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Non paper on complementary economic modelling undertaken by DG ENER analysing the impacts of overall renewable energy target of 45% to 56% in the context of discussions in the European Parliament on the revision of the Renewable Energy Directive

Modelling analysis

This non-paper presents the results of a modelling analysis that examines the impacts of higher shares of renewable energy in the EU27 in 2030. The results will be compared with the modelling results in the Impact Assessment underpinning the proposal for a revision of the Renewable Energy Directive (RED) (2021/0218(COD)), published in July 2021. This non-paper also complements the analysis done in staff working document supporting the REPowerEU plan (SWD/2022/230).

Further to the request of the European Parliament's ITRE coordinators, this non-paper analyses impacts for the EU of the renewable energy shares of 45%, 50% and 56% in the energy mix in 2030, achieved with efforts taken across the relevant sectors, such as electricity, heating and cooling, transport.

This non-paper compares the following scenarios:

- Fit-for-55 **(Ff55)**, achieving the 2030 targets adopted by the Commission in the Fit-for-55 package, namely 40% for the renewable energy share and 9% for energy efficiency;
- Fit-for-55 **(Ff55 high prices)** with high fossil fuel prices, reflecting the recent prices increases and assuming significantly higher future prices compared with previous assumptions;
- A scenario modelling the REPowerEU **(RPE)** context, i.e. implementing the REPowerEU Plan of 18 May 2022 (see below for details), achieving 45% renewable energy and 13% energy efficiency which aims to phase out Russian gas by 2027;
- The RPE context and a fixed 50% renewable energy target in 2030 **(RPE50)**;
- RPE context and a fixed 56% renewable energy target in 2030 **(RPE56)**.

1. INTRODUCTION AND POLICY CONTEXT

Russia's unprovoked and unjustified military aggression against Ukraine, has massively disrupted the world's energy system. It has caused an increase in energy prices and heightened energy security concerns, bringing to the fore the EU's over-dependence on gas, oil and coal imports from Russia and leading to the REPowerEU plan and its initiatives.

Although it is difficult to make projections for fossil fuel prices for the next years, in particular given the current exceptional volatility, price assumptions have been updated on the best available knowledge, compared with the price trajectories used in 2021, for the modelling of the Fit-for-55 package impacts.

The price trajectories used in the modelling analysis of this non-paper are the same to those used for the REPowerEU plan[1] and illustrate a significant increase in the fuel prices for the period until 2030 (see table in Annex I). Higher energy prices trigger more renewable energy investments and enable more investments in energy efficiency in the medium- and long-term as the payback period of these investments is reduced. Renewable electricity is already competitive with fossil fuels, and, given today's high gas prices, bio-methane and green hydrogen are also becoming competitive[2].

[1] See also the Annex of the SWD(2022) 230 final.

[2] https://www.irena.org/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_Hydrogen_breakthrough_2021.pdf?la=en&hash=40FA5B8AD7AB1666EECBDE30EF458C45EE5A0AA6

Also, the new scenarios were carried out in the RPE context. Apart from assuming higher energy prices, including in the mid- to long-term, the RPE scenarios differ from the 2021 Fit-for-55 scenarios in two ways. They include:

1) the RPE measures announced in the March Communication "REPowerEU: Joint European Action for more affordable, secure and sustainable energy"[3];

2) full phasing out of Russian fossil fuels, including gas by 2027.

These adaptations led the REPowerEU scenario to achieve a higher level of renewable share – 45% (as well as the energy efficiency level) than the Fit-for-55% scenarios.

The two additional scenarios reaching 50% and 56% RES shares were developed with these levels as targets (RPE50 and RPE56 respectively), but no further constraints or assumptions on top of the RPE context were introduced within the model. It should be noted that higher energy efficiency levels achieved in these scenarios were not prescribed via a specific target or an assumption, but resulted from the modelling. This allows for an effective comparison and provides insights in the cost optimisation of the different resources and renewable technologies reducing primary energy consumption. For example, higher renewable energy targets encourage greater use of heat pumps and electric vehicles, which also benefit energy efficiency.

