Decisions that matter

Impact of electricity from renewable energy sources

September 2021

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STUDY PRESENTATION

Goal of the analysis

This study aims to assess the impact of electricity from renewable sources in the electricity system and national economy between 2016 and 2020, and to simulate these impacts according to the goals of the National Energy and Climate Plan 2030, as well as to analyze the additional impact of green hydrogen and new climate ambition

The scope of this study is to update the previous version published in 2019, in order to simulate the impact of renewable electricity in Portugal, considering a new political and socioeconomic context.

The National Energy and Climate Plan (NECP) 2030 was approved in May 2020 and published in its final version on July 10, 2020, consolidating national targets and decarbonization measures and confirming the prominence of the renewable electricity sector. Even before its publication, the European Commission recognized the need to increase its ambition, with the declaration of a climate emergency by the European Parliament and the alert sent to the Member States of the need for all to assume the effort of the need to respond.

In August 2020, Portugal approved the National Strategy for Hydrogen - EN-H2, taking another step towards decarbonization and placing green hydrogen as a key vector for the decarbonization of the national economy towards carbon neutrality, but with the assumption that Portugal will not increase the mirrored ambition in the NECP 2030 of 45% to 55% reduction in greenhouse gas emissions (GHG) compared to 2005.

Consolidating the goal of climate neutrality by 2050 for the European economy and society, Europe establishes the European Green Deal and the European Climate Law, also aiming for economic recovery to respond to the pandemic crisis arising from COVID-19.

On July 14, 2021, comes the Fit for 55 package designed to achieve the new European climate ambition of reducing GHG by 55% in 2030, compared to 1990.

In this panorama, this study, in addition to updating historical data for the 2016-2020 time horizon regarding the socioeconomic, environmental and energy dependence aspects for the country, as well as in the daily electricity market, also analyses the projections for 2030 considering the NECP 2030 ambition set by the government and two alternative scenarios that aim to analyze the impact of green hydrogen and the need to respond to the increased climate ambition established in the Fit for 55.

Study presentation

Goal of the analysis

The impacts are analysed according to the targets of the National Energy and Climate Plan 2030, as well as the additional impact of green hydrogen and new climate ambition on a basis of additional benefits to the socioeconomic and environmental components

The projections for 2030 were developed considering 3 scenarios:

- NECP 2030 scenario, which is discussed in chapters 5 to 7 of this document.
- Alternative Scenario – Baseline, which is based on an increase in climate ambition to 55% reduction of GHG emissions compared to 1990 and assumes a cost of H_2 in the international market of 1.4-2.0 $/kg in 2030, being in line with the sector and export goals and targets reflected in EN-H2.
- Alternative Scenario – Export, which relies on an increase in climate ambition to 55% reduction of GHG emissions compared to 1990 and assumes a higher unit value for H_2 of 3.0-3.5 $/kg in the international market, leading to a sharper increase in global demand for green H_2.

The two alternative scenarios were developed by CENSE - FCT NOVA, using the TIMES-PT model, which contemplate different volumes of green H_2 production and, consequently, different needs for additional electricity generation capacity from renewable sources.

The results of these scenarios are presented in a perspective of additional benefits to the NECP 2030 scenario, which can be found in chapter 8.

The analyzed socio-economic and market impacts encompass solely the component of electricity from renewable sources for direct generation of electricity for various uses and for consumption in electrolyzers, not introducing the impact or H_2 production chain. However, it should be added that the analysis of the environmental impact of the Baseline and Export scenarios are evaluated both in terms of the country's global emissions, as well as the emissions inherent to the energy system, reflecting the importance and impact of green H_2 in the decarbonization of other sectors.

Main impacts

The analysis carried out allowed the identification of impacts in four aspects: Economic/social impact of the sector; Environmental impact of the sector; Impact of the sector on energy dependence; Impact on the electricity market

Economic/social impact of the sector

This analysis includes the assessment of the direct contribution of the renewable electricity sector to GDP, the indirect effect on other sectors of the economy, and the employment generated directly and indirectly.

For **GDP**, the analysis shows that the contribution of RES averaged ~3.7 billion € per year for the period 2016-2020, representing around 1.9% of GDP. It is estimated that by 2030, this amount will rise to ~12.8 billion € (~5% of GDP). With the increase of renewable production resulting from green H_2 and increased climate ambition, it is estimated that it could add an additional 1.9 to 6.7 billion € per year to the total impact value on GDP by the year 2030.

Regarding **employment**, it is concluded that in 2020 the impact of the renewable production sector was ~51 thousand employees, generating a GDP per worker of ~77.2 thousand €. Between 2020 and 2030, with the realization of the additional capacity estimates, the RES is expected to generate an additional of more than 90,000 employees, reaching ~160,000 jobs in 2030. An Increased climate ambition coupled with the introduction of green H_2 could further add between 24,000 and 83,000 jobs to these estimates for 2030.

In line with these results, it is estimated that, on average, between 2020 and 2030, the annual contribution to **Social Security** will be more than 1 billion €, with an estimated of 1.6 billion € for 2030. It is estimated that green H_2 and increased climate ambition could still add between 243 and 842 million € annually to total social security contributions in 2030.

Additionally, it is estimated that in the period 2020-30, the sector will account for about 10 billion € of accumulated **IRS** contributions.

Given the expected growth, in the period 2020-30 the sector should generate a cumulative total of about 4.2 billion € with **CIT** and **Municipal Surtax**, reaching an annual value of 482 million euros in 2030. The scenarios associated with green H_2 and increased climate ambition could mean an additional 81 to 161 million annually in **CIT** and Municipal Surtax in 2030.

As regards to **VAT**, in the year 2030 it should reach about 1.9 billion € of annual net contribution (4x higher than in 2020). This amount could increase between 350 million and 1.1 billion € per year to the net VAT balance in 2030, as a result of the implementation of the scenarios related to the green H_2 and the increase in climate ambition.

Private investment in RES power plants between 2020 and 2030 is expected to amount to 20 billion €. Investments associated with green H_2 and increased climate ambition could represent an additional 4.3 to 5.4 billion € by 2030.

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Main impacts

Environmental impact of the sector

The contribution to the environment of electricity production through renewable energy is expressed in the reduction of CO_2 emissions that would have occurred if this production had been ensured through conventional sources (coal and natural gas).

From the analysis carried out, it is verified that the production of renewable energy, between 2016 and 2020, allowed to:

i. Avoid the emission of more than 76 million tons of CO_2 equivalent;

ii. Save more than 1.8 billion € with CO_2 allowances.

Between 2020 and 2030, it is estimated that the CO_2 emissions avoided with the production of renewable electricity will continue to increase reaching 25.5 million tons of CO_2 equivalent annually in 2030, with savings on the cost of allowances reaching more than 2.3 billion € in 2030, as a result of the expected increase in the price of allowances (€108/t in 2030).

In a more comprehensive perspective, the most ambitious climate scenarios analyzed aim for a 55% reduction of GHG in 2030 compared to 1990, which is equivalent to a 65% reduction for the energy system compared to 2005.

This goal represents an emissions reduction in 2030 quantified at 41.6 million tons of CO_2 equivalent compared to 2005, an additional 4.3% compared to the most ambitious scenario of the NECP 2030.

Impact of the sector on energy dependence

The impact of energy dependency was analyzed based on the quantification of the substitution effect of imported electricity and fossil fuels imports for electricity production, namely coal and natural gas, as well as the calculation of the impact of this substitution on the energy dependency ratio.

Based on the analysis carried out, it is estimated that in 2020 ~514 billion € in imports of fossil fuels for electricity production were avoided.

Between 2020 and 2030, these savings are estimated to amount to more than 19 billion euros in avoided fossil fuel imports, reaching an annual value of 2.7 billion euros in 2030.

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STRUCTURE AND MAIN RESULTS OF THE ANALYSIS

Main impacts

Due to the reduction in energy consumption with the atypical context of the pandemic, in 2020 the energy dependence reached almost 66%, with RES electricity contributing to a reduction of 12.6 p.p., however it is expected that in 2030 the dependence on imported fossil fuels will be 67%, with the contribution of RES electricity reaching more than 22 p.p..

Impact on the electricity market

The existence of electricity produced from renewable sources has an impact on different parts of electricity tariffs, highlighting in this context (i) the effect that these technologies have on the price of the daily wholesale electricity market, due to their zero or almost zero marginal cost; and (ii) the cost differentials associated with existing feed-in tariffs for some of these producers when compared to market values.

From the analysis carried out it resulted the following main conclusions:

a. If there was no renewable Special Regime Production (SRP) from a renewable source, the selling price per MWh of electricity in the Iberian daily market would have been €24 higher (on average), between 2016 and 2020;

b. Considering the cost differential of renewable SRP and its impact on the daily electricity market price, there is a positive net effect for the system, with an accumulated value of around 1.7 billion euros, between 2016 and 2020.

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STRUCTURE AND MAIN RESULTS OF THE ANALYSIS

Main impacts summary

	NECP 2030 Scenario			Additional to the green H_2 and increased climate ambition scenarios	
	2020	2025	2030	Baseline Scenario	Export Scenario
Contribution to GDP	3,940 M€	9,459 M€	12,820 M€	+1,986 M€	+6,665 M€
Job creation	50,996	119,639	160,937	+23,943	+82,842
SS Contibution	518 M€	1,212 M€	1,638 M€	+243 M€	+842 M€
CIT Contibution	249 M€	368 M€	482 M€	+81 M€	+365 M€
Private investment	118 M€	1,523 M€	927 M€	+1,648 M€	+5,444 M€
CO_2 emissions avoided	19.9 $MtCO_2$-eq	19.5 $MtCO_2$-eq	25.5 $MtCO_2$-eq		
Imports avoided	514 M€	1,965 M€	2,668 M€		

2. Penetration of RES

Primary energy consumption

Analysis of the world's evolution of primary energy consumption

The following graph shows the evolution in primary energy consumption in the world, specifying the values for each technology.

In this case:

- There is an increase in primary energy consumption for the period 2016-2019 of 4.8%. In 2020, there was the impact of the COVID-19 pandemic, which resulted in a drop in consumption of 4.2% compared to 2019;
- The high prevalence of non-renewable technologies over renewable technologies is evident;
- Regarding non-renewables, oil and its derivatives are the most representative portion, with no significant change since 2016. Coal suffered a slight decrease, while natural gas follows a growth trend;
- Renewables registered a growth of 25.4% in these 5 years. However, they still have very low values compared to fossil technologies.

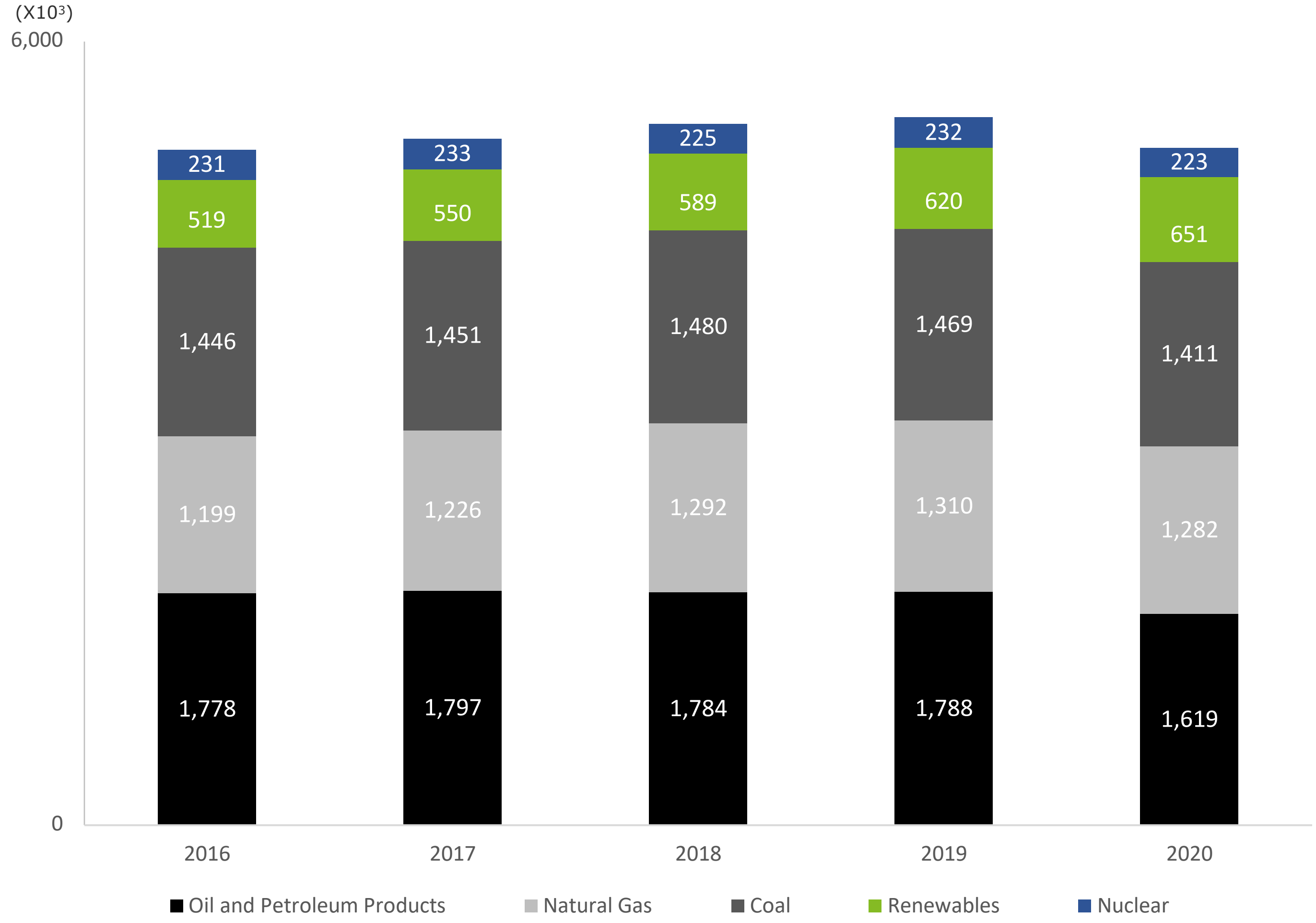

Figure 1. Primary energy consumption in the world (PWh)
Source: BP , APREN Analysis

Note – For conversion to PWh, the conversion factor provided by DGEG is used: 1 GWh = 86 tep.

PENETRATION OF RES

Primary energy consumption

Analysis of the European Union’s evolution of primary energy consumption

Analyzing the European situation regarding primary energy consumption it can be verified that:

- There is an increase in primary energy consumption between 2016 and 2017 and a reversal of this trend from that year until 2020. Again, there is a sharp drop in consumption in the last year, influenced by COVID-19;
- As in the global context, there is a high prevalence of non-renewable technologies compared to renewable ones;
- In the case of non-renewables, oil and its derivatives constitute the most representative portion. Coal has decreased significantly, while natural gas has not undergone a significant change;
- Renewables registered a growth of 10.7% in these 5 years. Again, following the global situation, the values referring to renewable technologies are still very low.

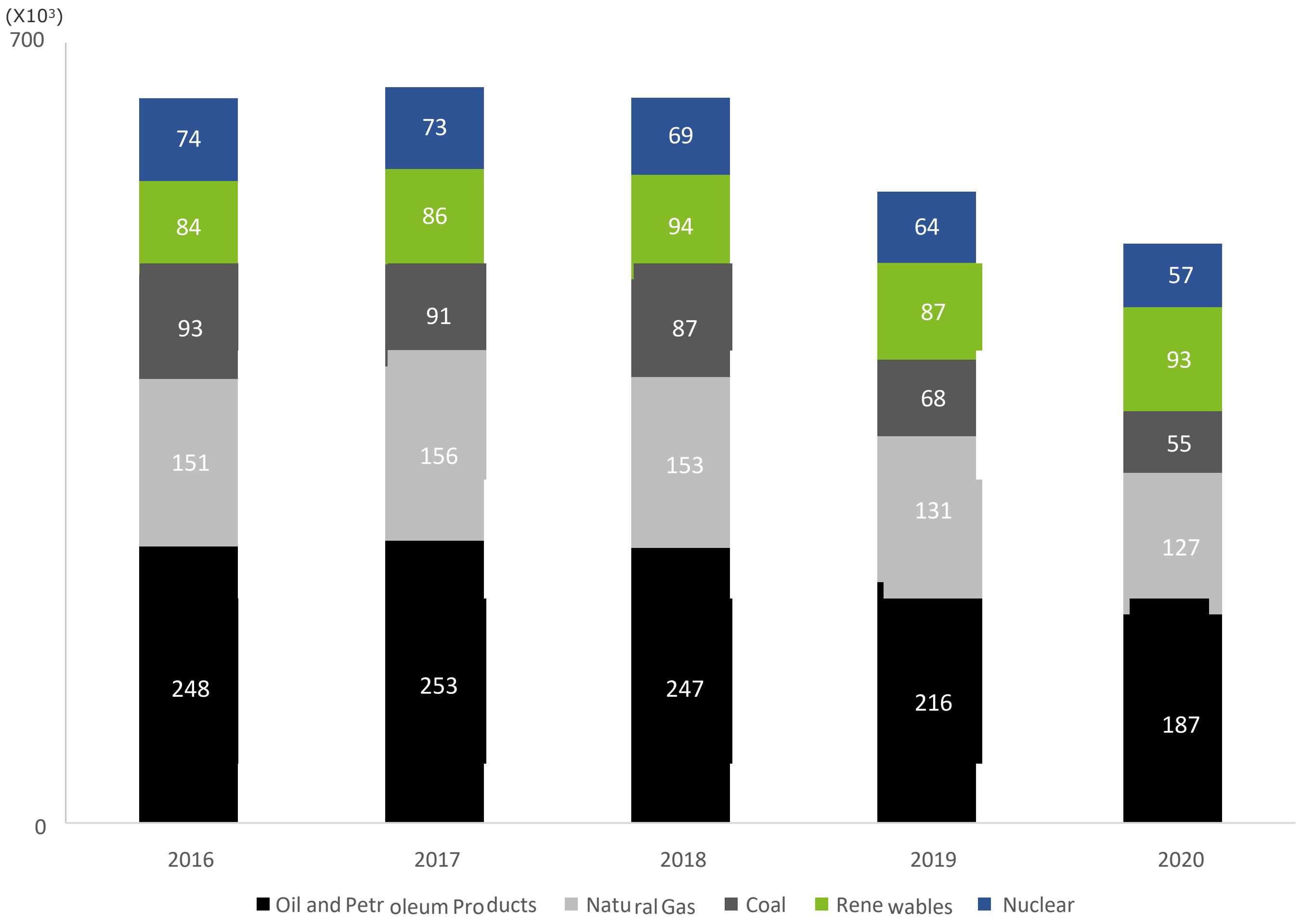

Figure 2. Primary energy consumption in the European Union (PWh)
Source: BP, APREN Analysis

Note – For conversion to PWh, the conversion factor provided by DGEG is used: 1 GWh = 86 tep.

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PENETRATION OF RES

Primary energy consumption

Analysis of Portugal's evolution of primary energy consumption

Portugal's scenario allows us to understand, in detail, the distribution of consumption, considering the different technologies. Specifically:

- There is a trend of stabilization of consumption in the first 4 years of the analysis, and there has been an increase of only 0.75% since 2016. In 2020, because of COVID-19, there was a drop in consumption, mainly in oil, coal and natural gas;
- The prevalence of non-renewable technologies in relation to renewable technologies is highlighted;
- Within non-renewables, oil and its derivatives constitute the most representative portion. Coal consumption decreased sharply between 2018 and 2020 by 79%. In reverse, natural gas follows an increasing trend, with consumption aggregated by 19.6% between 2016 and 2020;
- Renewables, as a result, have remained at the same level (with slight oscillations) in this 5-year interval, a reality that is expected to change in the current decade.

