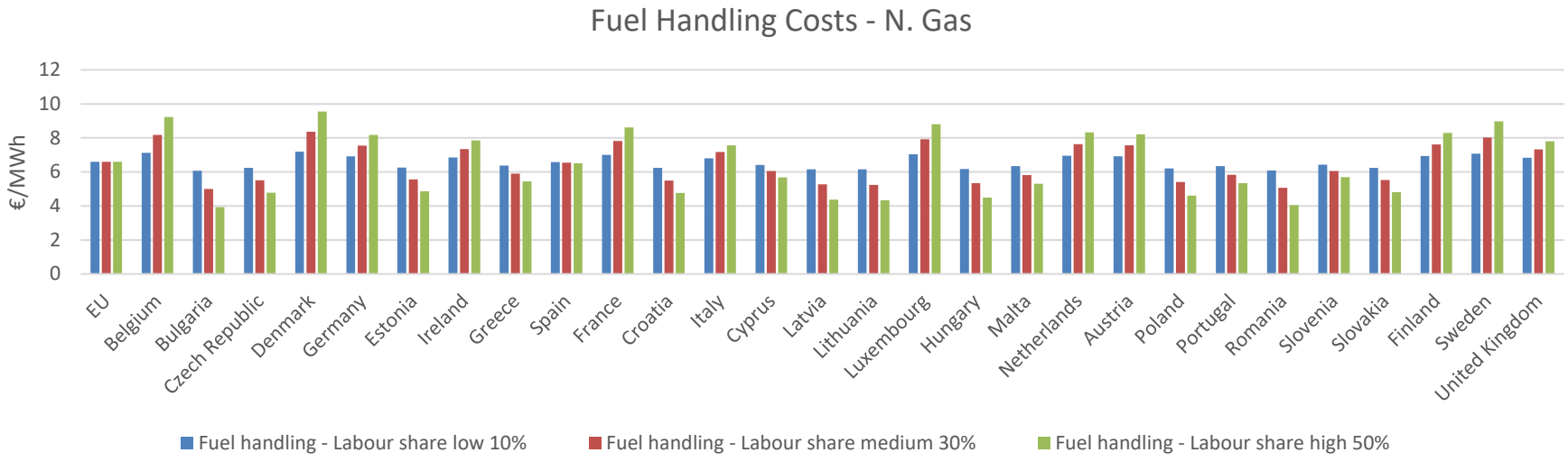

Figure 33 Fuel handling prices – Natural gas

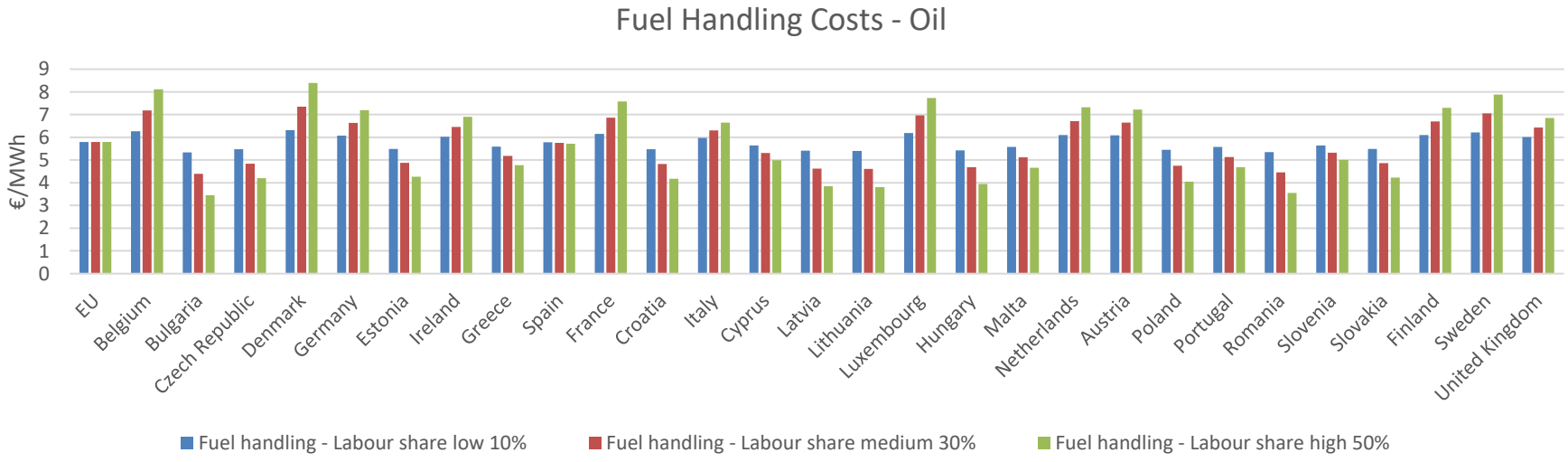

Figure 34 Fuel handling prices – Oil

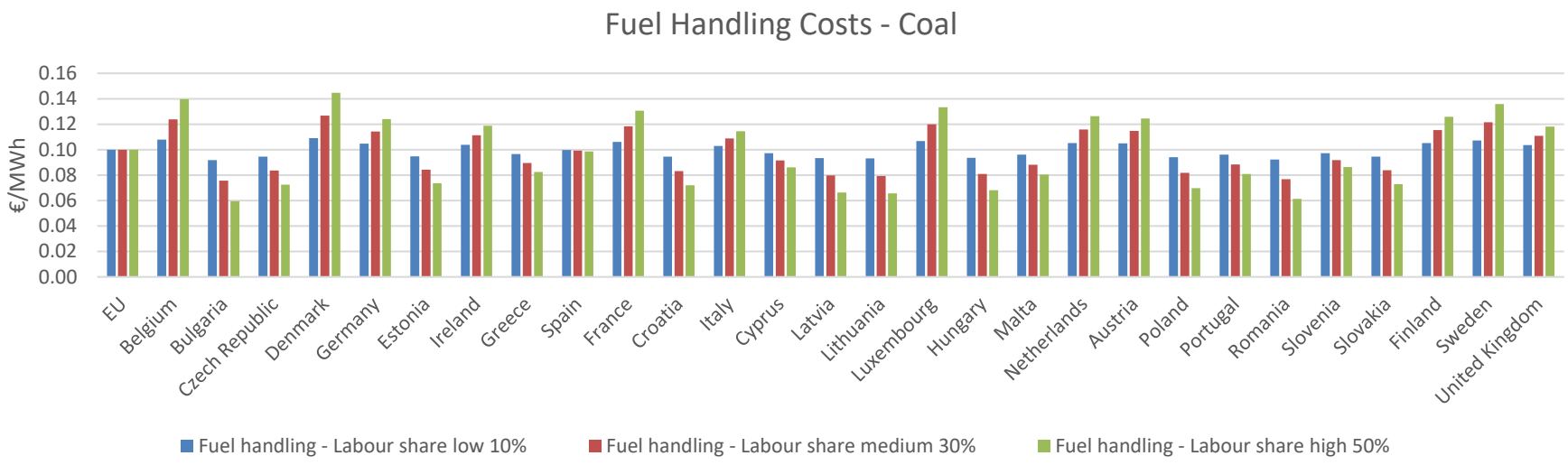

Figure 35 Fuel handling prices – Oil

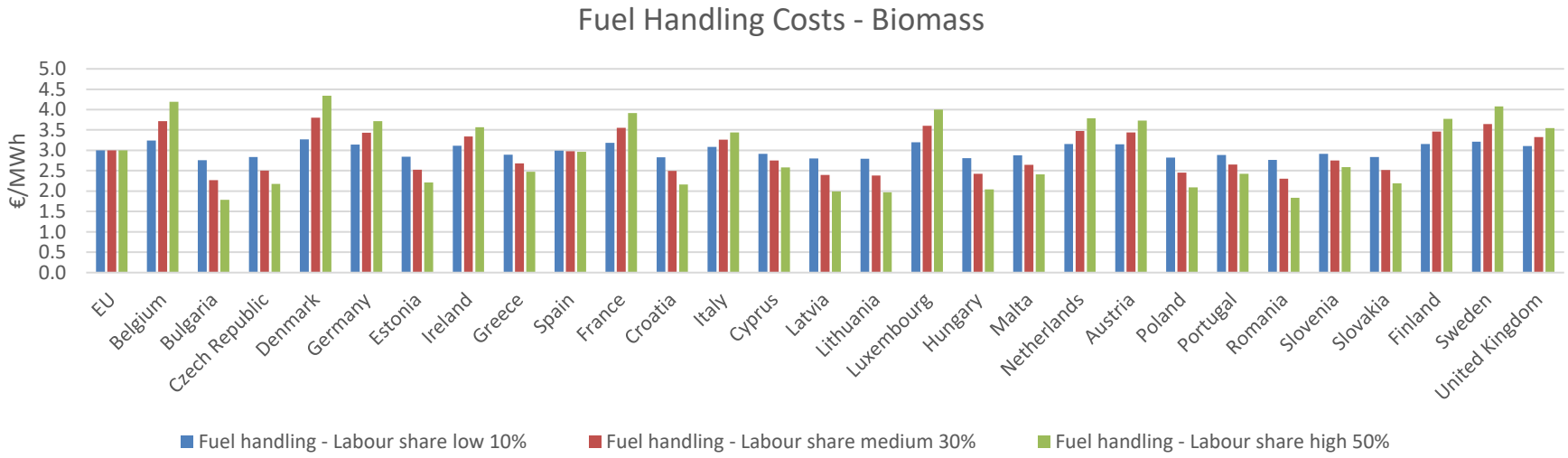

Figure 36 Fuel handling prices – Biomass

4. Conclusions

Deliverable 6.1: Future fuel price review presents the literature review and methodology used to create the assessment of current and future fossil fuel and biomass prices for the EU28 countries. Their high volatility depending on the base year, assumptions used etc. results in great differences between official predictions. This can result in variations of over 300% at times, as demonstrated by prices published in IEAs World Energy Outlook reports from various years. Additionally, it is especially difficult to obtain consistent price predictions on a national level due to different methodologies and datasets used.