Higher shares of renewable energy also bring other co-benefits, such as lower exposure to volatile international fossil fuel prices, less dependence on energy imports and thus higher energy security, lower GHG emissions, and can also lead to lower air pollution and, when sourced sustainably, natural resources depletion. Furthermore higher investments and measures that support renewable energy deployment will reduce the negative impacts of higher fossil fuel prices on energy system costs and household expenditures. While there would be no significant impact on net employment green jobs would be created thanks to higher investments in clean energy technologies.

Implementation of the full Fit-for-55 package would lower the EU's gas consumption by 30% (equivalent to 116 bcm) by 2030. More than three quarters of this would come from measures related to renewable energy pulled by the increased overall targets and measures in industry, buildings sector and production of bio-methane and renewable hydrogen. More details on the impacts on the demand sectors and renewable fuels are included in Annex II.

Research and innovation is crucial to achieve the EU renewable target for 2030, in particular in the transport sector where the role of innovative renewable fuels such as hydrogen and synthetic fuels as well as advanced biofuels will be crucial.

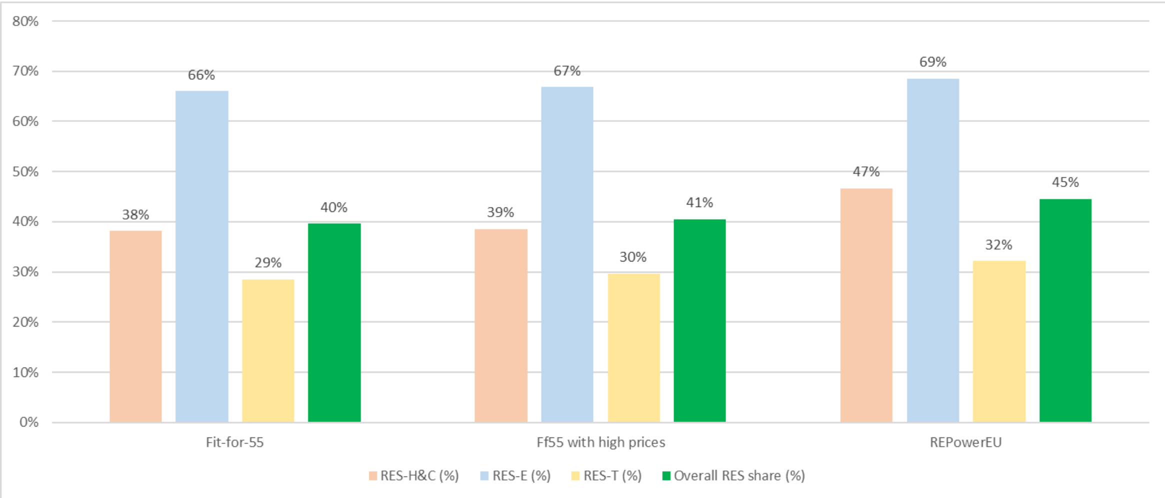
2. IMPACTS OF HIGHER RENEWABLE ENERGY TARGETS

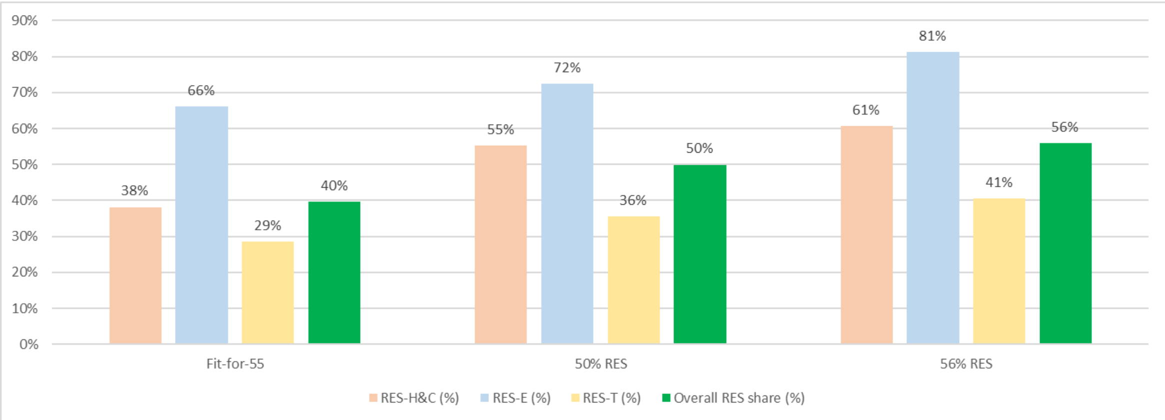
(a) Evolution of renewable energy across sectors