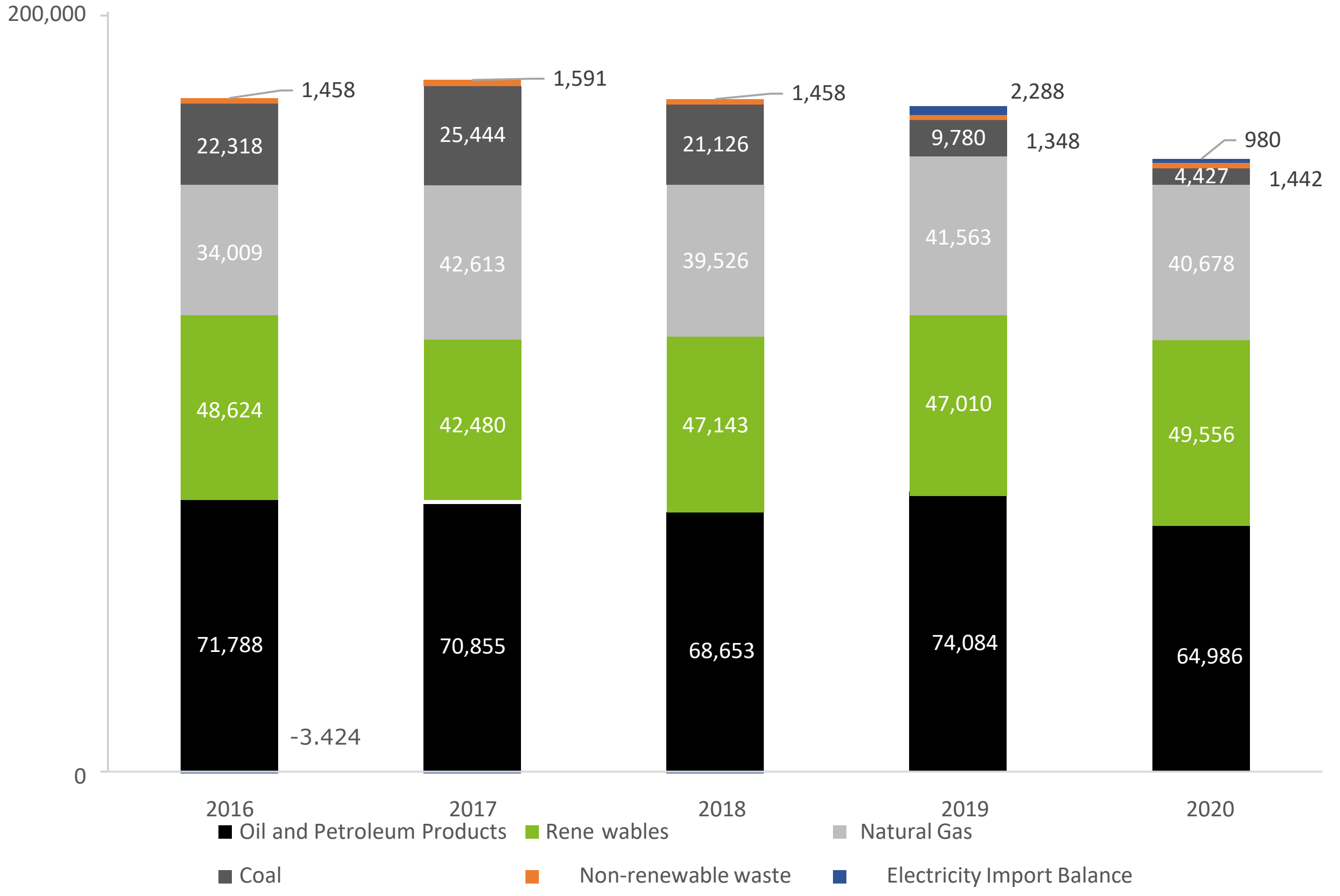

Figure 3. Primary energy consumption in Portugal (TWh)
Source: DGEG, APREN Analysis

Note - Renewables include: Wind, Biomass, Hydroelectricity, Biofuels and Heat Pumps. For the conversion to TWh is used the conversion factor provided by DGEG: 1 GWh = 86 tep.

PENETRATION OF RES

Final energy consumption

Analysis of Portugal's evolution of final energy consumption

Regarding final energy consumption, the following should be noted:

- There is a growing trend between 2016 and 2019, with a 4.2% increase in this period. The growth is transversal to all technologies (except the "Other" parameter). The impact of COVID-19 is evident in the sharp decline in 2020;
- As in primary energy consumption, the technology in focus is oil and its derivatives, with a slight increase over the years, until 2020, when a significant drop is noted. Electricity is the second that shows the highest values, with a residual growth until 2019. In 2020, it showed a value of 31,235 TWh out of 120,035 TWh, 26% of the total consumption value, a significant drop compared to 2019;
- Renewable energy (excluding renewable electricity) showed a value in the last year of 13,635 TWh out of 120,035 TWh, 11.4% of the total.

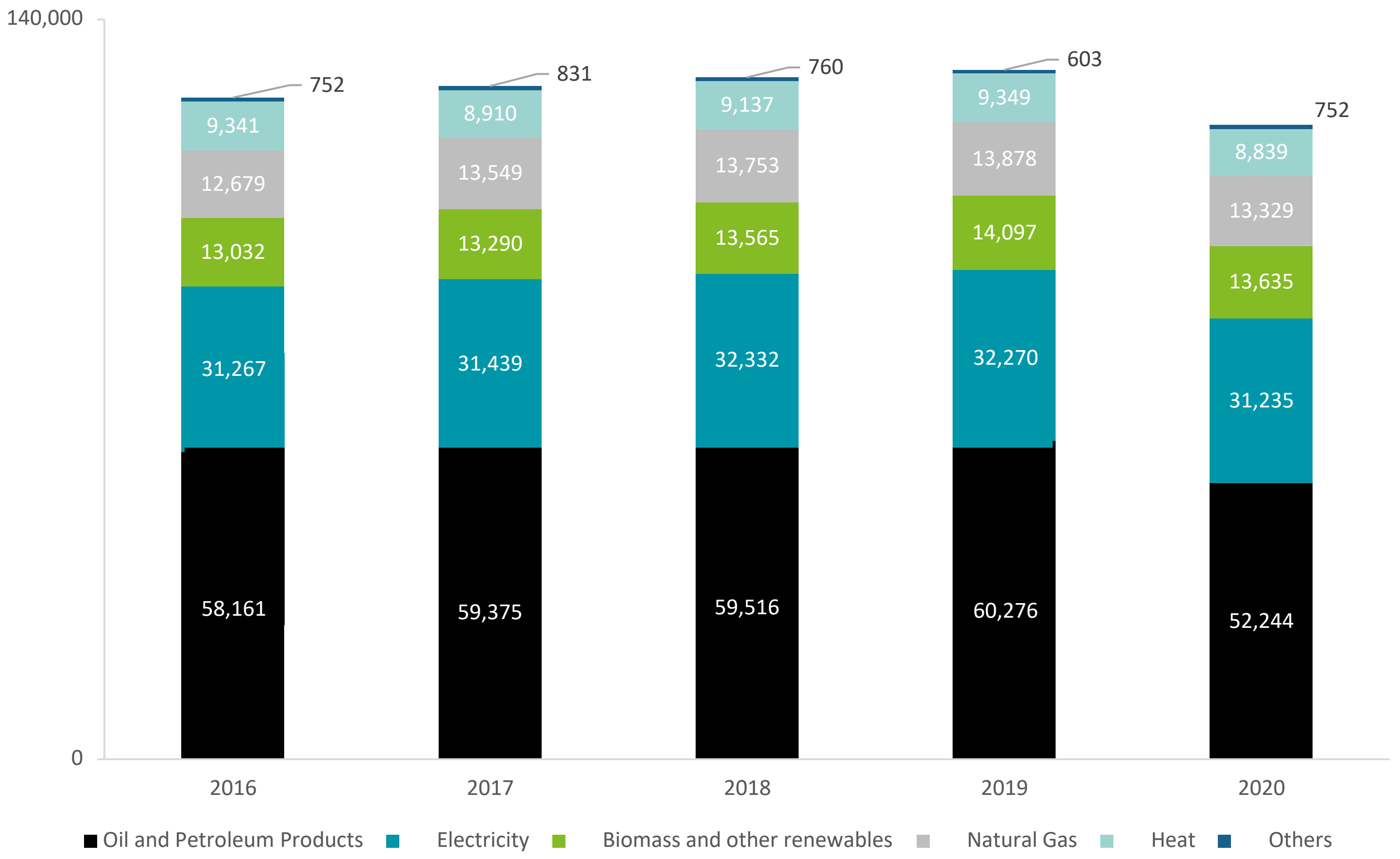

Figure 4. Final energy consumption in Portugal (TWh)
Source: DGEG, APREN Analysis

Note - Others include: Coal, Industrial Waste and Other Gases. For the conversion to TWh is used the conversion factor provided by DGEG: 1 GWh = 86 tep.

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Penetration of RES

Weight of RES on consumption

Analysis of renewable incorporation into electricity consumption, heating and cooling, transport and gross final energy consumption

The incorporation of renewable energy depends on three distinct sectors of final energy consumption: electricity, heating & cooling and transport. Therefore, it is important to highlight the following:

- From a global point of view, these parameters show a trend of stagnation in the 5 years;
- For heating and cooling and gross final consumption, from 2016 to 2019, there is a clear stagnation. In electricity there is an increase of 3.0%, including 2020;
- There is a positive evolution for transport, with an increase of 1.5% (until 2019) but, it must be noted, that in the first year of the analysis it was the element with the least renewable incorporation, only 7.6%.

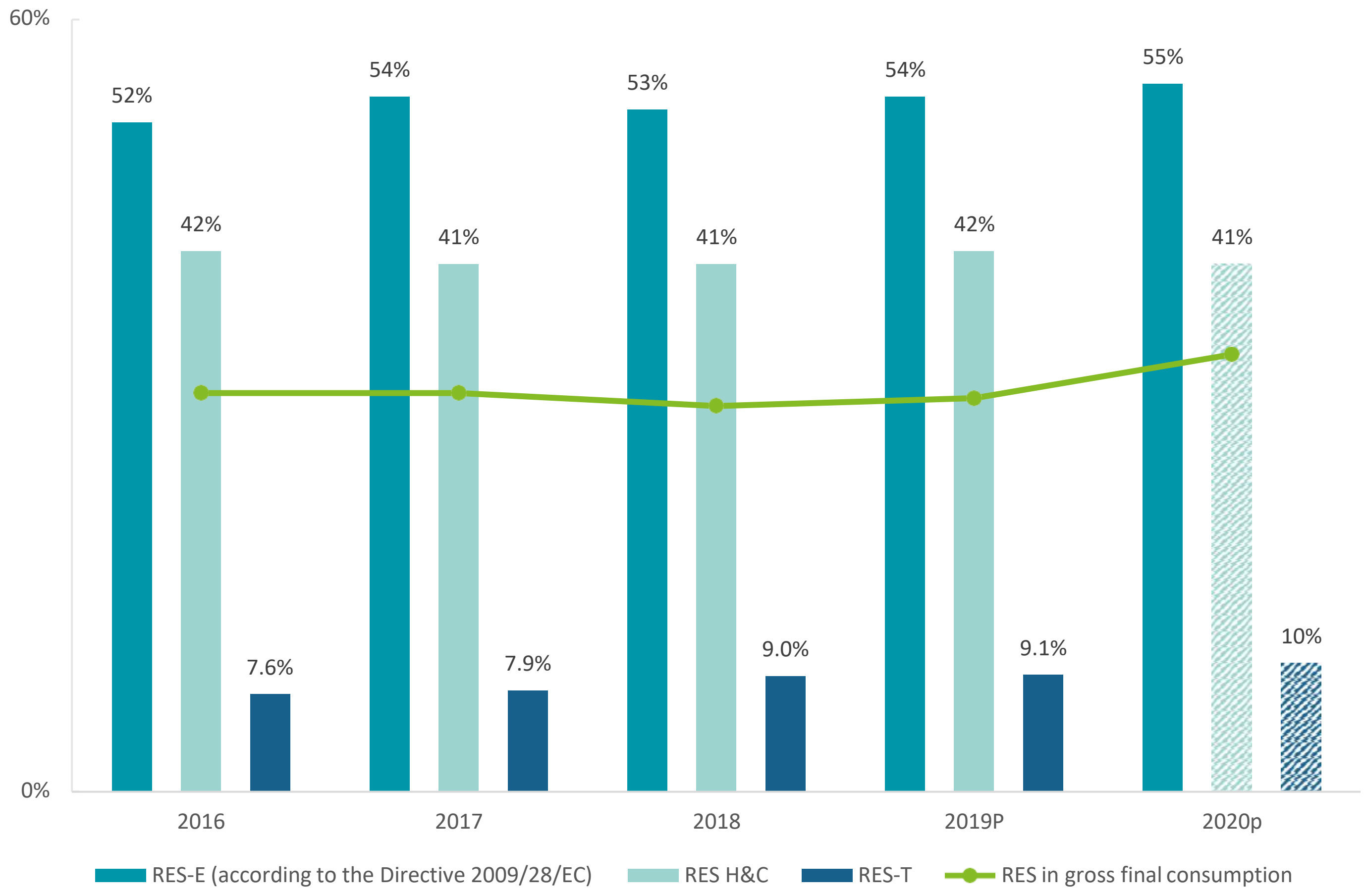

Figure 5. Renewable incorporation into electricity consumption, heating and cooling, transport and gross final energy consumption

Source: DGEG, APREN Analysis

Note: The values for heating and cooling and transport in 2020 are the targets presented in the NECP. Published data on these parameters are not available at the time of the preparation of this study.

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National energy dependency

Analysis of national energy dependency jointly with the share of renewables in electricity production

Regarding energy dependence, it should be noted that from 2017 there is a clear downward trend, with emphasis on the expected decrease in 2020, 66%, a value that was very close to the NECP target for 2030. It should be kept in mind that 2020 was not a typical year, combining several factors which allowed the reduction of the import of fossil fuels, due to the decrease in consumption (a drop of 8%).

The graph on the right shows the intra-annual variability of energy dependence, which is explained by the variability of renewable resources, particularly hydro.

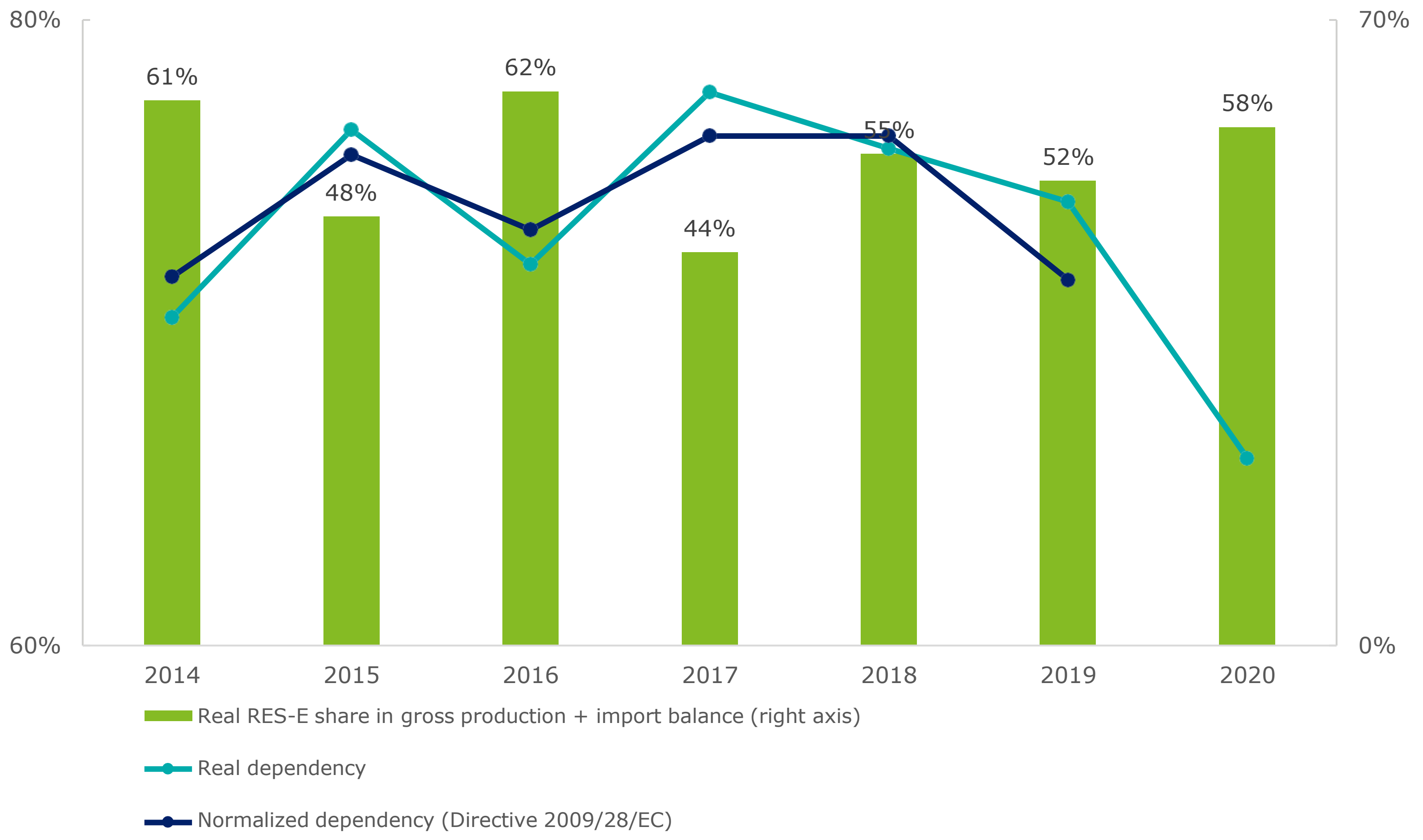

Figure 6. National energy dependency and share of renewables in electricity consumption

Source: DGEG, APREN Analysis

Note: At the time of the preparation of this study, there is no value for normalized dependence in 2020.

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Installed capacity

Analysis of the evolution of installed power in renewable energy sources and non-renewable energy sources

In terms of installed capacity, the following points stand out:

- Installed capacity in Portugal for electricity generation increased 4.8% between 2016 and 2020;
- Regarding non-renewable installed capacity, there has been a slight reduction since 2016, but with the phase-out planned for electricity from coal, due to the closure of the two power plants in operation in Portugal (Pego and Sines), an even greater decrease in power from non-renewable sources is expected in the coming years;
- In the opposite direction to the previous point, renewable power has an average annual growth of 2%, resulting in an overall 5-year increase of 8.4%.

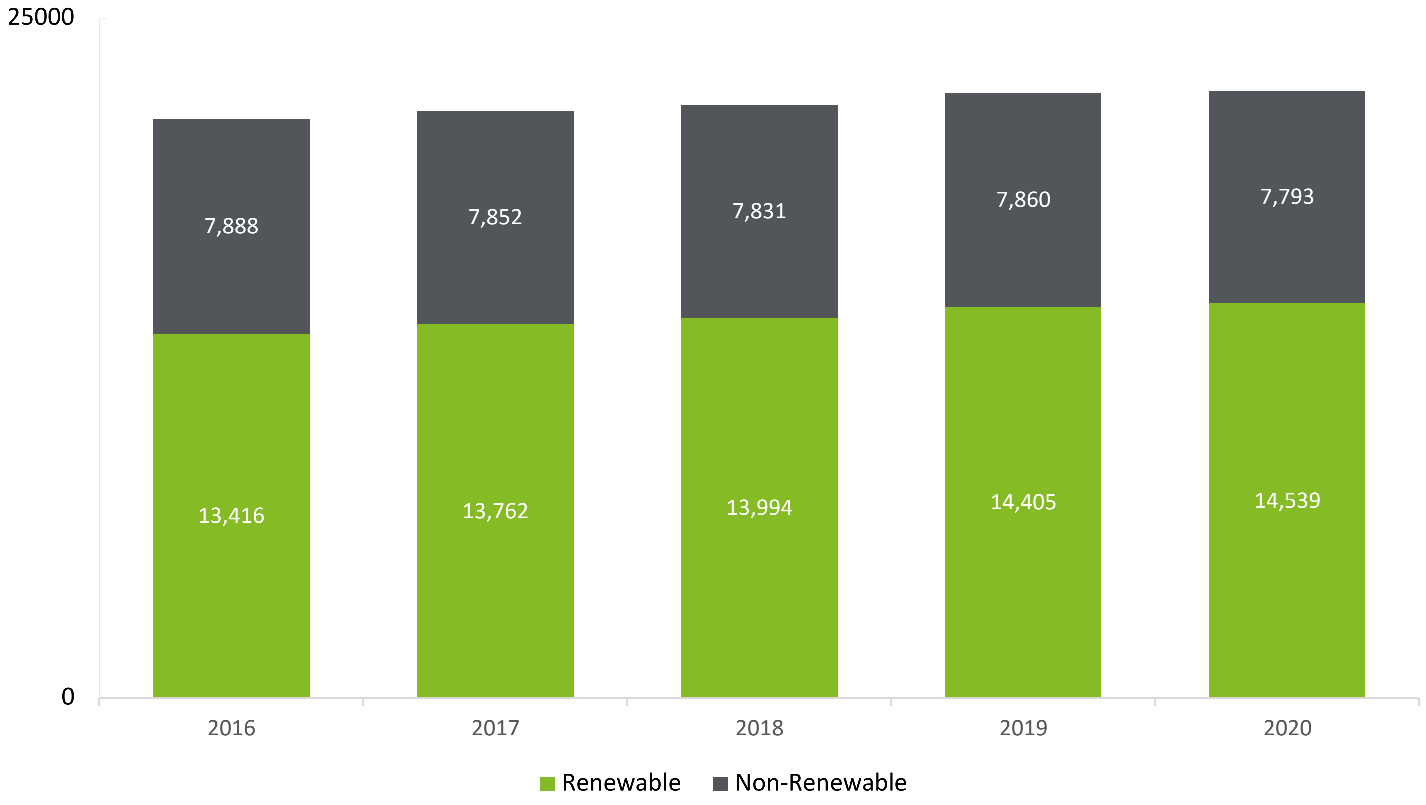

Figure 7. Evolution of installed capacity (MW)
Sorce: DGEG, APREN Analysis

Note: Due to the lack of data, the non-renewable value for 2020 is the result of a linear progression.