For the reasons mentioned above, a methodology based on the extraction and import prices, import dependencies and labour costs has been developed and implemented using a wide variety of datasets. The end result of the analysis includes 8 fossil fuel scenarios, with 3 sub-scenarios each, for natural gas, oil and coal and three scenarios for biomass (average biomass prices), straw, wood chips and wood pellets per country. This results in a total of 84 fuel and biomass price datasets per country for the years 2015, 2030 and 2050. All prices are given in €/MWh adjusted for inflation to 2015 levels.

In order to enable separate analysis of fuel and fuel handling prices, both were analysed separately. In addition to the above mentioned fuel prices, 3 sets of scenarios have been created for natural gas, oil, coal and biomass handling per country.

The presented methodology and results give a broad range of price predictions for the period from 2015 to 2050 for each of the EU28 countries in a mutually comparable way. The analysis is based on data published in several documents deemed most relevant and complete to ensure maximum validity and consistency while still providing flexibility and as broad an overview as possible. The analysis has been concluded with a total of 96 datasets per country for fossil fuels, biomass and fuel handling.

5. References

[1] International Energy Agency, *World Energy Outlook 2002*. 2002.

[2] International Energy Agency, *World Energy Outlook 2004*. 2004.

[3] International Energy Agency, *World Energy Outlook 2006*. 2006.

[4] International Energy Agency, *World Energy Outlook 2008*. 2008.

[5] International Energy Agency, *World Energy Outlook 2010*. 2010.

[6] International Energy Agency, *World Energy Outlook 2012*. 2012.

[7] International Energy Agency, *World Energy Outlook 2014*. 2014.

[8] International Energy Agency, *World Energy Outlook 2016*. 2016.

[9] OECD, "Inflation (CPI)," *Organisation for Economic Co-operation and Development*, 2017. [Online]. Available: https://data.oecd.org/. [Accessed: 15-Nov-2017].

[10] ECB, "Euro foreign exchange reference rates," *European Central Bank*. [Online]. Available: https://www.ecb.europa.eu/. [Accessed: 15-Nov-2017].

[11] S. Simoes *et al.*, *The JRC-EU-TIMES model. Assessing the long-term role of the SET Plan Energy technologies*. JRC, 2013.

[12] B. Pfluger, F. Sensfuß, G. Schubert, and J. Leisentritt, *Tangible ways towards climate protection in the European Union (EU Long-term scenarios 2050)*. Fraunhofer ISI, 2011.

[13] Energistyrelsen, *Baggrundsrapport til Basisfremskrivning 2017*. Danish Energy Agency, 2017.

[14] European Comission, "Roadmap for moving to a competitive low carbon economy in 2050," 2011.

[15] "Eurostat." [Online]. Available: http://ec.europa.eu/eurostat/. [Accessed: 05-Oct-2017].

[16] D. Connolly *et al.*, *Heat Roadmap Europe 2050*. Euroheat & Power, 2012.

[17] C. Bang, A. Vitina, J. S. Gregg, and H. H. Lindboe, *Analysis of biomass prices - Future Danish prices for straw, wood chips and wood pellets "final report."* Ea Energy Analyses, 2013.

[18] Eurostat, "Labour costs in the EU," 2017.

[19] P. Ruiz, A. Sgobbi, W. Nijs, F. D. Longa, and T. Kober, *The JRC-EU-TIMES model. Bioenergy potentials for EU and neighbouring countries*. JRC, 2015.

[20] K. Grave *et al.*, *Prices and Costs of EU Energy - Final report*. Ecofys, 2016.

[21] Ea Energy Analyses A/S, "Welfare economic prices of coal, petroleum products and natural gas," 2014.

6. Appendices

6.1. Appendix 1 – fossil fuel prices

https://heatroadmap.eu/wp-content/uploads/2020/01/HRE_D6.1_Appendix_1.xlsx

6.2. Appendix 2 – biomass prices

https://heatroadmap.eu/wp-content/uploads/2020/01/HRE_D6.1_Appendix_2.xlsx

6.3. Appendix 3 – additional biomass prices

https://heatroadmap.eu/wp-content/uploads/2020/01/HRE_D6.1_Appendix_3.xlsx

6.4. Appendix 4 – fuel handling prices

https://heatroadmap.eu/wp-content/uploads/2020/01/HRE_D6.1_Appendix_4.xlsx