Higher renewable targets are achieved by efforts spread across sectors: power (RES-E), heating and cooling (RES-H&C) and transport (RES-T).

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

Figure 1: Sectoral and overall RES shares in 2030

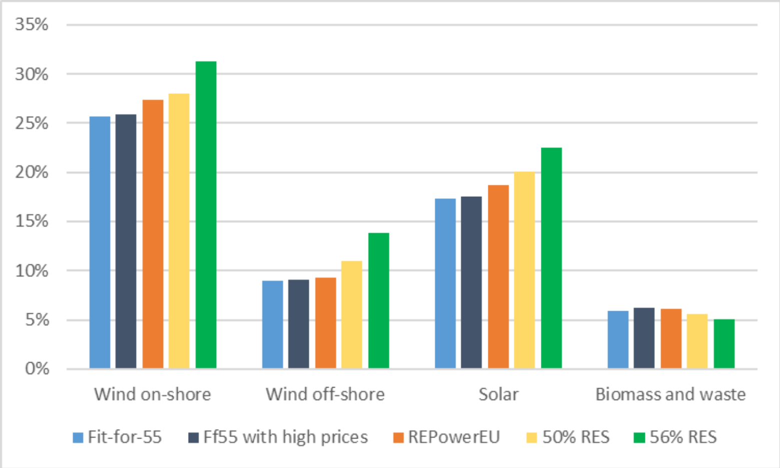




Higher ambition drives stronger electrification of the economy. Net power generation in 2030 increases by 7-8% in the RPE50 and RPE56 scenarios compared to Ff55. Higher targets lead to an increase in the use of wind (both onshore and offshore) and solar in the electricity mix. In 2030, wind and solar represent 55% of electricity generation in the RPE scenario, 59% in the RPE50 scenario, and 68% in the RPE56 scenario, compared with 52% in the Ff55 scenarios (53% in the Ff55 high prices). The biomass share is stable across all scenarios, at around 5-6% of electricity generated.

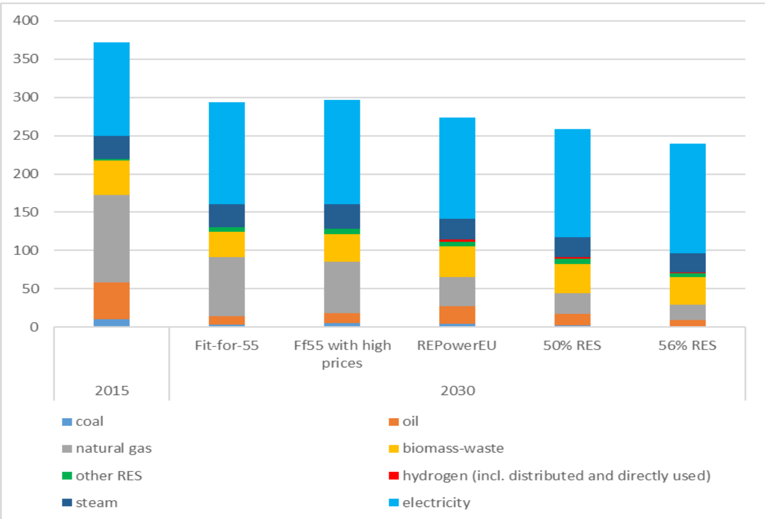
Figure 2 illustrates the changes in the shares of these renewable generation technologies, compared with Ff55. In the RPE50 and RPE56 scenarios, installed capacity, compared to the RPE scenario, is higher for wind by 43 GW and 146 GW and for solar by 67 GW and 157 GW respectively. This would lead to total renewable capacities of around 1350 GW and 1540 GW in 2030.