PENETRATION OF RES

RES installed capacity

Analysis of installed power for renewable energy sources by technology

Focusing on the renewable component, the following graph shows the distribution of installed capacity by technology. Analyzing in detail:

- There is an annual increase of the installed renewable capacity for the period under analysis. If we analyze the evolution from 2019 to 2020, only 134 MW of renewable capacity were installed, resulting in an accumulated total of 14.5 GW of installed capacity in Portugal, an increase of 0.9%, which falls below the target predicted for this year in the NECP;
- Hydro technology supports about half of the installed capacity for each year, with solar energy being the one that had the highest percentage evolution since 2016, an increase of 98% (we still were 1 GW behind the target set in the NECP). On the other hand, there is a clear stagnation of the wind sector, only 19 MW were installed in 2020.

Figure 8. Evolution of renewable installed capacity (MW)

Source: DGEG, APREN Analysis

Note: Hydro includes Small Hydropower (SHP) and Large Hydro. Bioenergy includes biomass, biogas and urban solid waste.

PENETRATION OF RES

RES Production

Analysis of the evolution of electricity production from renewable energy sources and non-renewable energy sources together with gross production and import balance

Following the analysis of the electricity production, dividing between renewable and non-renewable production, it should be highlighted:

- Of the 5 years being analyzed, there are three (2016, 2017 and 2018) in which electricity production reached such high values that allowed a negative import balance, i.e., Portugal exported electricity;
- Generally, there has been a greater renewable incorporation, except in 2017 which was a very dry year in Portugal and Spain;
- With the phase-out of coal-based power plants, and as a result of the decrease in the installed power of fossil technologies, as well as the increase in renewable power predicted in the NECP, in the coming years an increasing difference is expected in the percentage of renewable production compared to fossil production.

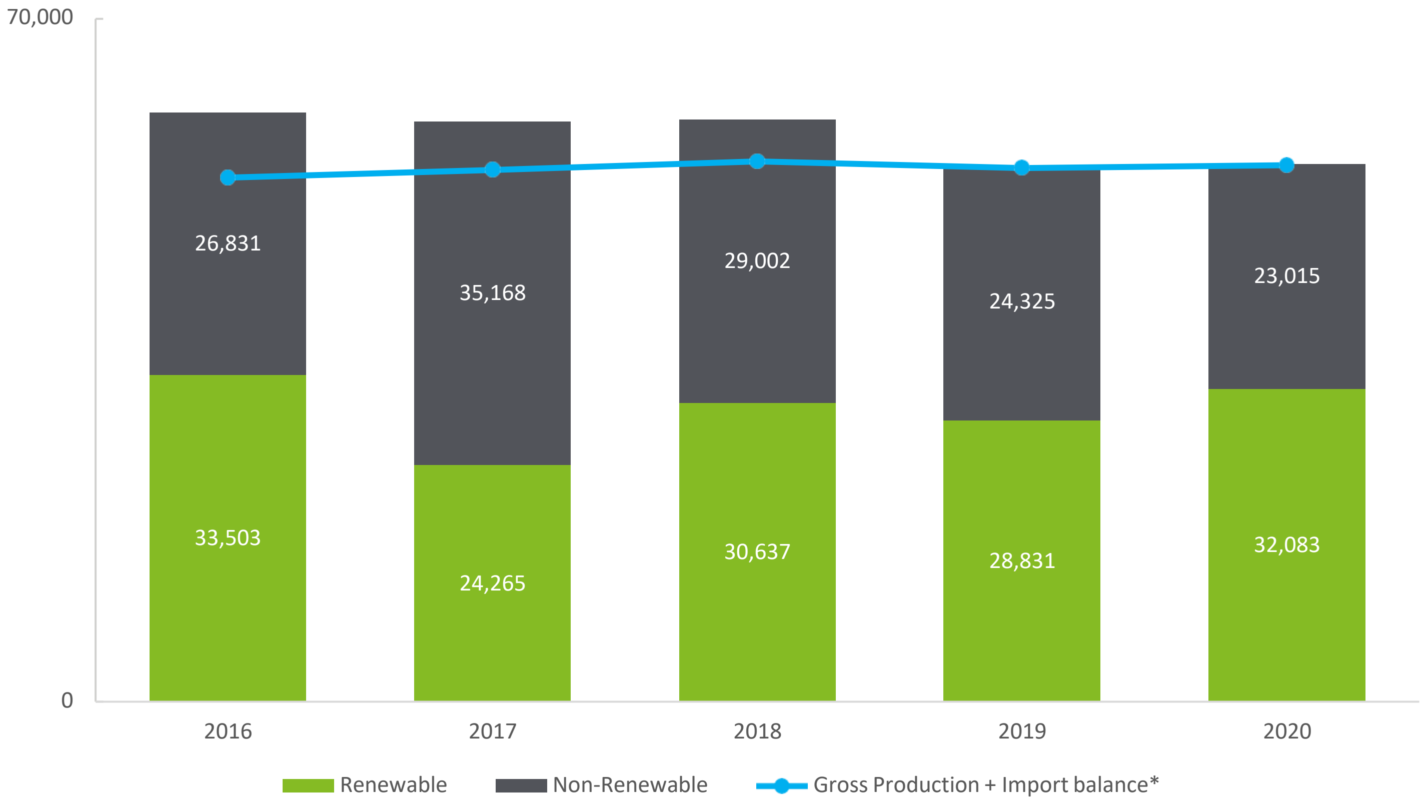

Figure 9. Evolution of electricity production (GWh)
Source: REN, DGEG, APREN Analysis

*Excludes Pumping.

Penetration of RES

RES Production

Analysis of the evolution of electricity production by renewable energy sources by technology and the normalized total value. Perspective of the rate of renewable production between 2016 and 2020.

The graph on the right represents the evolution of renewable production. Its analysis highlights the following:

- The two renewable technologies with the highest representativeness in electricity generation are hydro and wind;
- There is an intra-annual variability for hydro, resulting from the variation in the rainfall level of the respective years. The year 2017 stands out, which was an exceptionally dry year, with low hydropower production.
- The year with the highest absolute value of production, 2016, is distinguished from the others, essentially, by the high hydropower generation, which is due to be a humid year;
- Considering the curves relating to the normalized total and the % of renewable incorporation in gross production + import balance, one can say that in the last 5 years there is a residual increase of these parameters, but we are clearly facing a situation of stagnation of renewable incorporation.

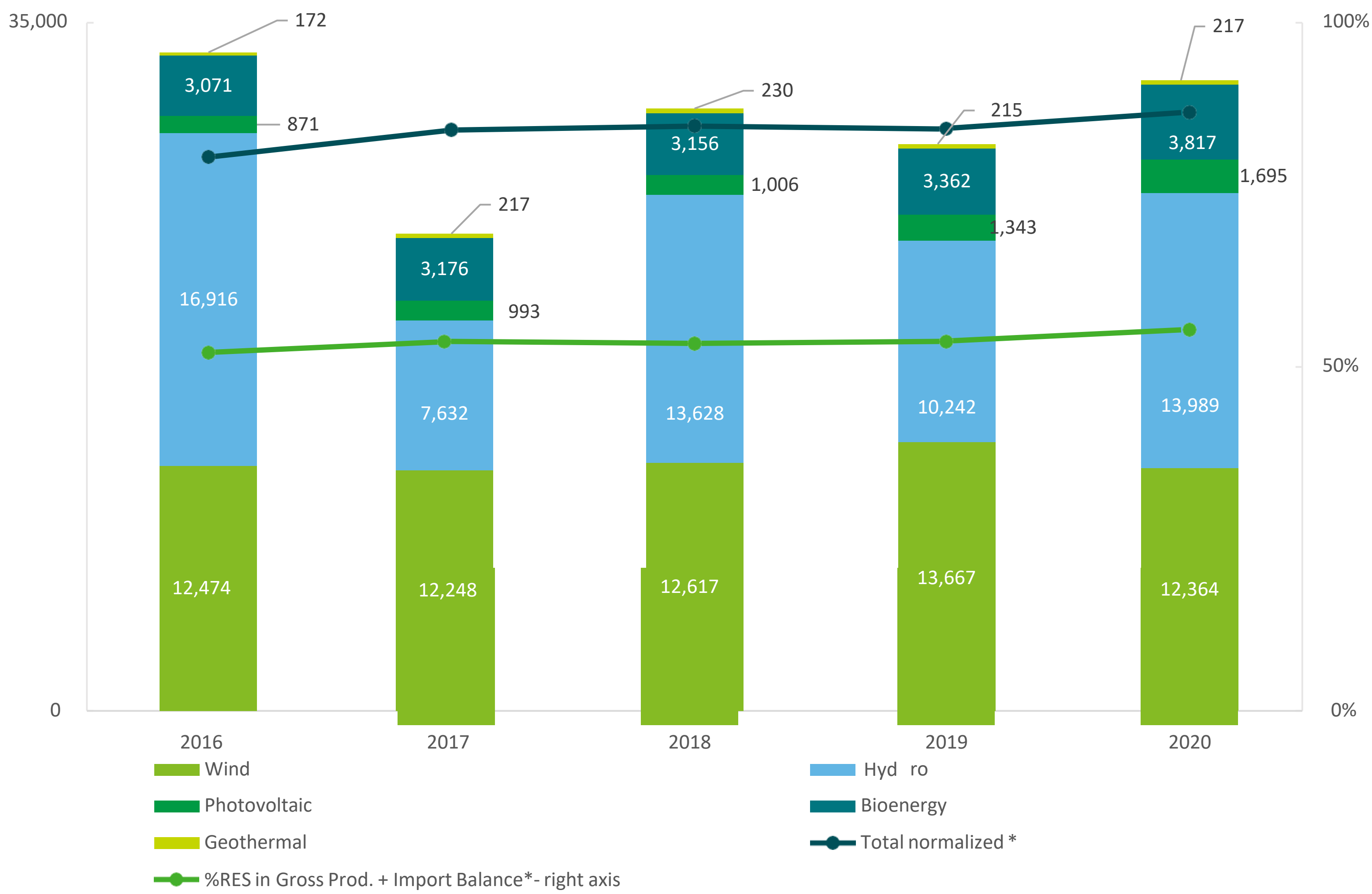

Figure 10. Evolution of renewable electricity production between 2014 and 2020 (GWh)

Source: DGEG, APREN Analysis

*Standard values - in accordance with Directive 2009/28/EC.

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3. Energy Policy

ENERGY POLICY

European policy

Analysis of the main policies carried out at European level

On 15 January 2020, the European Parliament voted and approved the European Green Deal, an agreement drawing up an action plan to leverage the efficient use of resources, the transition to a clean and circular economy and the restoration of biodiversity associated with pollution reduction. It should also be noted the European Climate Law proposed on 4 March 2020 that has the objective of European climate neutrality until 2050, as established in the European Green Deal.

On 14 July 2021, the Fit for 55 package was designed to achieve Europe's new GHG reduction ambition by 55% in 2030, compared to 1990. It includes the proposal for a new renewable incorporation target of 40% and the revision of several legislative pieces to align with the new climate target, particularly: the European Emissions Trading System, the Energy Taxation Directive, the Renewable Energy Directive, the Energy Efficiency Directive and the Alternative Fuels Infrastructure Directive. The package also includes the new Carbon Border Adjustment Mechanism.

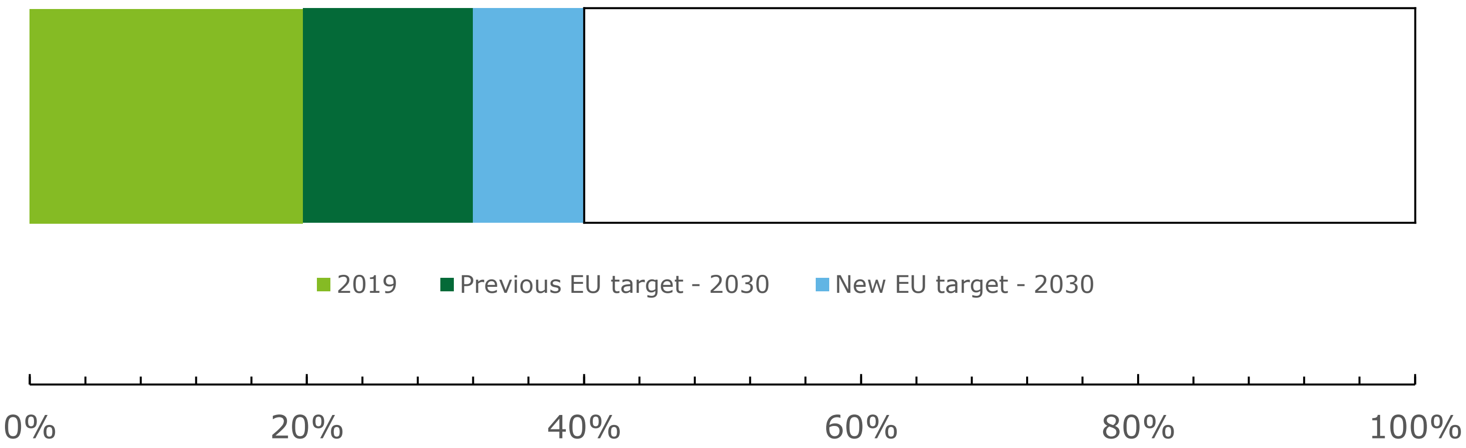

Figure 11. Incorporation of renewables into gross final energy consumption
Source: EC, APREN Analysis

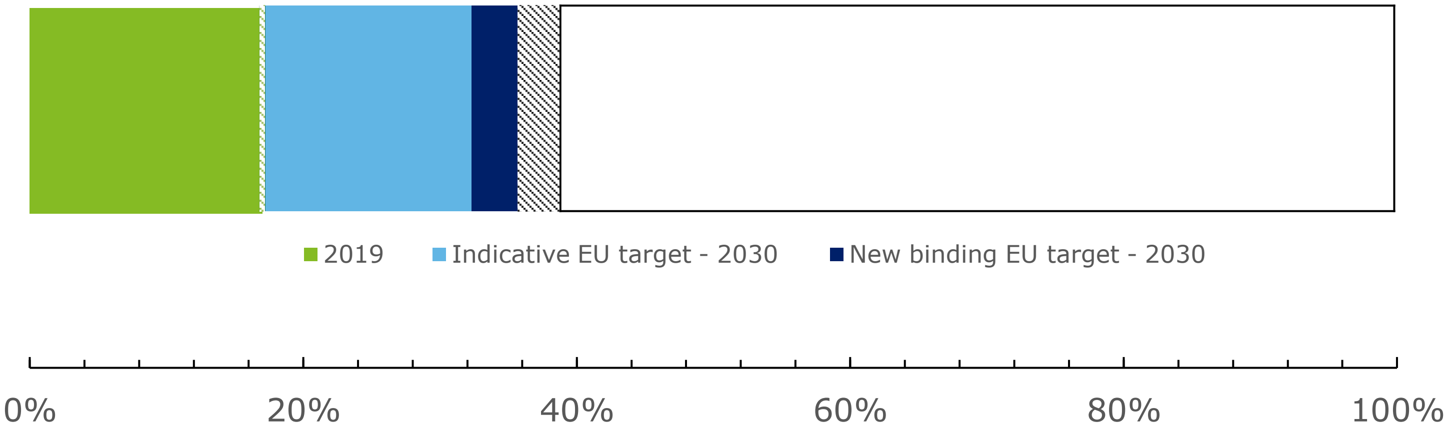

Figure 12. Energy efficiency gains for final and primary energy consumption.
Source: EC, APREN Analysis

Note: In relation to energy efficiency, the new target for 2030 is not accurate (36-39%), with a 3% margin as noted in the graph.

Energy Policy

National policy

Analysis of the main policies carried out at national level

On July 10, 2020, the NECP 2030 was approved. The document, which had already been submitted to the EC in December 2019 and which is aligned with the Roadmap for Carbon Neutrality 2050, establishes the country's long-term national commitment and strategy for carbon neutrality in 2050. The NECP 2030 defines the sector targets of power and renewable incorporation in the final energy consumption for 2030, as it can be seen in the graph on the side.

There is a growth in renewable incorporation for all sectors, with particular emphasis on electricity consumption, an increase of 11% between 2025 and 2030.

The NECP 2030 does not yet include the contribution to the new European climate target or to the EN-H2 targets published in August 2020.

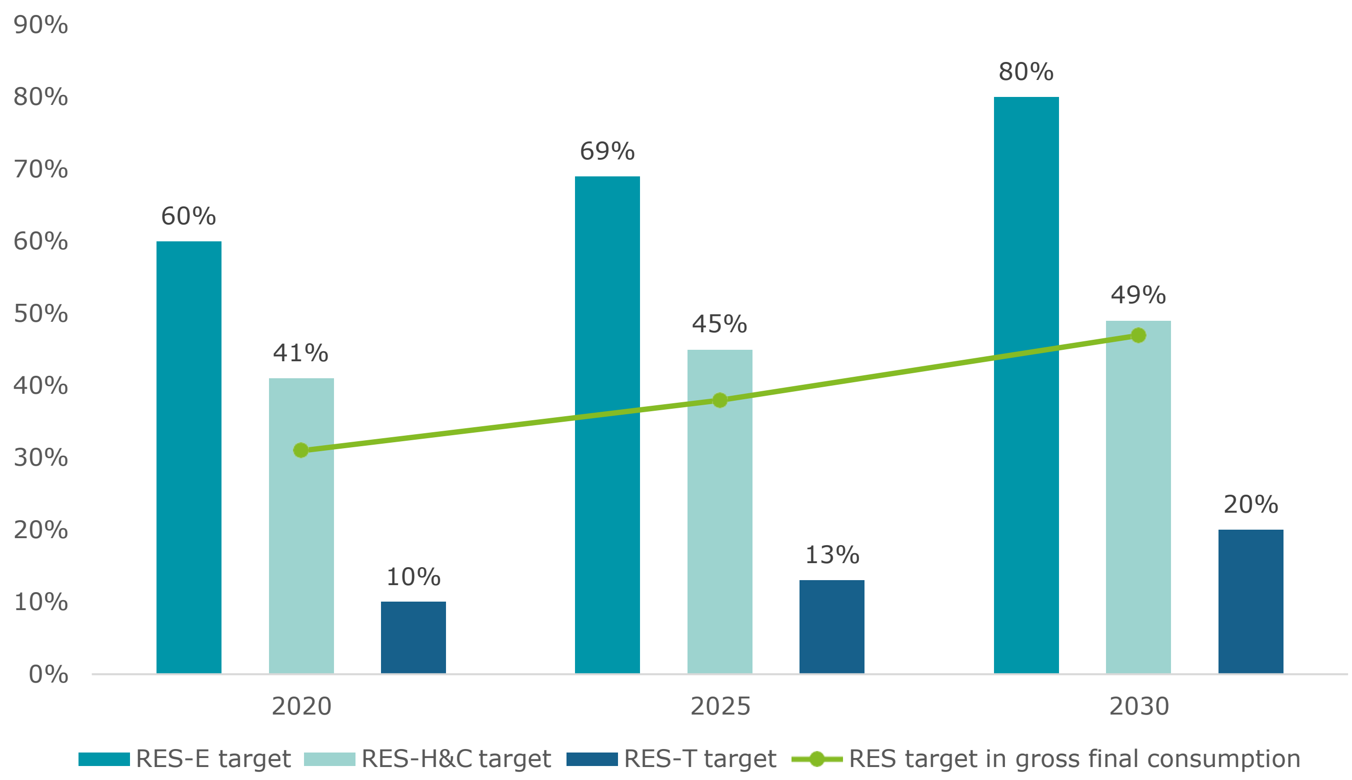

Figure 13. NECP target for renewable incorporation into electricity consumption, heating and cooling, transport and gross final energy consumption
Source: NECP, APREN Analysis

Note: As mentioned in the legend, the chart concerns the NECP goals. Previously, some actual values had been presented for 2020. In this case we fell short of the RES-E target, the actual value was 55%, but we exceeded the RES target in gross final consumption, the real value was 34%.