Figure 2: Shares of selected RES technologies in power generation in 2030 in the different scenarios (%)



In the **buildings** sector, especially households, heat pumps deployment is a key contributor to combined renewable energy and energy efficiency efforts. Renewable energy produced by all types of heat pumps for heating and cooling significantly increases with the level of ambition compared to the Ff55 scenario in 2030. Electrification is driven by rapid deployment of electric heating, most notably heat pumps, leading to efficiency gains in production and further integration of variable renewable electricity. In 2030, compared with Ff55, electrification in households[4] increases by 21 p.p. in the RPE50 scenario and to 27 p.p. in the RPE56 scenario. The number of heat pumps is 22% and 37% higher respectively in the RPE50 and RPE56 scenarios.

Figure 3: Final energy consumption in buildings (households and services) by fuels (Mtoe)

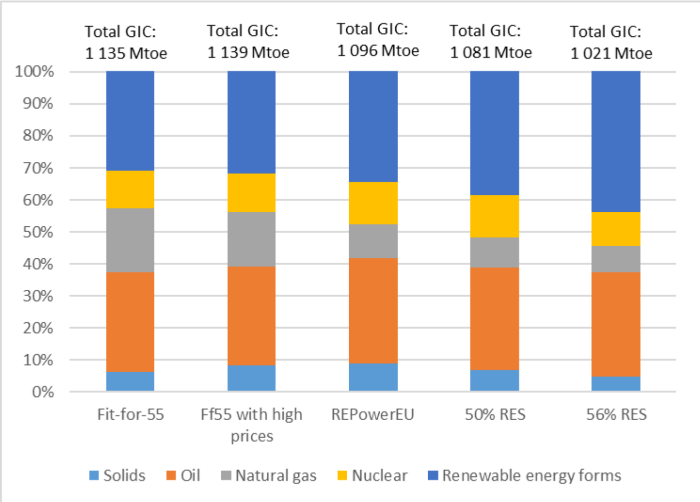


On the **transport** side, the growth in electrification and uptake of advanced biofuels, are notable trends across all scenarios. Both additional advanced biofuels and the share of renewable fuels of non-biological origin in transport increase or remain consistent in the scenarios (see Annex II).

[4] Defined as the share of electricity in households' final energy consumption.

Figure 1Figure 4 below illustrates how renewables substitute notably natural gas in the energy mix in the scenarios with higher renewable ambition.

Figure 4: Energy mix in 2030 across scenarios (% by fuels, total GIC in Mtoe)



(b) Investments

Compared to Ff55, the scenarios show significant additional investments: the average annual **investment expenditures** on energy, excluding transport, are 5% (or EUR 24bn[5]/year) higher in the RPE scenario, 15% higher in the RPE50 scenario (EUR 69bn/year) and up to 30% higher in the RPE56 scenario (EUR 141bn/year). These significant additional investments are even higher when compared to the Reference scenario used as the baseline in the 2021 IA for the proposal of the RED revision[6]. In this case, the increase in investments per year is EUR 201bn for the RPE50 scenario (+59%) and EUR 273bn for the RPE56 scenario (+80%). In addition to this investments challenge, the radically increased RES ambition would also face bottlenecks in skilled workforce, supply chains issues and cash flow constraints. The latter, alongside with inflation across the economy, are likely to translate to higher overall costs, including via increased cost of capital. Figure 5 illustrates that investments in the supply side (power generation and power grids) increase relatively more than in the demand side (residential and tertiary sectors).

Figure 5: Total average annual investment expenditures across sectors and scenarios (2021-2030, EUR22bn)[7]

[5] All monetary figures are expressed in EUR 2022.

[6] The reference scenario reached 33% of RES share in 2030.

[7] Some measures of the REPowerEU Plan as reported in the SWD of May 2022 (SWD(2022) 230) such as gas infrastructures (*e.g.* LNG terminals and pipeline corridors) are not covered by the investment figures from modelling projections reported here.

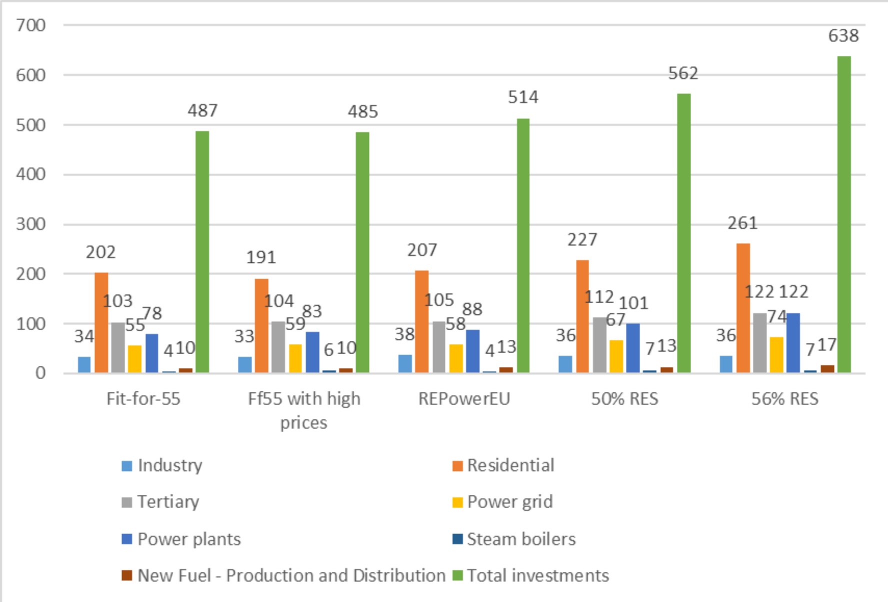
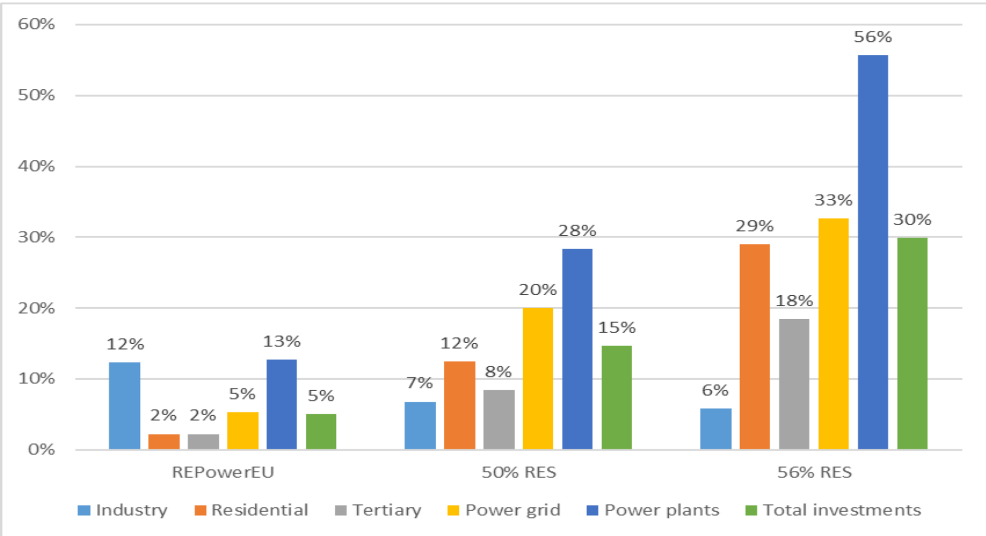


Figure 6: Increase in annual investment expenditures across sectors and scenarios compared to Fit-for-55 (%)