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National policy

Analysis of the main policies carried out at national level

Analyzing what is foreseen to be the installed power, the NECP presents the targets for 2020, 2025 and 2030. Specifically:

- As expected, the high prevalence of renewables is highlighted, with a clear trend towards decarbonization. A practical example of this is the absence of coal, starting in 2025, and the expected reduction of natural gas by the end of the decade .
- From 2020 to 2030, a growth in renewable installed capacity of 12.67 GW is expected, an increase of 85.2%.
- The technology with highest growth of installed capacity over the next 10 years, will be solar, which is expected to be practically on pair with wind power in 2025. In terms of wind power, the development will be mainly through over-equipment and repowering.

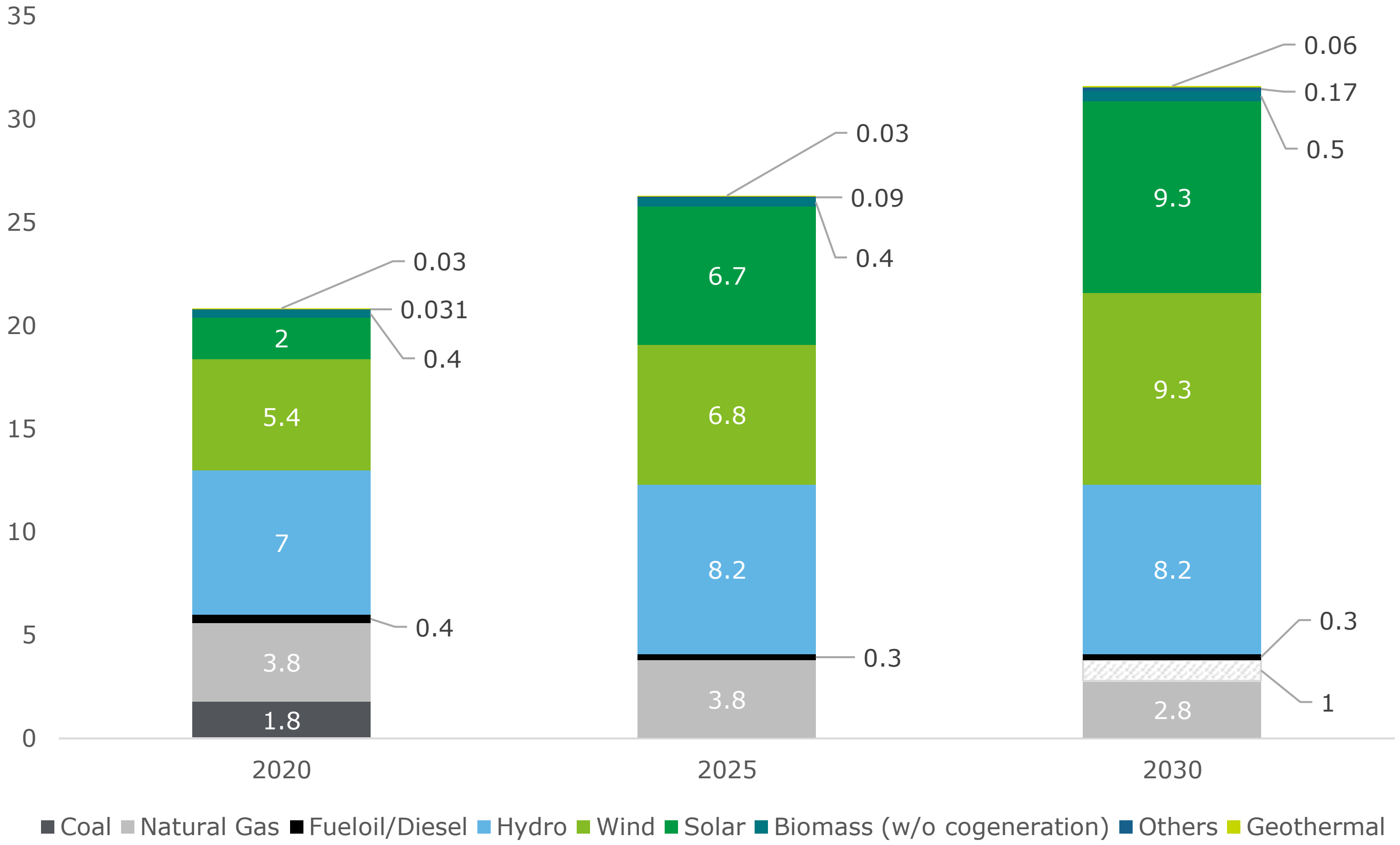

Figure 14. NECP targets for the evolution of installed power for electricity production by technology in Portugal in the 2030 horizon (GW)

Source: NECP, APREN Analysis

Note: Hydro includes SHP and Large Hydro. Solar includes photovoltaic (more than 96%) and concentrated thermal solar. Others include waves and other renewables. In relation to natural gas, in 2030 the value is not accurate (2.8-3.8 GW), with 1GW of margin as observed in the graph. Again, the 2020 values correspond to the NECP goals, and the actual values were previously presented.

National policy

Analysis of the main policies carried out at national level

On August 14 2020, EN-H2 was also approved, which foresees the installation of 2 to 2.5 GW of electrolyzers by 2030 for the production of hydrogen using electricity generated from renewable energy sources (RES), i.e., green hydrogen.

To ensure the implementation of this strategy, it is necessary to strengthen the investment and development of renewable power plants, in addition to the targets defined in the NECP 2030 for installed capacity.

An investment of around 9 billion euros is planned to achieve these targets, with more than 80% of the investment coming from the private sector.

The main objectives to which the Portuguese Government proposes can be seen in the following indicators.

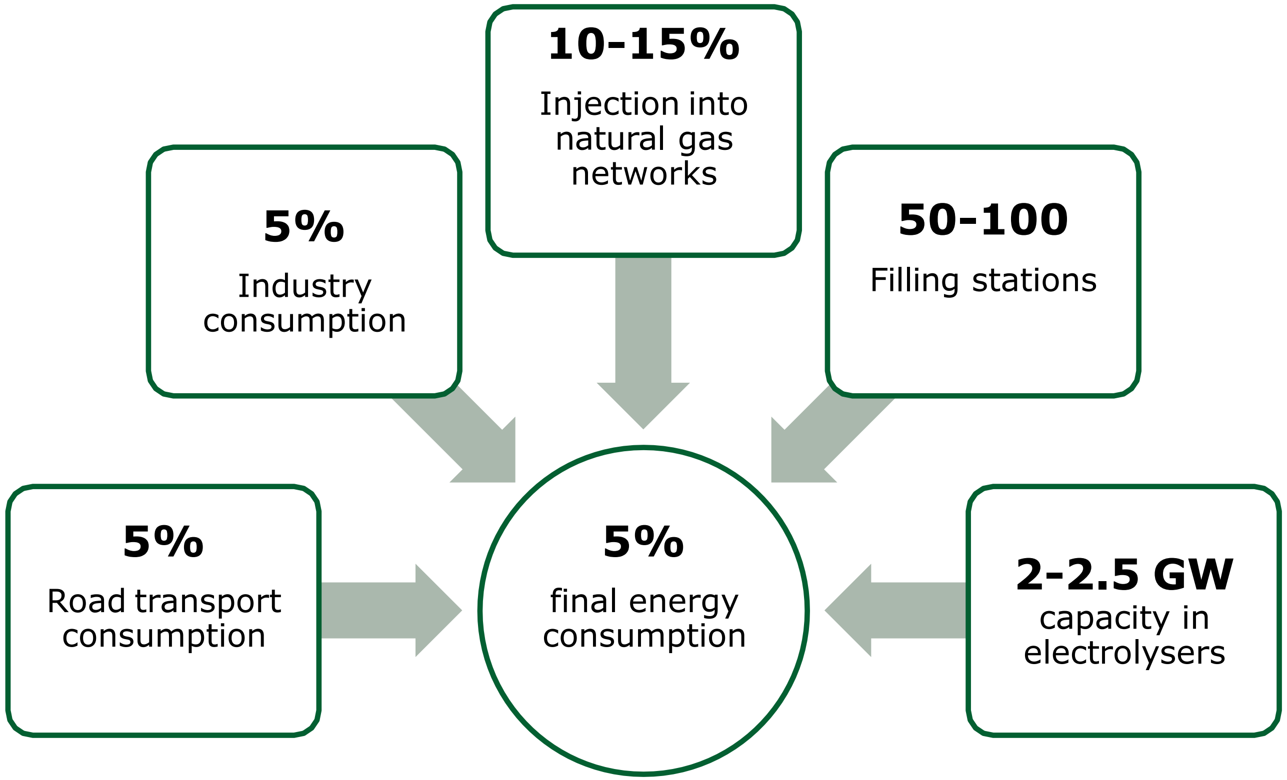

Figure 15. Objectives for the 2020-2030 decade set out in the National Hydrogen Strategy
Source: EN-H2, APREN Analysis

4. National Electricity System

Costs of the electricity system

Analysis of the costs of the electricity system in Portugal

The representation of the costs of the national electricity system is found in the graph next to it. In this case, it is important to highlight the following facts:

- Total total cost was 6.8 billion euros;
- The most relevant element, 45.8%, corresponds to energy, with a value of 3.1 billion euros;
- The networks, i.e., the transmission and distribution networks totaled 1.6 billion euros (23.1%);
- The General Economic Interest Costs (CIEG) component represents 28.2% of total costs, totaling a cost amount of 1.9 billion euros. The largest component of CIEGs concerns the SRP Differential, which represents 12.9% of the total, adding up to a cost of 884 million euros in terms of costs.

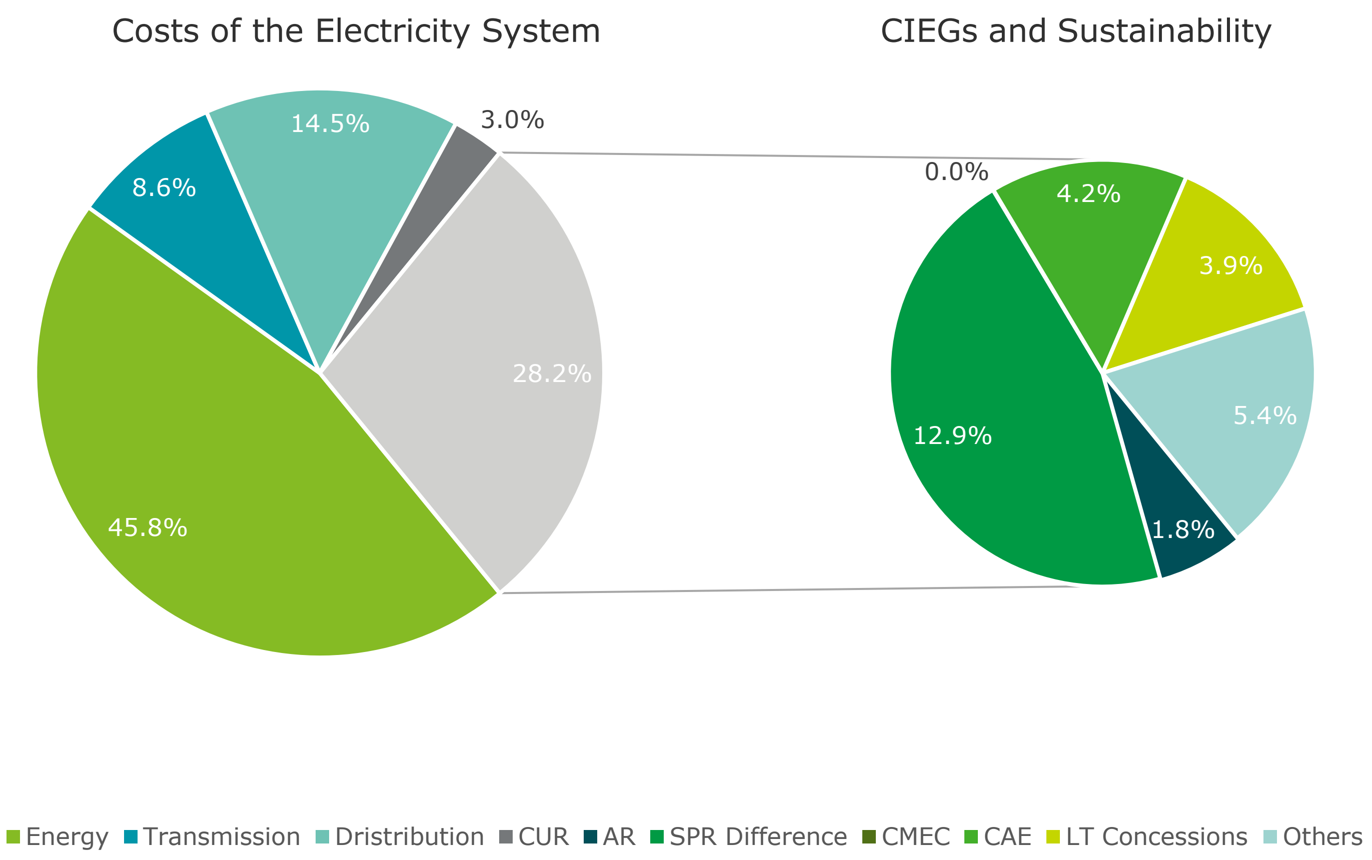

Figure 16. Costs of the electricity system
Source: ERSE, APREN Analysis

Regulated activity costs

Analysis of regulated activity costs

The costs of regulated activities, namely:

- Purchase and Sale of Electricity from the Commercial Agent (CVEEAC);
- Retailer Change Logistics Operator (OLMC);
- System Global Management (GGS);
- Electricity Transmission (TEE);
- Electricity Distribution (DEE);
- Social Rate.

Regarding the energy balance, the costs and investments of companies with regulated activities (REN Trading, ADENE, REN, EDP Distribution and EDP Universal) are presented in the annually allowed revenues published by ERSE, in order to determine the necessary adjustments to be passed on to the 2020 Tariffs.

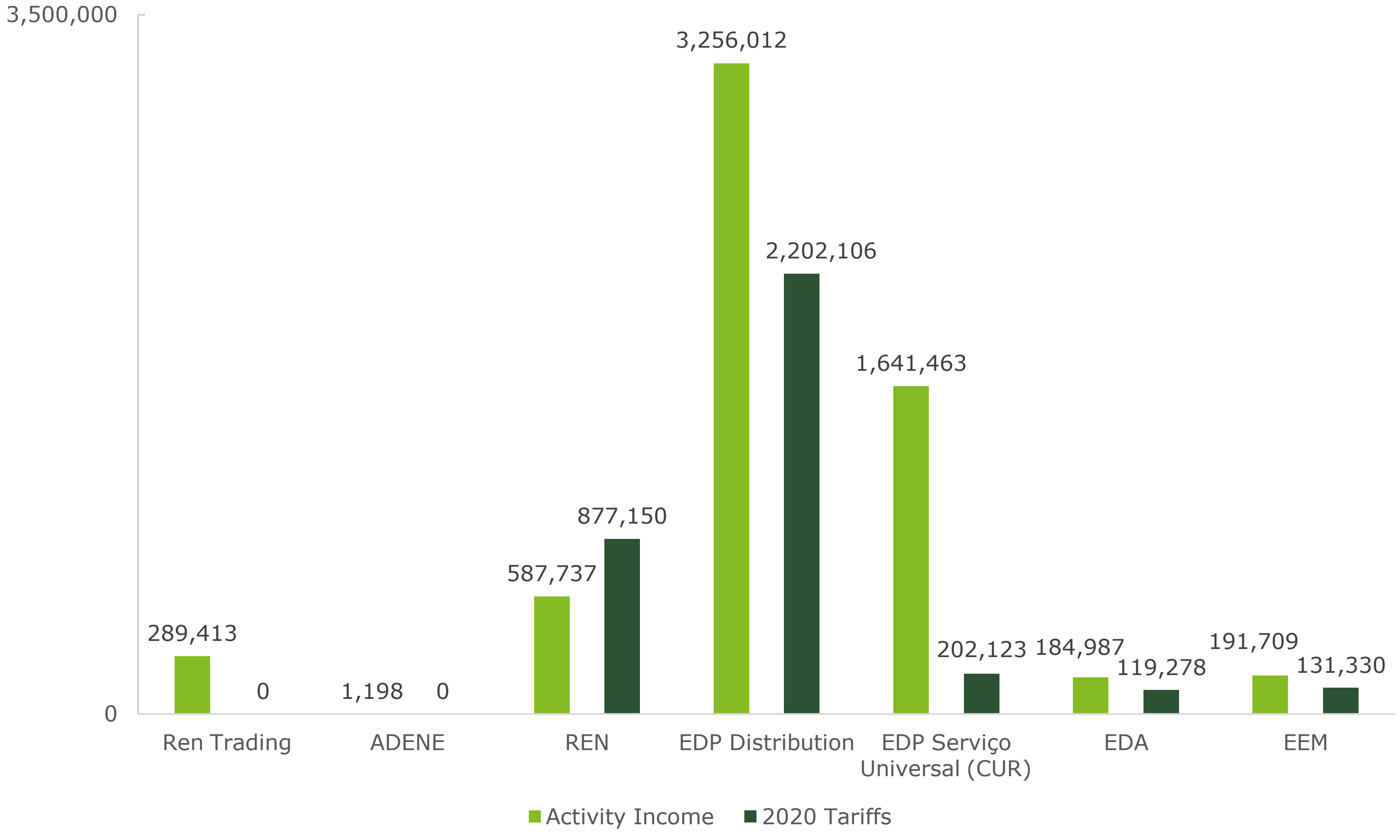

Figure 17. Regulated activity costs (M€)
Source: ERSE, APREN Analysis

4. Impact on the Electricity Market

The Electricity Market in Portugal

Price structure for the consumer

The price of electricity borne by companies and private consumers results from the costs related to production and sale of electric energy, transmission and distribution networks, and the commercialization of electricity.

The **Regulated activities for electricity supply** are the following:

- System global management;
- Electricity transmission;
- Electricity distribution;
- Retailer Change Logistics Operator;
- Purchase and sale of electric energy;
- Commercialization of electric energy.

Only for the last resort supplier (applies to the last two items)

Commonly, the electricity supply price payed by the end consumer can be divided into three components:

- Networks;
- Power;
- Fees and taxes.