(c) Impacts on energy system costs

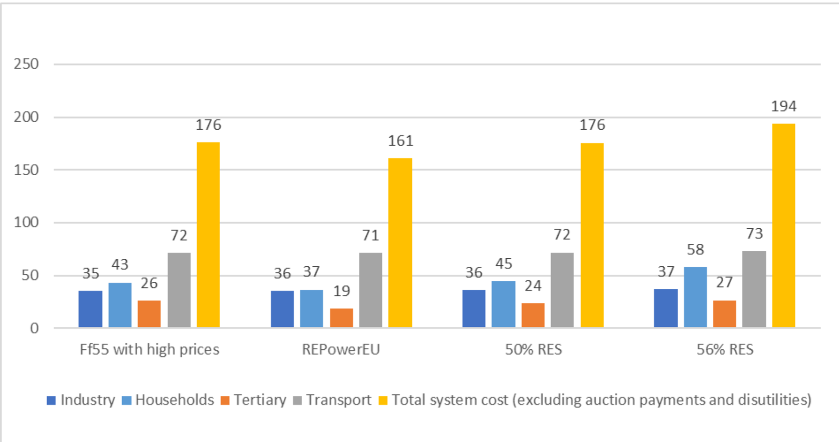
Over the period 2021-30, total **energy system costs** are higher in the RPE scenario by EUR 161 bn (+9%) compared to Ff55 (

Figure 7). The RPE50 and RPE56 scenarios bring this difference up to EUR 176 bn (+10%) and EUR 194 bn per year (+11%), respectively. However, this is almost totally due to increased international energy prices: when comparing with the Ff55 high prices scenario, differences are small at respectively -1%, 0% and +1%, notably because higher renewables allow to reduce fossil fuel costs. In other words, an increase of the renewable energy target to 45% would reduce the overall energy system costs by 1% compared to Ff55 with high prices. Nonetheless, as underlined in the previous section, the 50% and 56% cases translate into significantly higher investment costs and the necessity of a very high and sustained pace of annual installation rates up to 2030.

Important drivers of costs increases are investments in the residential sector and in power generation (power plants). These are higher by respectively EUR 59 bn and EUR44 bn annually in the RPE56 scenario compared with Ff55 in the period 2021-30. The costs for households are slightly lower in the RPE scenario than in the Ff55 high prices, and the same apply to the tertiary in the RPE and RPE50 scenarios. This can be explained by lower energy purchases and fossil fuel expenditures due to fuel switching to renewable based heating systems. Modern renewable heating systems (geothermal and air/water source heat pumps, solar thermal) do not need fossil fuel input for heating while energy consumption is limited to auxiliary energy to drive e.g. heat pumps and control systems. These manifest in positive disposable income effects from lower operating costs, reduced fuel expenditure and stable prices unaffected by global price fluctuation. While some of the renewable heat appliances require higher upfront costs, they reduce household expenditure once installed, and over their lifetime they result in significant savings and increased disposable income which are more nuanced with high prices.

In relative terms, differences in annual energy system costs for the decade 2021-2030 are the highest in the industry sector (+14% in RPE, RPE50 and RPE56 compared to Ff55) as well as in transport (+12% in RPE, RPE50 and RPE56 compared to Ff55).

Figure 7: Increase in average annual energy system costs in the period 2021-2030 compared with Fit-for-55 (EUR22 bn)



(c) Import dependency

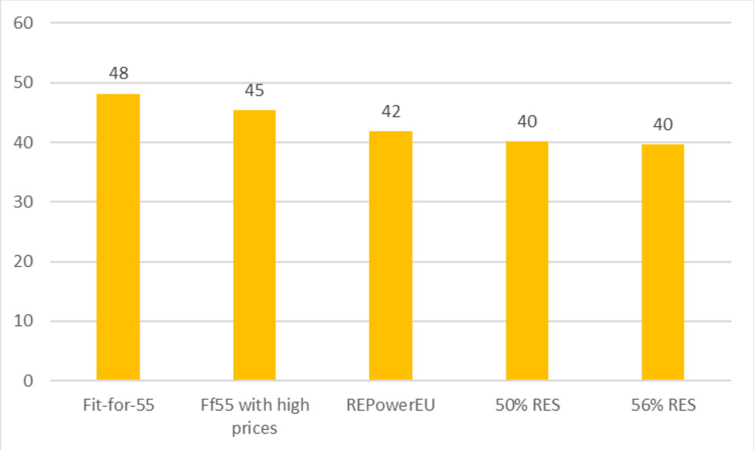
While primarily aimed at supporting the decarbonisation of the European economy, the proposal to further increase renewable energy ambition also leads to reinforced energy security. **Import dependency**[8] is projected to decrease with more ambitious renewables targets. Oil and gas imports represent 48% of primary energy supply in 2030 in Ff55, 42% in RPE and 40% in both RPE50 and RPE56 scenarios (Figure 8).

In particular, net imports of oil and gas imports are significantly lower with increased renewables ambition. In the RPE scenario, gas imports are 50% lower than in Ff55 in 2030. In RPE50 and RPE56, they are respectively 56% and 64% lower than in Ff55. When it comes to oil, net imports are lower with increased renewables ambition. In RPE50 and RPE56, they are respectively 2% and 6% lower than in Ff55.

[8] Defined as the ratio of net imports over total primary energy supply.

As a result, total import dependence also decreases with higher levels of renewables ambition, from 51% in Ff55 to 42% in the RPE56 scenario.

Figure 8: % of oil and gas imports in primary supply of energy in 2030



2. Macroeconomic impacts

An analysis was also performed to assess the macroeconomic impacts of renewable target of 45%, 50% and 56% of gross final energy consumption in 2030. Four scenarios (Ff55 high prices, RPE, RPE50 and RPE56) and one baseline scenario (Ff55) were analysed with the GEM-E3 macroeconomic model.

Ff55 high prices scenario would have a negative impact on GDP of -0.28% in 2030 compared to -0.26% in RPE scenario. In other words, in the high fuel prices context, **the model foresees a slightly improved impact of achieving 45% of the renewables share in 2030, in terms of GDP impacts, as compared to achieving 40% of RES**. However, increasing renewable ambition further accentuates the negative impact on GDP: it reduces further to -0.34% and -0.41% in the RPE50 and RPE56 scenarios.

The RPE scenario has a slightly positive impact on the trade balance compared to Ff55, with a decrease in exports (-0.48% compared to Ff55 in 2030), but a higher decrease in imports (-0.94%). When compared with Ff55 high fuel prices, the impact of the RPE scenario is limited with a decrease of 0.2% for both imports and exports. The positive impact is higher in RPE50 and RPE56, as the decrease in imports is almost twice as large as the decrease in exports.

The impact of RPE on overall investments is negligible, with a decrease of 0.3% compared to Ff55, similar to what is observed when moving from Ff55 to Ff55 high prices. The more ambitious scenarios lead to further decline in investments, which are lower by 0.6% in the RPE56 scenario compared with Ff55.

At the sectoral level, we note large negative impacts on domestic production in gas and gas extraction and positive economic impacts on sectors such as biomass, ethanol, EV transport equipment, batteries, equipment for wind power technology and PV panels, and very significant positive impacts on the hydrogen sector (+155% in the RPE compared with Ff55, +129% compared with Ff55 high prices).

There is a limited contraction of **employment** of a similar magnitude in all scenarios, with a decrease of employment of 0.23%-0.25%, showing that phasing out Russian gas can be achieved without negative job impact. This suggests that the negative impact is more caused by high fuel prices rather than by moving to the 45% RES target. The impacts are linked to those on GDP described above and are also affected by changes in the sectoral composition and the labour intensity of the different sectors. A holistic set of policies is needed to address structural dependency on fossil fuel labour and to galvanise a more ambitious approach to the energy transition rather than relying solely on consumer behaviour change due to high fossil fuel prices. Furthermore, the investments in the energy transition would increase the capabilities in Europe for manufacturing clean energy equipment across their value chains, would support local employment and the re-skilling and up-skilling of the European workforce, whilst accelerating the shift to greener jobs and boosting employment.