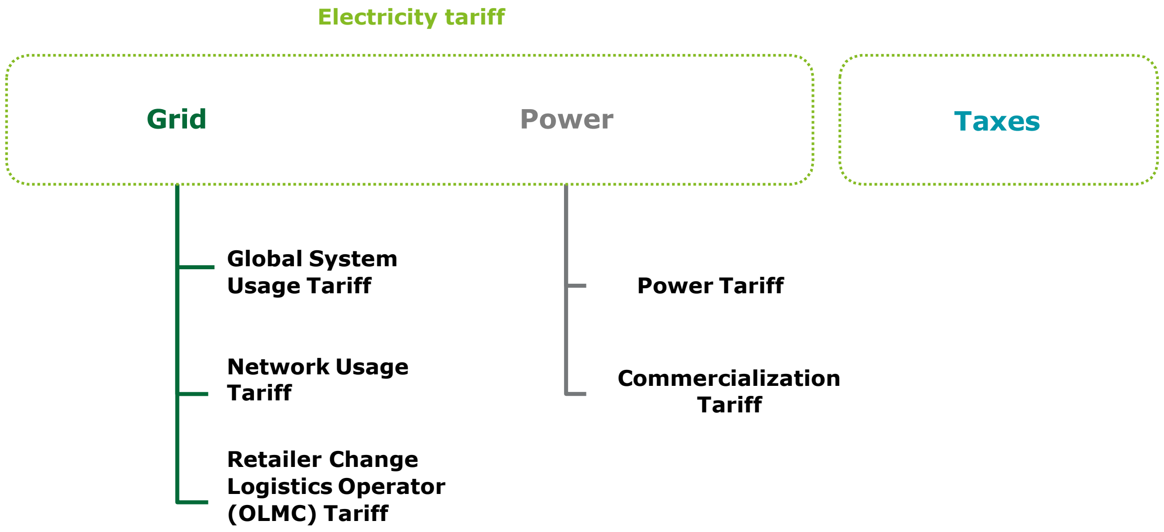

Figure 18. Electricity charges in Portugal
Source: ERSE, Deloitte Analysis

The **grid value** represents the amount related to the infrastructure that transport electric energy from its production to its consumption point. The **power value** is related with the cost of electric energy produced and its commercialization. Finally, **fees and taxes** include the several types of taxation, namely VAT (Value-Added Tax), IECE (*Imposto Especial de Consumo de Eletricidade*) and CAV (Audiovisual Contribution).

The sum of regulated tariffs for networks and power is the **End-User Sale Tariff.**

Impact of the SRP on the tariff

The main impacts of the usage of RES on the electricity tariff are reflected on the global system usage tariff through the CIEG and through the purchase and commercialization of electricity in the Iberian Market.

In order to promote and attract investment to the renewable energy sector, Portugal has created a remuneration regulatory framework based on feed-in-tariffs (FIT) as a stability mechanism to promote the transition into endogenous energies from an early stage. The incorporation of the cost differential of these tariffs against the market price is incorporated in the End-User Sale Tariff.

Therefore, the main impacts on the consumer tariff from the promotion and usage of RES are two:

1)On the **Global System Usage Tariff are considered the costs arising from energetic, environmental and General Economic Interest policy measures (CIEG)**, among which is included the SRP cost differential.

2)On the other hand, the usage of RES has an influence in the reduction of the marginal cost of electricity in the market, since the **marginal cost of electricity production from RES tends to be lesser than those from other sources.**

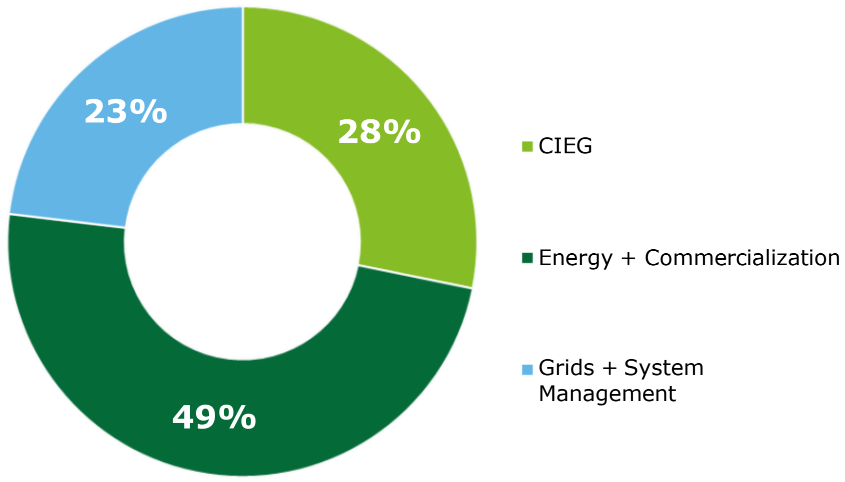

Figure 19. Electricity price composition in 2020

Source: APREN, Deloitte Analysis

There are still other impacts, namely investments **associated with the adjustment of the transmission and distribution networks to the growing amount of electricity from RES**, that were not analyzed in the present study.

Differential cost with the renewable SRP

The differential cost of the renewable SRP is a significant component of the CIEG and it is reflected in the end consumer sale tariff. This maintained the downward trend in 2019 and 2020, having reached the lowest value since 2016.

In order to promote the Special Regime Production (SRP) from a renewable source, the tariff includes a component related to the cost differential of the SRP against the market value, which then impacts the End Consumer Sale Tariff.

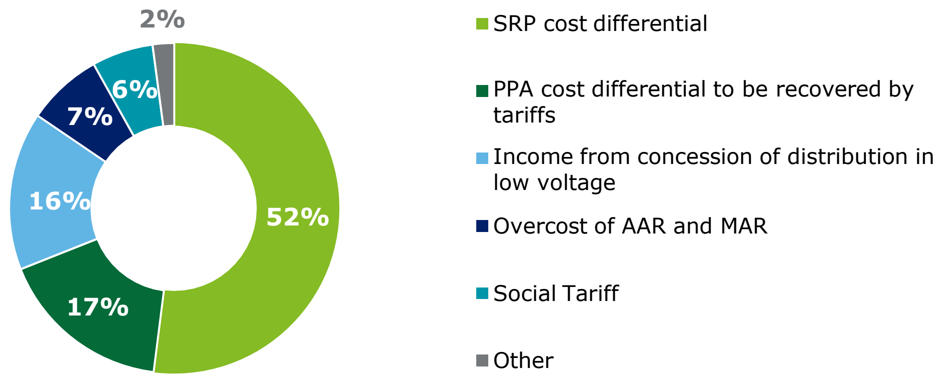

Figure 20. CIEG recovered in 2020 tariffs

Source: ERSE, APREN Analysis

This cost differential when compared with the market values (renewable and non-renewable SRP) corresponded to approximately 52% of the total amount charged in tariff related to the CIEG in 2020.

Between 2016 and 2020, **the costs related with the renewable SRP were approximately 4.4 billion euros.**

In 2020, this value was around EUR 773 million, reflecting a **downward trend** since 2017, where the maximum value was recorded.

Nonetheless, it is necessary to take into consideration that the amount incoming from the renewable SRP cost differential has contributed to the fulfillment of the goals established for 2030, by incentivizing the investment in the sector.

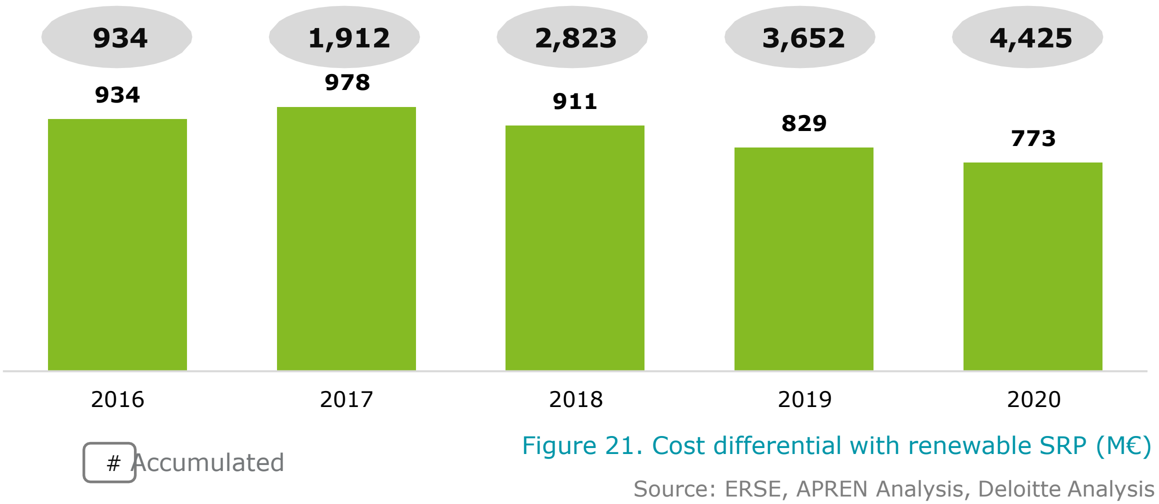

Figure 21. Cost differential with renewable SRP (M€)

Source: ERSE, APREN Analysis, Deloitte Analysis

Note: The value of the differential presented corresponds to the direct difference between actual acquisition costs (FIT) and the market reference price, not including sustainability measures and adjustments from previous years to be reflected in tariffs.

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Impact on the Iberian Market

The impact of the renewable sources positively affects the market price of the electricity commercialized in the Iberian Market due to its low marginal cost, which allowed accumulated savings of 6.1 billion euros between 2016 and 2020

At the MIBEL (Electricity Iberian Market), the offerings of purchase and sale of electric energy are aggregated by the suppliers and producers, allowing for the development of supply and demand curves. The intersection of these curves defines the market equilibrium point – the daily market price for electricity for the respective hour.

The renewable SRP typically has a zero marginal cost (or close to it), which contributes for the introduction of electricity offerings lower than the market cost, thus reducing the daily market price for electricity for a certain hour.

Between 2016 and 2020 **the electricity sale price without renewable SRP was, on average, 24 €/MWh higher than the sale price with renewable SRP.**

It is estimated that the accumulated savings acquired since 2016 are, approximately, **6.1 billion euros**, of which around 2.5 billion euros corresponds to 2019 and 2020. It should be noted that by 2020 the value of savings is much higher due to the impact of the drop in consumption due to the pandemic.

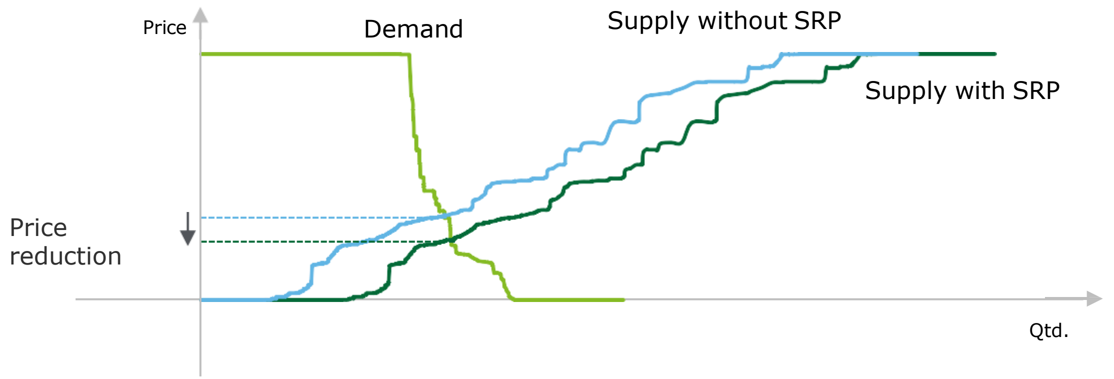

Figure 22. Impact of RES production on the daily market electricity price
Source: Deloitte Analysis

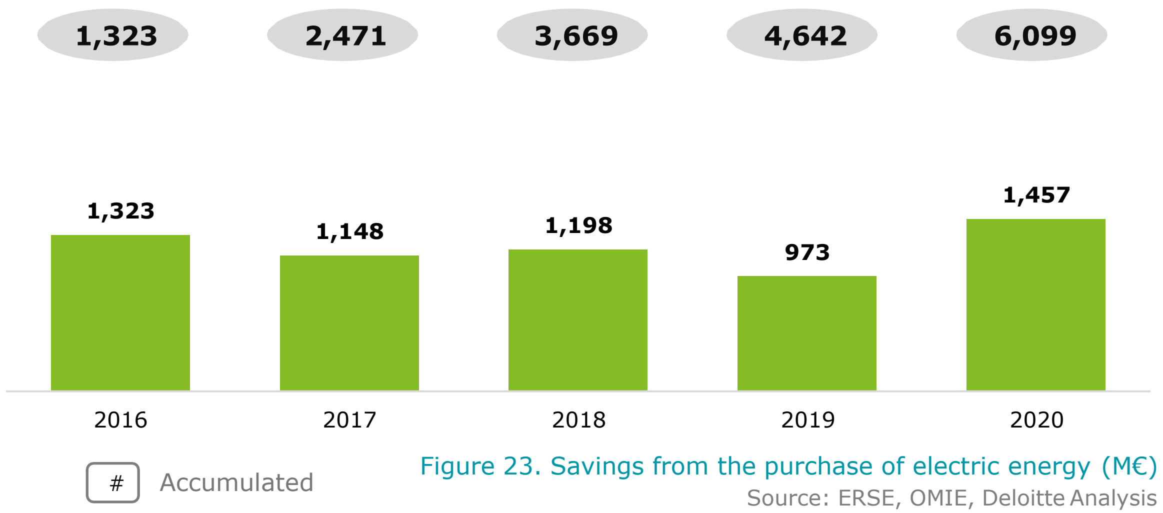

Figure 23. Savings from the purchase of electric energy (M€)
Source: ERSE, OMIE, Deloitte Analysis

Economic impact of the renewable SRP

Balance of the SRP Cost differential versus the Iberian Market Savings

Considering the cost differential of the renewable SRP and its impact on the daily market electricity price, there is a positive net effect for the system, with an accumulated value of around 1.7 billion euros between 2016 and 2020.

Without SRP the daily market electricity price would increase

Without SRP the cost differential with the SRP would not exist

It is important to analyse the impact of the introduction of electricity produced from RES on the daily market of electricity against its cost differential, evaluated as the difference between the FIT and the daily market electricity price.

In order to simplify, it was assumed that there were no variations in the other components of the tariff (e.g., costs associated with the transmission and distribution networks).

When analysing the values of the cost differential with renewable SRP, it is verified that for the **period 2016-2020 a positive cumulative balance of 1.7 billion euros was reached**.

In 2020, the positive impact for the system reached 684 million euros, the highest value for the period analysed.

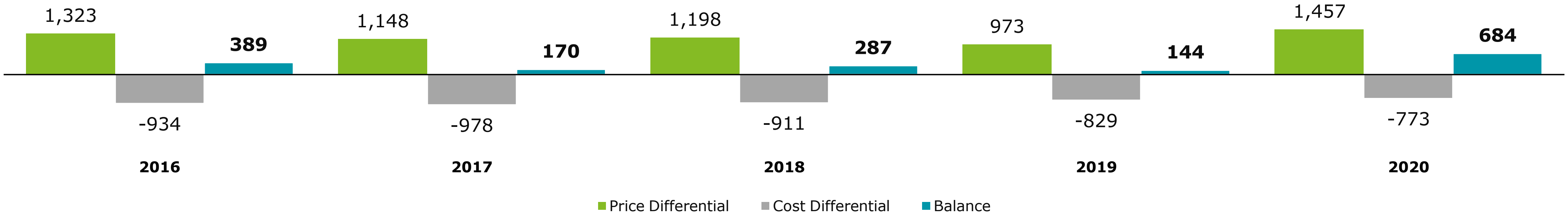

Figure 24. Differential between the obtained savings with the renewable SRP and the cost differential of the renewable SRP (M€)

Source: ERSE, Deloitte Analysis

IMPACT ON CONSUMER BILLS

Net effect for the Consumer of the renewable SRP cost differential versus Savings in the Iberian Market

RES can generate annual savings on electricity bills, on average, of up to 50 euros for a domestic consumer and up to 4,500 euros for a non-domestic consumer

For the comparison of electricity prices between Portugal and the other countries of the European Union, the following consumption bands are representative of most Portuguese domestic and non-domestic consumers :

- **Domestic** (DC Band): 2,500 to 5,000 kWh;
- **Non-Domestic** (IB Band): 20,000 kWh to 500,000 kWh;

Considering thar the differential between the savings obtained from the presence of renewable SRP in the market and the additional cost renewable SRP is €0.009/kWh, it means that SRP-RES can generate **annual savings in the electricity bill of up to 50 euros for a domestic consumer and up to 4,500 euros for a non-domestic consumer.**

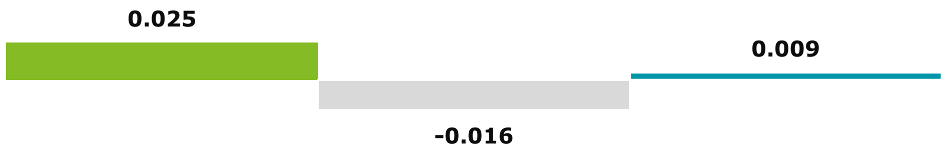

Figure 25. Differential between the savings obtained with the presence of renewable SRP and the overcost of renewable SRP (€/KWh) Source: ERSE, Deloitte Analysis

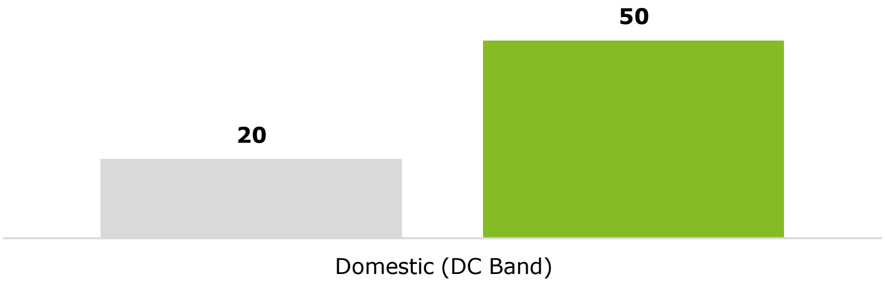

Figure 26. Minimum and maximum annual savings values in electricity consumption (€) for a domestic consumer

Source: ERSE, OMIE, Deloitte Analysis

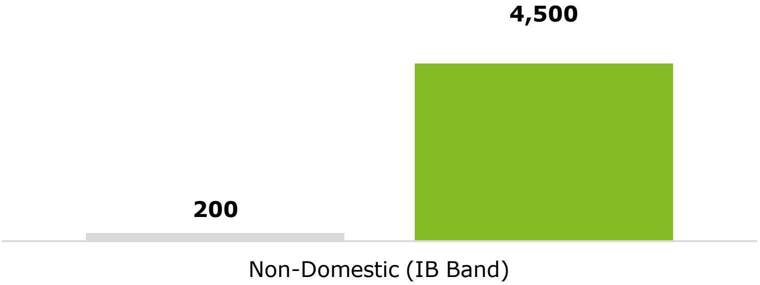

Figure 27. Minimum and maximum annual savings values in electricity consumption (€) for a non-domestic consumer

Source: ERSE, OMIE, Deloitte Analysis

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Consumer savings

Findings

- The price of electricity borne by companies and private consumers results from the costs related to production and sale of electric energy, transmission and distribution grids, and the commercialization of electricity;
- The main impacts, resulting from the usage of SRP-RES, on the electricity tariff are reflected on the global system usage tariff through the CIEG and through the purchase and commercialization of electricity in the Iberian Market;
- The differential cost of the renewable SRP is a significant component of the CIEG and it is reflected in the end consumer sale tariff. It maintained the downward trend in 2019 and 2020, having reached its lowest level since 2016;
- The impact of the renewable sources positively affects the market price of the electricity commercialized in the Iberian Market due to its low marginal cost, this allowed accumulated savings of 6.1 billion euros between 2016 and 2020;
- Considering the cost differential of the renewable SRP and its impact on the daily market electricity price, there is a positive net effect for the system, with an accumulated value of around 1.7 billion euros between 2016 and 2020;
- RES can generate annual savings on electricity bills of up to 50 euros for a domestic consumer and up to 4,500 euros for a non-domestic consumer, on average.

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5. Economic/Social Impact

Impact on GDP

RES GDP contribution between 2016 and 2020

The cumulative RES contribution towards the GDP surpassed 18 billion euros between 2016 and 2020, corresponding to an average annual value of ~3.7 billion euros

The weight of **the electricity production sector from RES on the Gross Domestic Product (GDP) was relatively stable between 2016 and 2020**. The year 2017 was, however, an exception, since it was affected by adverse conditions (“dry year”).

Although there is a stabilized growth trend of the installed capacity, it is noteworthy that 2020, a year marked by the pandemic crisis, only registered a slight drop in the growth trend of the previous two years.

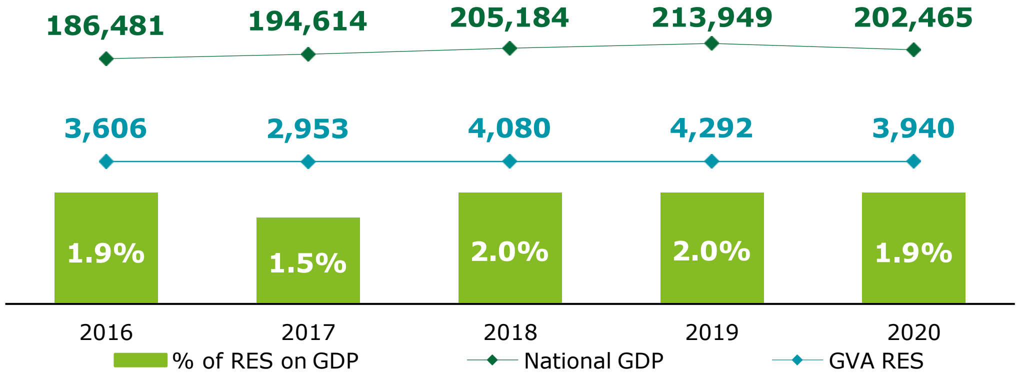

Figure 28. GDP and renewable GVA evolution in Portugal (M€)

Source: *RES sector players*, SABI, Deloitte Analysis

The **investment in production of energy from renewable sources has resulted in the significant contribution of the sector towards the country’s GDP**.

Although less favorable conditions were verified in the year of 2017, the years 2018, 2019 and 2020 represented a strong contribution of RES to GDP, showing values around 4 billion euros in each year.

It is verified that most of the contribution to GDP comes mostly from the direct impact resulting from the contribution of RES electricity producers.

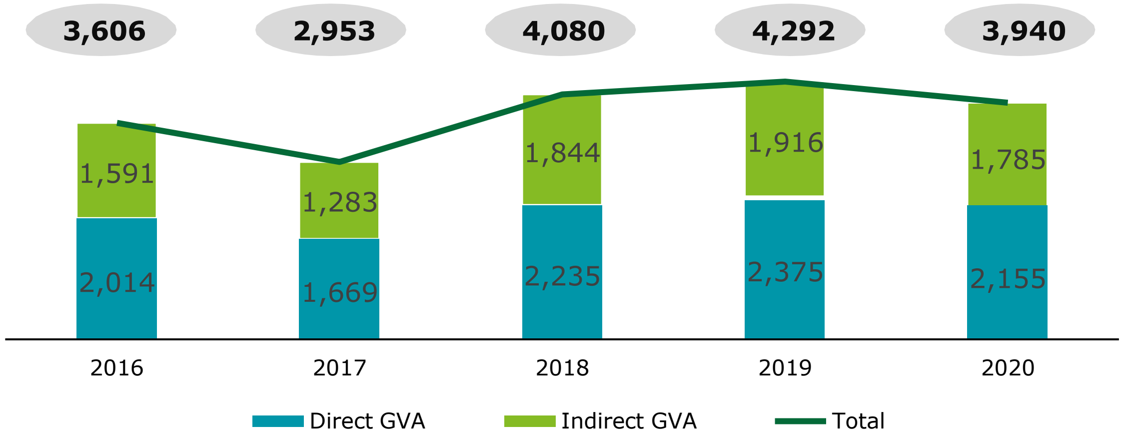

Figure 29. Evolution of the total contribution of the RES electricity sector towards the GDP (M€)

Source: *RES sector players*, SABI, Deloitte Analysis

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Impact on GDP

Detail of the contribution towards the GDP by RES between 2016 and 2020

Within the RES context, the wind sector was the one which impacted the GDP the most in 2020. In terms of the contribution by MW, solar stands out with an average annual contribution of 958k €/MW, between 2016 and 2020

Wind was the energy source that registered the highest contribution towards the GDP (42%), followed by hydro (34%). In total, it is estimated that they generated more than 3.5 billion euros in GVA (Direct + Indirect) in 2020.

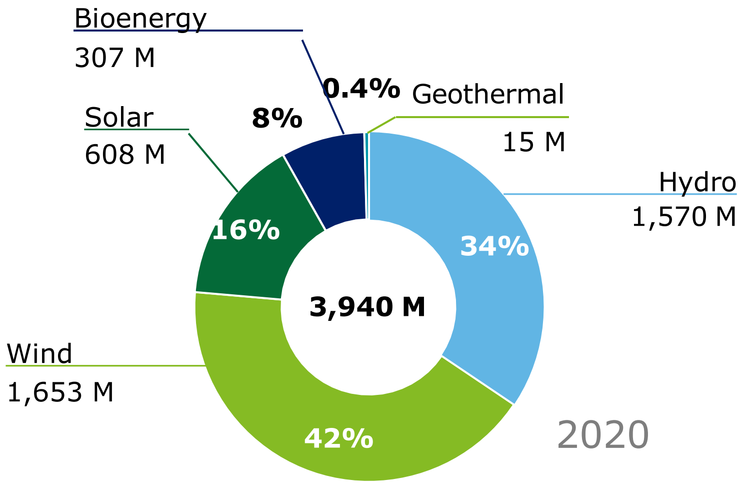

Figure 30. Distribution of total contribution towards the GDP by RES in 2020 (M€)

Source: RES sector players, SABI, Deloitte Analysis

The source that contributed the most towards the GDP by installed MW was solar, with an average annual contribution of 958k €/MW. Wind power comes in third with €330k/MW.

Analysing the last 5 years, the hydro sector is stabilized. The wind sector, on the other hand, has a slight downward trajectory, while solar had a peak in 2019, with a sharp drop in 2020. This is mainly due to the reduction in the price of the Iberian Electricity Market (MIBEL), caused by the reduction in consumption and consequently a reduction in the average daily market price in 2020 (most of the power plants that come into operation in recent years are on a market regime).

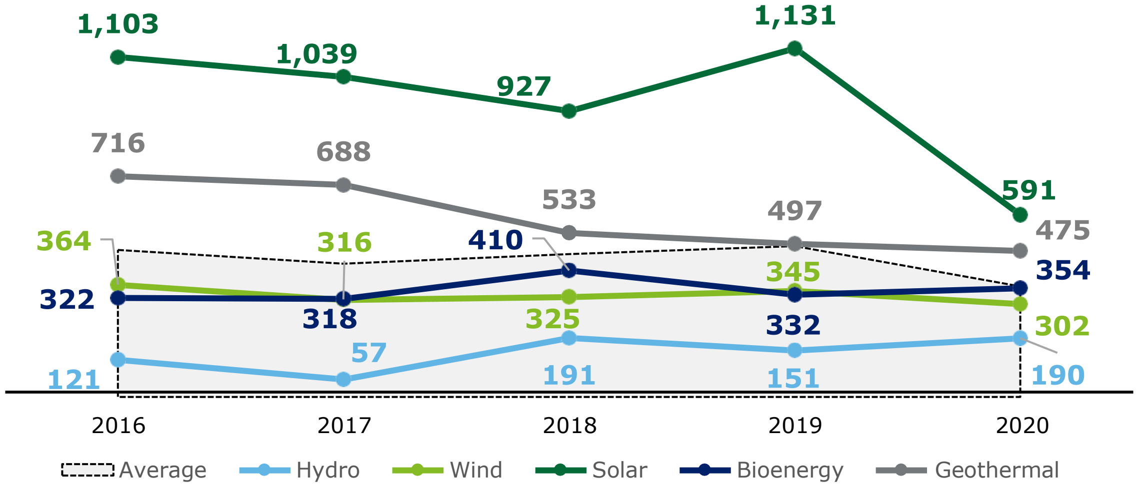

Figure 31. Evolution of the k€ ratio generated for the GDP by installed MW

Source: RES sector players, SABI, Deloitte Analysis

Impact on GDP

RES contribution to GDP – NECP 2030 Scenario

According to the established goals for the 2030 horizon, it is estimated that the GVA derived from RES will grow, reaching ~12.8 billion euros in 2030, representing 5% of the GDP

Through the growing trend verified for the period of analysis, it is expected that the GVA of the renewable energy sector will continue to increase, **reaching approximately 5% of the GDP in 2030**.

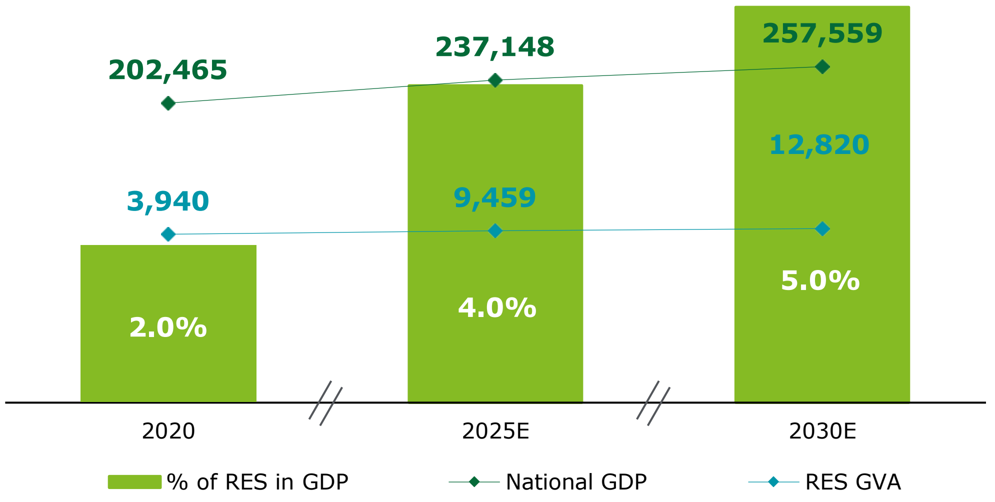

Figure 32. Estimate on the evolution of the GDP and GVA of RES in Portugal (M€)

Source: RES sector players, INE, SABI, Deloitte Analysis

This progression represents an **average annual growth rate of 10.6%**, which is related with the increase in installed capacity and, consequentially, increase in production.

Thus, in 2030, it is estimated that the contribution of RES towards the GDP will represent ~12.8 billion euros, with a direct contribution of ~7.1 billion euros and indirect contribution of ~5.7 billion euros.

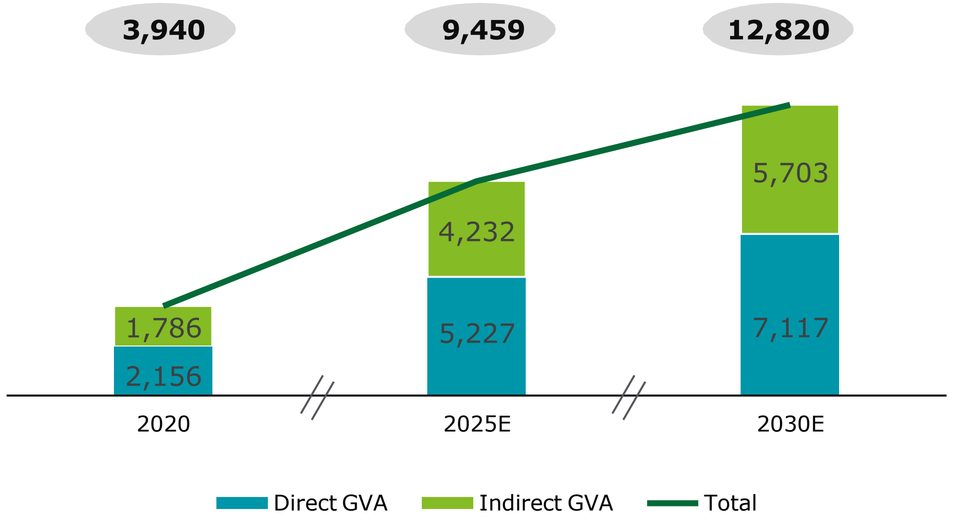

Figure 33. Estimate of the total contribution of the RES electricity sector towards the GDP (M€)

Source: RES sector players, SABI, Deloitte Analysis

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IMPACT ON GDP

***Mix* of RES contribution to GDP – NECP 2030 Scenario**

In 2030, solar will be the main contributor of RES towards the GDP, representing approximately 62% of the total, followed by wind with approximately 23%

In terms of the contribution mix towards the GDP (calculated by adding Direct GVA to Indirect GVA), it is expected that **solar energy will surpass wind energy** as the main contributor towards the GDP (62%). Wind (23%) and hydro (12%), will remain having relevant values for contribution towards the GDP.

When comparing the estimated data between 2020 and 2030, it is possible to verify that the total contribution of RES to the GDP will more than triple, thus requiring an adequate territory planning, the achievement of the defined policies and the involvement of the different sectors of the Portuguese society, in order to guarantee a transition that is able to deliver on the defined goals.

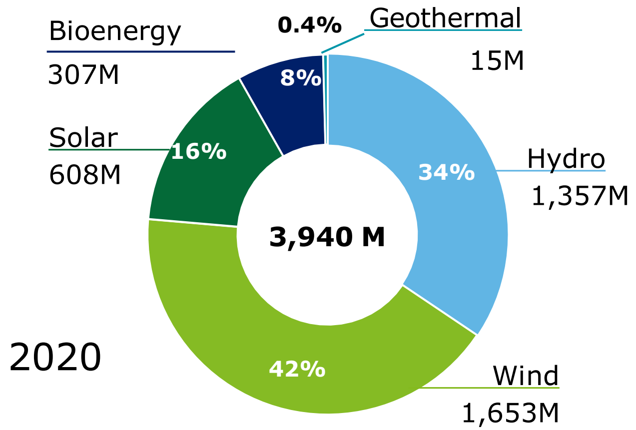

Figure 34. Distribution of total contribution towards the GDP by RES in 2020 (M€)

Source: RES sector players, SABI, Deloitte Analysis

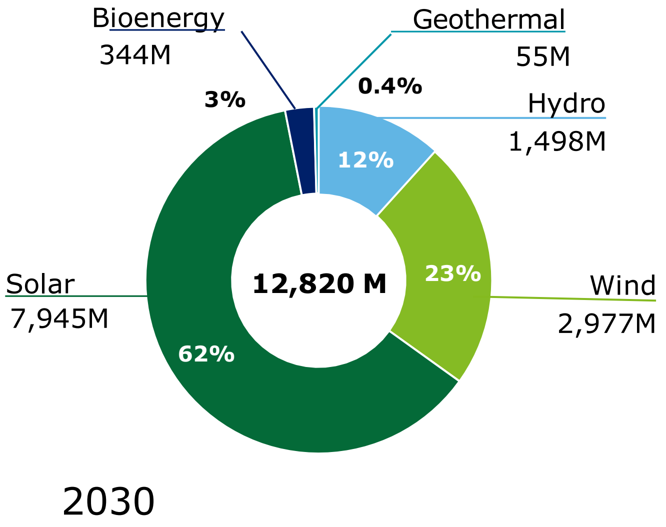

Figure 35. Distribution of total contribution towards the GDP by RES in 2030 (M€)

Source: RES sector players, SABI, Deloitte Analysis

IMPACT ON EMPLOYMENT

Employment from RES between 2016 and 2020

Between 2016 and 2020, RES have generated more than 45 thousand jobs (average per year), with a value added per employee far superior to the national average

For the period of analysis, **the employment generated by RES grew to values above 45 thousand jobs**, reaching its peak of the last 5 years in 2019. The values of 2017 were affected by the less favourable conditions registered, which translated into less direct and indirect employment.

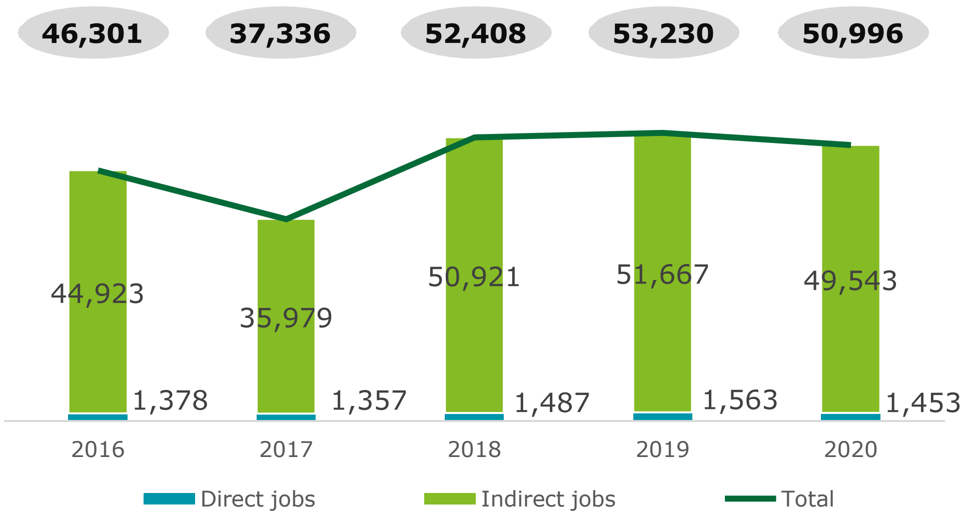

Figure 36. Evolution of the employment generated directly and indirectly by the RES sector

Source: RES sector players, SABI, Deloitte Analysis

With the slight decline in 2020, the impact of the crisis is perceived, registering a reduction in employment, possibly created by the stoppage and delay in the development of ongoing projects with an impact on the entire value chain.

Between 2016 and 2020, it is estimated that the **contribution towards the GDP by each worker** (considering direct and indirect employment) **in the RES sector has registered an annual average of ~75 thousand euros, a value which is two times larger than the national average**, which represented ~39 thousand euros for this period.

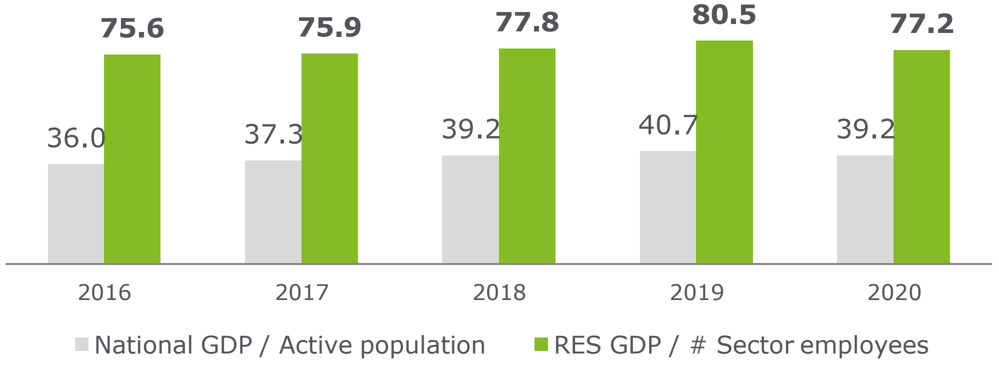

Figure 37. Evolution of the GDP per worker ratio based on total employment (K€)

Source: RES sector players, SABI, INE, Pordata, Deloitte Analysis

Detail of the employment at RES between 2016 and 2020

Wind and hydro are the sources which generated a larger volume of employment (76%, on average, of the RES total) between 2016 and 2020. However, it is solar that generates more employment per installed MW

Wind and hydro registered the highest number of workers in the sector, contributing altogether with approximately 76% of the total value (38,753).

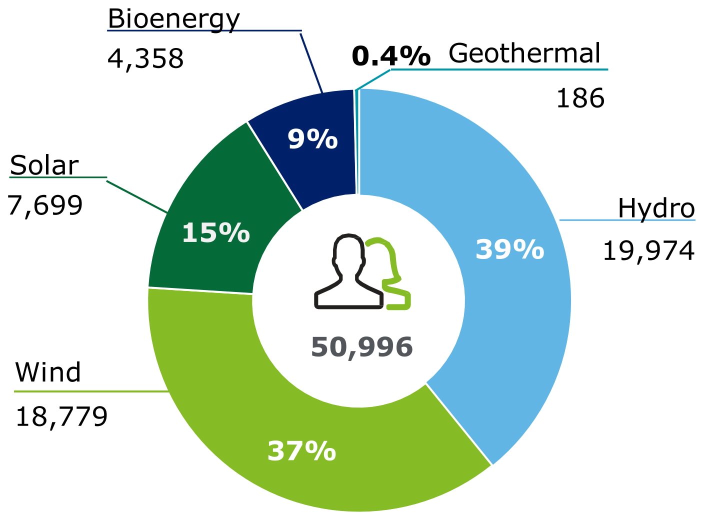

Figure 38. Distribution of total contribution towards job creation by RES in 2020

Source: RES sector players, SABI, Deloitte Analysis

Solar was the one which generated more jobs (considering direct and indirect employment) per installed capacity, registering on average 12 workers per installed MW, a value which is 6 times superior to that of the hydro source.