Annex I- Detailed projections for the different scenarios for 2030

	Fit-for-55	Ff55 high prices	REPowerEU (RPE)	50% RES (RPE50)	56% RES (RPE56)
GDP (in EUR22 bn)	16 677	16 630	16 633	16 620	16 608
Population (Million)	449	449	449	449	449
Employment (in million persons)	189	189	189	189	189
Investments (EUR22 bn)	3 679	3 669	3 667	3 663	3 657
Investments as a share of GDP (%)	22%	22%	22%	22%	22%
International oil price (€'22 per boe)	84	96	96	96	96
International gas price (NCV) (€'22 per boe)	42	71	71	71	71
International coal price (€'22 per boe)	18	19	19	19	19
Carbon price ETS sectors (€'22/ t of CO2)	61	75	71	71	71
Primary energy consumption (Mtoe)	1033	1037	1006	992	931
Final energy consumption (Mtoe)	787	783	751	739	722
FEC reduction compared to 2020 baseline	-9%	-10%	-13%	-14%	-16%
Overall RES share	40%	41%	45%	50%	56%
RES-H&C share	38%	39%	47%	55%	61%
RES-E share	66%	67%	69%	72%	81%
RES-T share	29%	30%	32%	36%	41%
Net electricity generation (GWh)	3 355 183	3 412 888	3 450 049	3 584 303	3 630 225
Share of gross electricity generation (%)					
Renewables	69	70	72	75	83

Hydro	11	11	11	10	10
Wind	35	35	37	39	45
Solar, tidal etc.	17	18	19	20	23
Biomass & waste	6	6	6	6	5

Renewable energy from heat pumps (ktoe)	27 370	26 426	27 024	32 001	44 185

Total energy system costs[9] (, average annual 2021-2030, in EUR22 bn)	1802	1977	1963	1977	1995
Industry	256	292	292	293	293
Households	615	658	651	660	673
Tertiary	317	343	335	340	343
Transport	613	684	684	684	686

Average annual energy-related investment expenditures (2021-2030, EUR22 bn)					
Demand side					
Industry	34	33	38	36	36
Residential	202	191	207	227	261
Tertiary	103	104	105	112	122
Transport (investment expenditure for vehicles, vessels, etc.)	754	747	750	750	749
Supply side					
Power grid investment	55	59	58	67	74
Power plants	78	83	88	101	122
Steam boilers	4	6	4	7	7
New Fuel - Production and Distribution	10	10	13	13	17

9 excluding auction payments and disutilities

Annex II- Renewables levels across scenarios

	Fit-for-55	RPE	RPE50	RPE56
Overall RES share in 2030				
EU	**40%**	**45%**	**50%**	**56%**
Heating and cooling				
Average yearly increase for 2020-2030 at EU level	**1.5 percentage point***	**2.3 percentage point**	**3.2 percentage point**	**3.7 percentage point**
District Heating and cooling				
Average yearly increase for 2020-2030 at EU level	**2.1 percentage point**	**2.3 percentage point**	**3.4 percentage point**	**3.6 percentage point**
Buildings				
EU RES Share in Buildings in 2030 at EU level	**49%**	**60%**	**69%**	**84%**
Transport				
RES-T share in 2030 / GHG intensity reduction in transport	**28% / 13%**	**32% / 16%**	**36% / 17%**	**41% / 18%**
Share of advanced biofuels in 2030 (single-counted)	**2.2%**	**2.2%**	**2.8%**	**4%**
Share of RFNBOs in 2030 (single counted)	**2.6%**	**5.7%**	**5.7%**	**5.7%**
Biomethane production beyond the transport sector	**18 bcm**	**35 bcm**	**35 bcm**	**35 bcm**
Industry				
RES share in industry -	**1.1 percentage points**	**1.9 percentage point**	**2.2 percentage point**	**2.4 percentage point**

Average yearly increase for 2020-2030 at EU level				
RFNBOs in industry	**50% of hydrogen consumed in industry is renewable**	**78% of hydrogen consumed in industry is renewable**	**78% of hydrogen consumed in industry is renewable**	**78% of hydrogen consumed in industry is renewable**

** for the purpose of the RED revision proposed as part of the Fit-For-55 package, the heating and cooling target was divided into the annual minimum and top-ups*