Hydro has registered a growth of employees per MW installed (1.8 in 2016 and 2.8 in 2020). Similarly, bioenergy also registered a growth trend between 2016 and 2018. On the other year, the wind source recorded a decrease in the average number of employees per MW installed.

Solar has the sharpest drop since employment has increased less than installed capacity, which reflects the increase in scale of this sector.

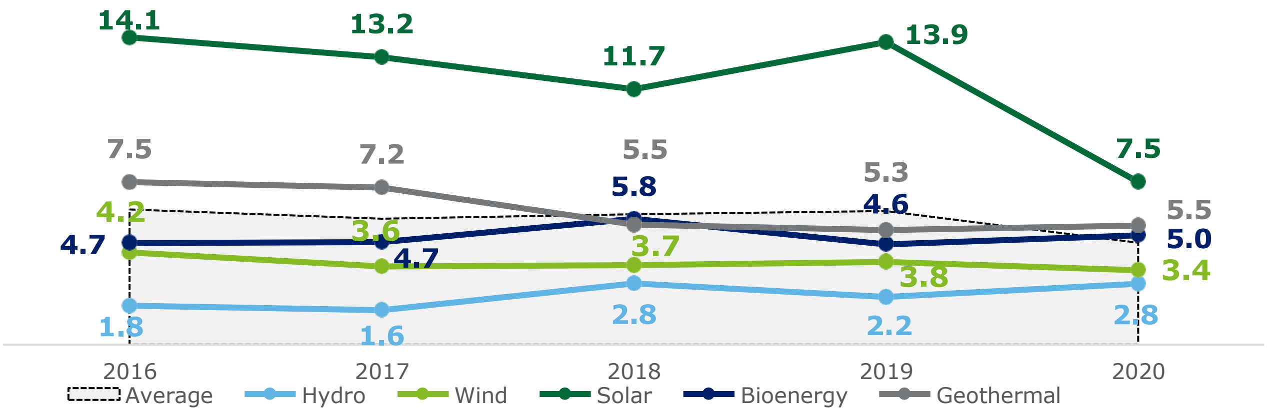

Figure 39. Evolution of the employment ratio (direct and indirect) by installed MW

Source: RES sector players, SABI, Deloitte Analysis

IMPACT ON EMPLOYMENT

Employment at RES– NECP 2030 Scenario

With the expected growth of the installed capacity and electricity generated from renewable sources in the upcoming years, the impact of the RES sector on employment will continue to intensify, particularly due to the growth of solar

Between 2020 and 2030, the impact of RES on employment will more than triple, generating an **additional of more than 90 thousand workers** in the sector.

These values are due to the sector's growth, namely of the solar. It is estimated that the latter will be responsible for about 62% of the associated workers, directly and indirectly, to the sector in 2030.

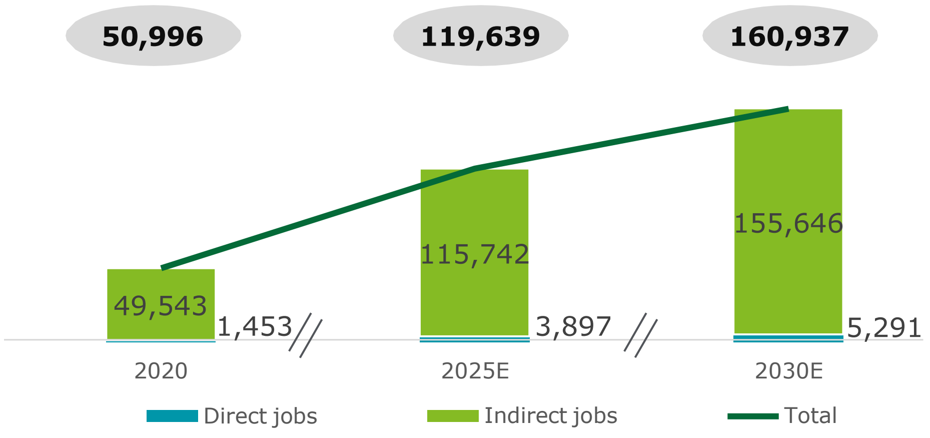

Figure 40. Estimate of job creation in the RES electricity sector

Source: RES sector players, SABI, Deloitte Analysis

Employment will grow on all energy sources, although at different paces. Due to the high growth of solar, the weight of hydro will be reduced to 14% in 2030. Nonetheless, all energy sources will increase the number of workers between 2025 and 2030 (e.g., wind power will grow by about 8 thousand jobs).

The steep increase of workers in the sector until 2030 should be accompanied by a reinforcement of the professional training for the sector in a context of increasing complexity of the energy system, increasingly integrated with a high renewable participation. This requires a focus on increasing skills in digital technologies, new business models for decentralized generation and planning, management and efficiency of generation, transmission, distribution and consumption, in order to ensure a reliable and cost-effective system.

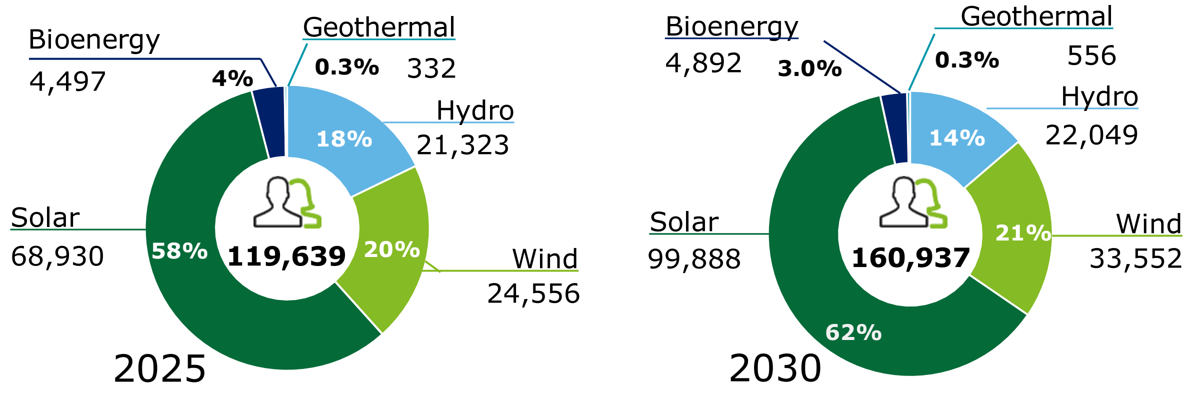

Figure 41. Distribution of job creation by Renewable Energy Source in 2020 and 2030

Source: RES sector players, SABI, Deloitte Analysis

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Impact on employment

RES Contribution to Social Security – NECP 2030 Scenario

In 2030 the contributions for Social Security from RES will reach more than 1.6 billion euros

Considering the growth for employment for the period of analysis, it is estimated that the total contribution of the RES sector towards Social Security will maintain a similar trend.

Assuming an average monthly base salary for employees in the sector of electricity, gas and water (2,087 €, in 2019, growing at the inflation rate), it is estimated that, **between 2020 and 2030, the sector will represent a cumulative total of more than 12 billion euros of contributions**, among individual and company contributions.

The average annual value of contributions estimated between 2020 and 2030 is about one billion Euros, which would be enough to ensure about 300 thousand minimum pensions[1].

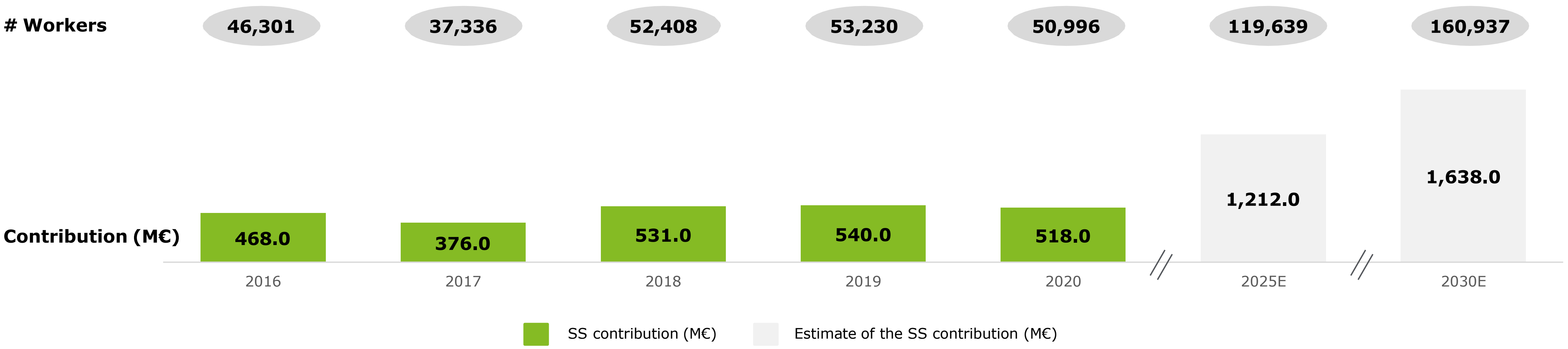

Figure 42. Impact of RES on Social Security

Source: RES sector players, SABI, Pordata, Deloitte Analysis

[1] Assuming a minimum monthly value for old-age and disability pensions, in 2020, of 273.4€

Impact on employment

RES Contribution to IRS – NECP 2030 Scenario

In 2030 the value of IRS from employees associated with RES will be more than 1.3 billion euros

Considering the same growth of employment, the IRS contribution will also increase, in line with Social Security (SS).

Assuming an average monthly base salary for employees in the sector of electricity, gas and water (2,087 €, in 2019, growing at the inflation rate), and the average rates seen in this income bracket in 2020, it is estimated that **between 2020 and 2030, the sector's employees will contribute with a cumulative total of more than 10 billion euros of IRS.**

Thus, the average annual IRS estimated between 2020 and 2030 is around 920 million euros.

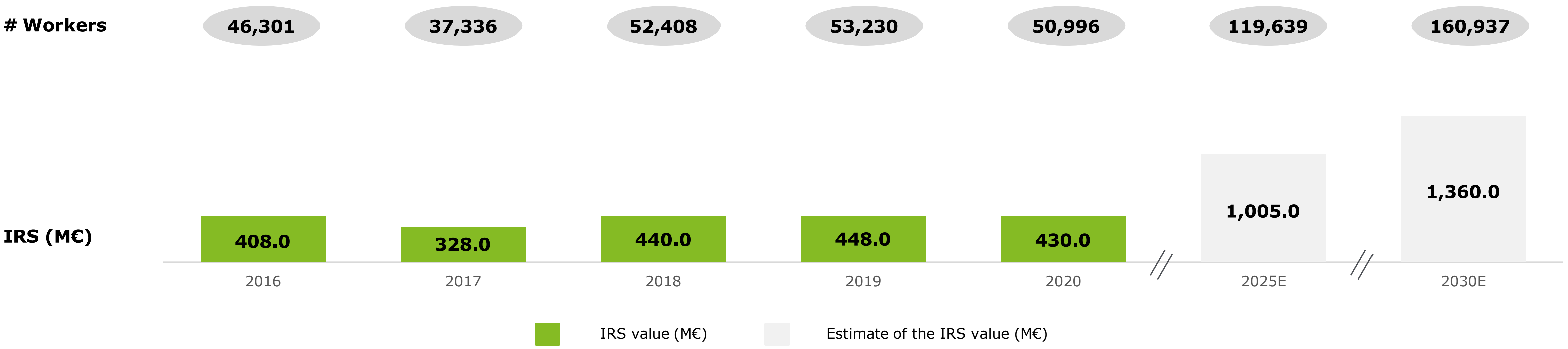

Figure 43. Impact of RES on the IRS

Source: RES sector players, SABI, Pordata, Deloitte Analysis

Impact on taxes

Evolution of the Corporate Income Tax and Municipal Surtax in the Renewable sector– NECP 2030 Scenario

Between 2016 and 2020, the Portuguese State collected each year on average about 228 million euros of Corporate Income Tax and about 16 million euros of Municipal Surtax from the RES sector. It is estimated that in 2030 this value will rise to more than 515 million euros.

In 2020, the RES power plants contributed with more than 225 million euros towards the Corporate Income Tax, with hydro and wind sectors contributing each one with approximately 38% of that value. In terms of the Municipal Surtax, it is estimated that, for the same time period, the State collected 17 million euros.

In 2030, it is estimated that the sector will contribute with 482 million euros of Corporate Income Tax.

When it comes to the Municipal Surtax, it is estimated that the sector will contribute with 34 million euros.

Between 2020 and 2030, it is predicted that the sector will generate a cumulative total of approximately 4.2 billion euros of Corporate Income Tax and Municipal Surtax.

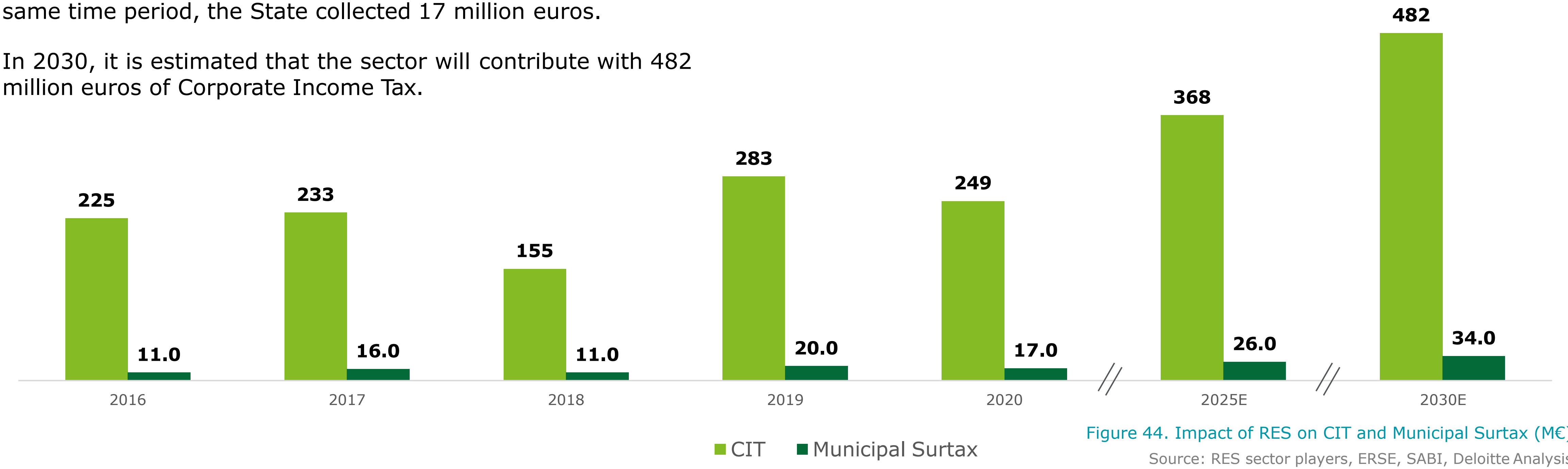

Figure 44. Impact of RES on CIT and Municipal Surtax (M€)

Source: RES sector players, ERSE, SABI, Deloitte Analysis

IMPACT ON TAXES

Impact on VAT – NECP 2030 Scenario

In 2020, electricity producers had a net contribution of 496 million euros to VAT, and the annual value is expected to rise to 1.9 billion euros in 2030

In 2020, RES power plants recorded around 682 million euros to be settled from their operating income and 186 million euros to be deducted from their operating costs.

In the period 2016-2020, the accumulated balance between the VAT to be settled and deducted **generated by the centres is 2.4 billion euros.**

In 2030, is expected that the VAT to be paid and VAT to be deducted annually will be around 2.4 billion euros and 441 million euros, respectively, resulting in an annual balance of around 1.9 billion euros – **almost 4x higher than in 2020**.

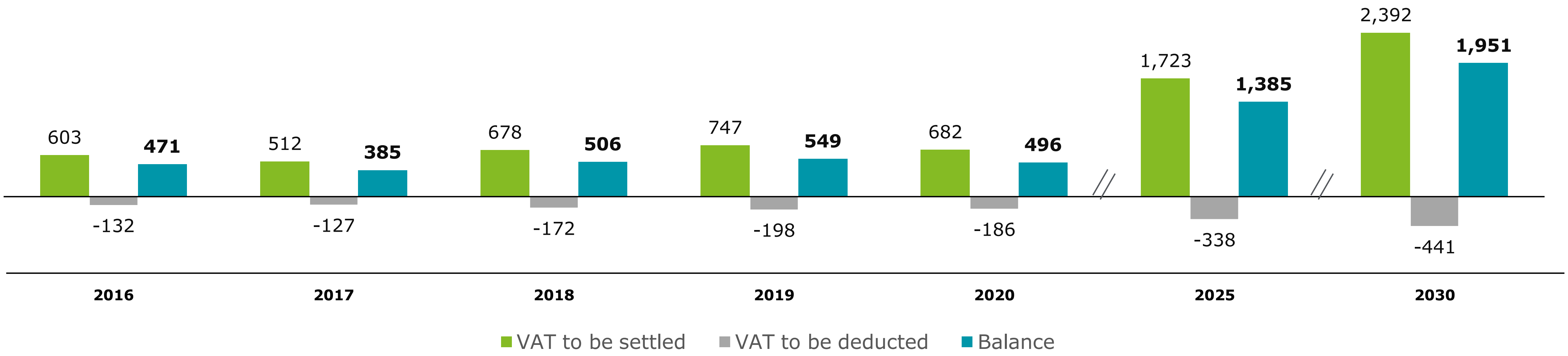

Figure 45. Impact of RES on VAT (M€)

Source: RES sector players, ERSE, SABI, Deloitte Analysis

Direct private investment in RES based power plants between 2011 and 2020

Between 2011 and 2020, direct private investment in the power plants based on RES had an annual average of around 745 million euros, with wind energy and hydro having the highest volume of investments.

Between 2011 and 2020, direct private investment in the power plants based on RES amounted to around 7.4 billion euros, representing an annual average of around 745 million euros. Peak investment in this period was reached in 2016, due to the inauguration of the hydropower plants Salamonde II, Baixo Sabor, Venda Nova III and Foz Tua.

Hydro absorbed the largest share of investment, with a total accumulated investment of around 3.2 billion euros, representing an annual average of around 323 million euros. **Wind was the renewable source with the second largest share of investment**, with a cumulative total of around 2.4 billion euros, representing an annual average of around 248 million euros. **Solar recorded the third largest share of investment**, with a cumulative total of around 1.3 billion euros, representing an annual average of around 131 million euros.

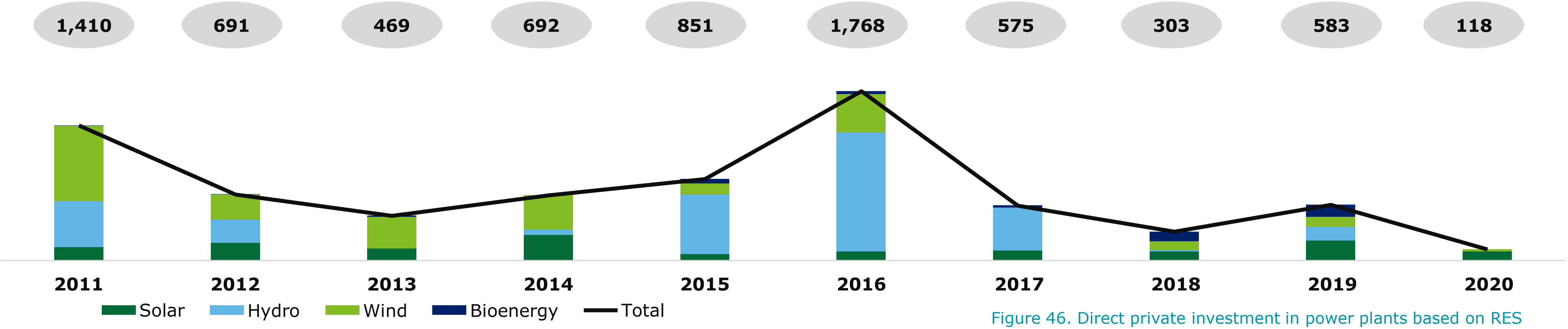

Figure 46. Direct private investment in power plants based on RES between 2011 and 2020 (M€)

Source: IRENA, DGEG, APREN Analysis, Deloitte Analysis

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Annual investment

Direct private investment in RES based power plants until 2030 – NECP 2030 Scenario

Direct private investment in RES power plants is expected to reach an average of around 2 billion euros annually, with solar and wind energy being the main focuses of investment

From 2021 to 2030, **direct private investment in RES based power plants** and the **repowering of wind power plants** is expected to amount to around **20 billion euros**, representing an **annual average of around 2 billion euros**. The investment peak is expected to be reached in 2025.

Solar will absorb the largest share of private investment, with a total accumulated investment of around 8.2 billion euros by 2030, representing an annual average of around 821 million euros.

The **investment in wind will continue**, with a total accumulated private investment of around 5.4 billion euros by 2030, representing an annual average of around 542 million euros. This also highlights **the investment associated with the repowering of wind power***, which is expected to total around 4.8 billion euros between 2021 and 2030, representing an annual average of 483 million euros of investment.

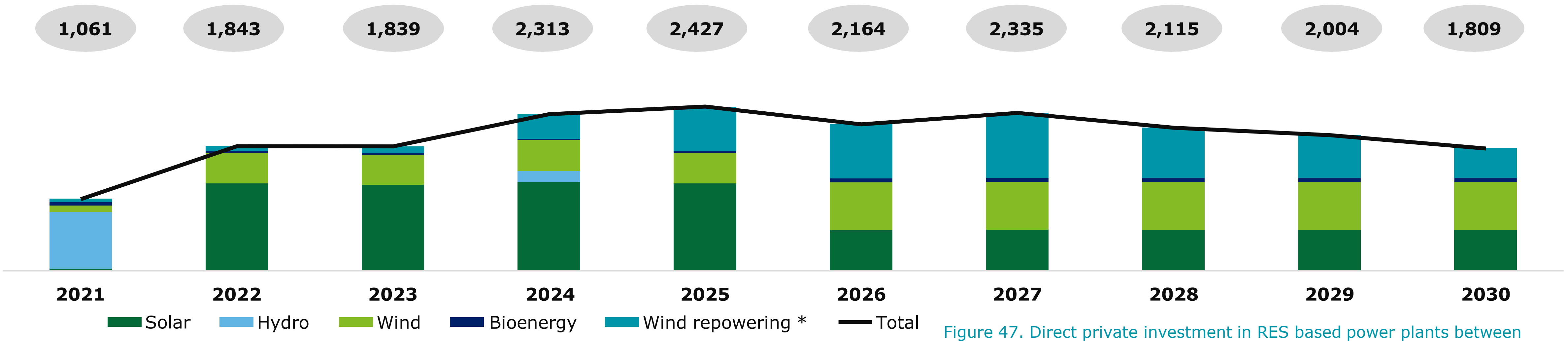

Figure 47. Direct private investment in RES based power plants between 2021 and 2030 (M€)

Source: IRENA, NECP 2030, APREN Analysis, Deloitte Analysis

*Estimate based on the assumption that a wind power plant needs repowering after 20 years of operation.

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ECONOMIC/SOCIAL IMPACT OF THE SECTOR

Conclusions

- The cumulative RES contribution towards the GDP surpassed 18 billion euros between 2016 and 2020, corresponding to an average annual value of ~3.7 billion euros;
- Within the RES context, the wind sector was the one which impacted the GDP the most in 2020. In terms of the contribution by MW, solar stands out with an average annual contribution of 958k €/MW, between 2016 and 2020;
- According to the established goals for the 2030 horizon, it is estimated that the GVA derived from RES will grow, reaching ~927 million euros in 2030;
- In 2030, solar will be the main contributor of the RES towards the GDP, representing approximately 62% of the total, followed by wind with approximately 23%;
- Between 2016 and 2020, the RES have generated more than 45 thousand jobs (average per year), with a value added per employee far superior to the national average;
- Wind and hydro are the ones which generated a larger volume of employment (76% on average of the total RES) between 2016 and 2020, however, it is solar that generates the more employment per MW installed.

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ECONOMIC/SOCIAL IMPACT OF THE SECTOR

Conclusions

- With the expected growth of the installed capacity and electricity generated from renewable sources in the upcoming years, the impact of the RES sector on employment will continue to intensify, particularly due to the growth of solar;
- In 2030 the contributions for Social Security and IRS from RES will reach more than 1.6 billion euros and 1.3 billion euros, respectively;
- Between 2016 and 2020, the Portuguese State collected each year on average about 228 million euros of CIT and about 16 million euros of Municipal Surtax from the RES sector. It is estimated that in 2030 this value will rise to more than 515 million euros;
- In 2020, the electricity producers had a net contribution of 496 million euros to VAT, with an annual value expected to amount to 1.9 billion euros in 2030;
- Between 2011 and 2020 around 7.4 billion euros of private funds were directly invested in RES based power plants. It is expected that between 2021 and 2030 direct investment in power plants will be around 20 billion euros in renewable energy sources to meet the objectives set out in the NECP.

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6. Environmental Impact

AVOIDED EMISSIONS

Avoided CO_2 emissions

Renewable electricity prevented the emission of 19.9 million tons of CO_2 in 2020, by replacing more polluting sources

The increase in renewable energy production allowed, between 2016 and 2020, to avoid the emission of more than 50 million tons of CO_2 equivalent.

From 2017, there is an annual increase in avoided emissions, as a result of the increase in production from renewable sources and the consequent reduction in production from fossil energy sources.

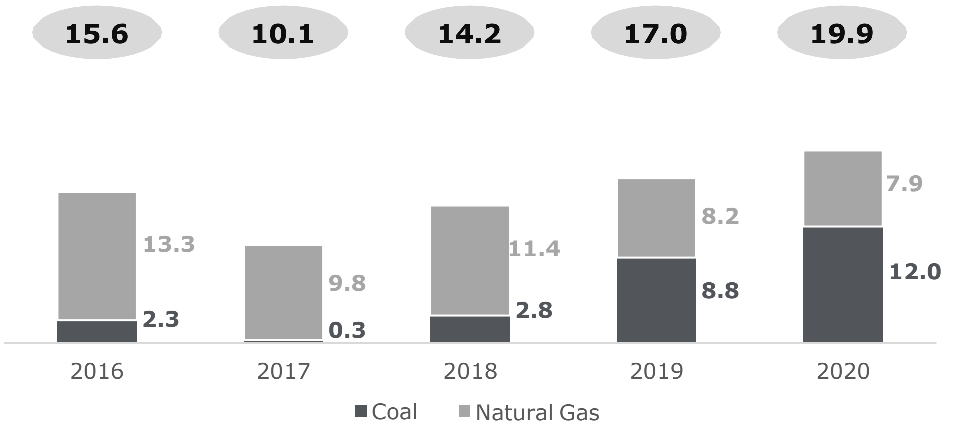

Figure 48. Avoided CO_2 emissions ($MtCO_2$-eq) between 2016 and 2020

Source: DGEG, ERSE, RMSA, Sendeco2, Deloitte Analysis

With the closure of the Sines thermal power plant in January 2021 and the closure of the Pego plant scheduled for the last quarter of 2021, Portugal will no longer have in operation thermoelectric plants to produce electricity from coal.

In the scope of the NECP 2030 Scenario, despite the drop in avoided emissions associated with the replacement of coal by natural gas, avoided emissions are expected to continue to increase until 2030, with the growth of renewable generation.

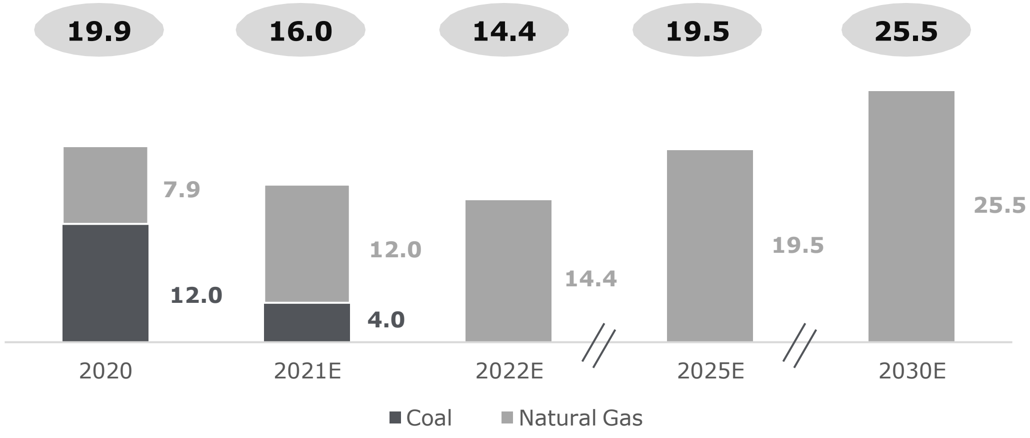

Figure 49. Avoided CO_2 emissions ($MtCO_2$-eq) by 2030

Source: DGEG, ERSE, Sendeco2, Deloitte Analysis

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AVOIDED EMISSIONS

CO_2 Allowances costs avoided

By 2030, total annual savings are expected to amount to around 2.4 billion euros with CO_2 allowances, associated with 25.5 million tons of CO_2 equivalent avoided and a projected €108/t price for 2030

In the last two years, the production of electricity by RES allowed **accumulated savings of more than 819 million euros** – 2.5x higher than the accumulated of the previous 3 years (2016-2018), as a result of the increase in the volume of avoided emissions and the growth in the price of CO_2 emission allowances traded in the European Emissions Trading System (from €5.35/t in 2016 to €24.75/t in 2020).

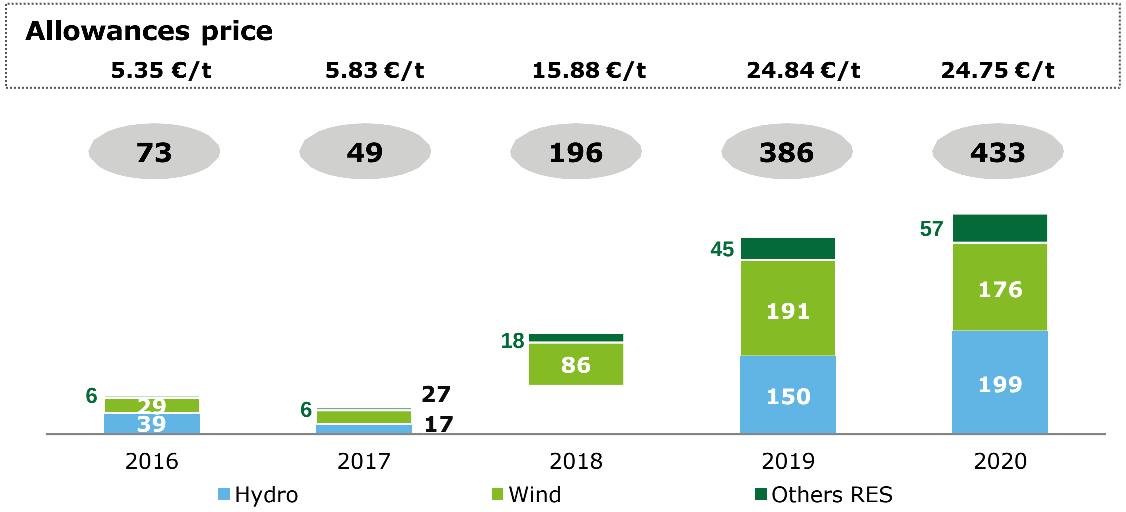

Figure 50. Total costs avoided with CO_2 allowances due to RES production (M€)

Source: DGEG, ERSE, Sendeco2, Deloitte Analysis

For the NECP 2030 scenario, a significant increase in the contribution of RES in avoided costs of allowances is expected, which will be 2x by 2025 and more than 5x higher than 2020. This result is not only due to increased RES electricity production but also, and mainly, due to the expected increase in allowance prices (€69/t CO_2 in 2025 and €108/t in 2030). The savings mix will be largely represented, as a total, by 3 renewable sources (wind, hydro and solar).

By 2030, the RES that will contribute the most to savings in CO_2 allowances will be wind and solar, with savings of 1,006 million euros and 708 million euros with these two sources, respectively.

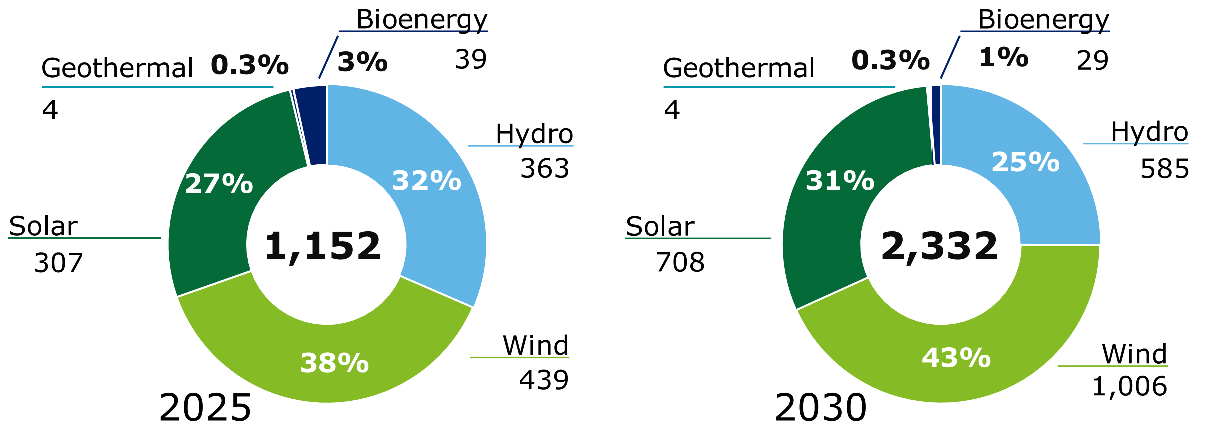

Figure 51. Estimated costs of CO_2 allowances avoided due to RES production in 2025 and 2030 (M€)

Source: DGEG, ERSE, RMSA, Bloomberg, Deloitte Analysis

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ENVIRONMENTAL IMPACT OF THE SECTOR

Findings

- Electricity from a renewable source, by replacing more polluting sources, has avoided the emission of 19.9 million tons of CO_2 equivalent in 2020, which corresponds to savings of 433 million euros in CO_2 emission allowances;

- In the NECP 2030 scenario, the total annual savings are expected to amount to around 2.4 billion euros with CO_2 allowances, associated with 25.5 million tons of CO_2 equivalent avoided and a price of 108€/t expected for 2030.

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7. Impact on Energy Dependency

Impact on avoided imports

Avoided fossil fuel imports between 2016 and 2020

Between 2016 and 2020, the production of renewable electricity saved about 4.1 billion euros in imports of coal and natural gas

The production of renewable electricity has prevented an average annual value equivalent to 28,236 GWh in fossil fuel imports between 2016 and 2020, avoiding a total of about 141 thousand GWh of imported fossil fuels during this period.

By 2020, it is estimated that ~514 million euros in fossil fuel imports were avoided, 727 million less than in 2018. This difference is explained by the fall in coal and natural gas prices in this period and a drop in consumption in 2020 as a result of the pandemic crisis, which led to a lower need for fossil fuels to ensure supply.

Between 2016 and 2020, around 4.1 billion euros was saved in fossil fuel imports by the use of renewable energy sources to produce electricity.

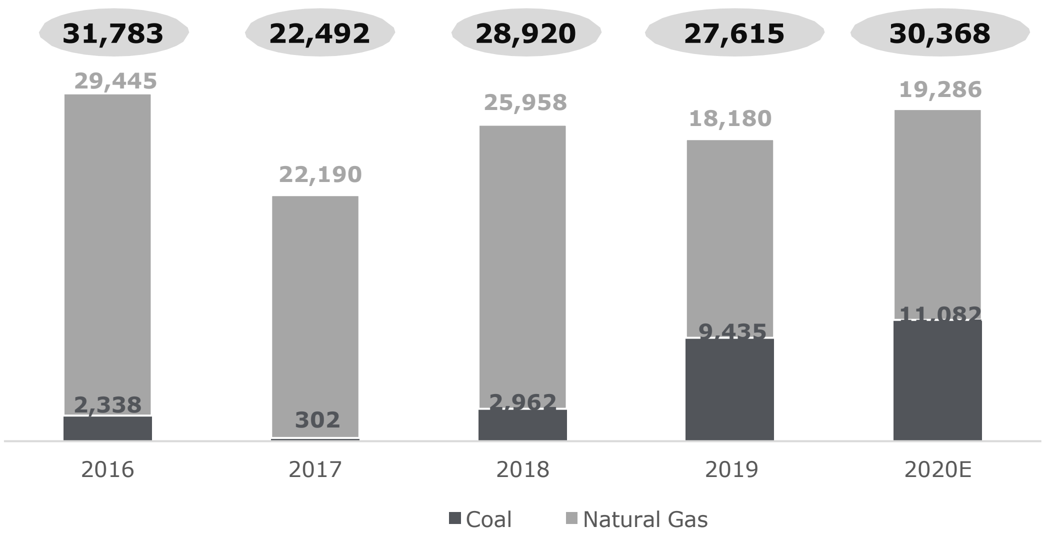

Figure 52. Evolution of avoided imports (GWh)
Source: DGEG, Deloitte Analysis

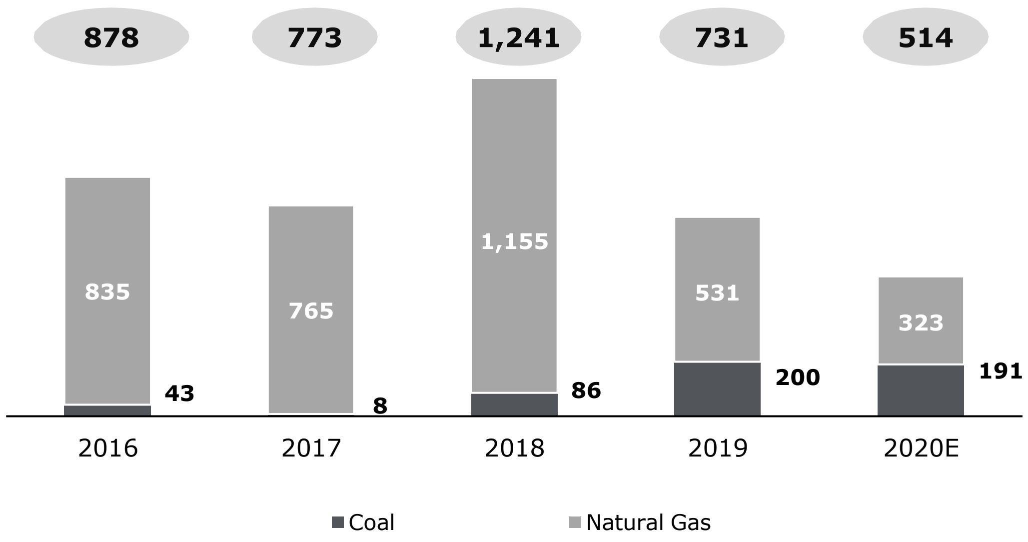

Figure 53. Total import costs avoided by type of fossil fuel imported (M€)
Source: DGEG, Deloitte Analysis

IMPACT ON AVOIDED IMPORTS

Avoided fossil fuel imports – NECP 2030 Scenario

With the increase in electricity production through RES provided for in the NECP, the volume of avoided fossil fuel imports will also increase by 2030, when the import of about 60 TWh will be avoided

Renewable electricity production has a positive impact on the trade balance and on the reduction in the energy dependency rate.

As a result of the expected increase in RES production, it is estimated that in 2030 avoided imports would reach 60,305 GWh, more than 2x higher than 2020.

Renewable electricity production will result in cumulative savings of more than 19 billion euros between 2020 and 2030, of avoided fossil fuel imports.

Electricity production from coal will cease in 2021 and the role of natural gas in the energy mix will decrease (e.g., the Tapada do Outeiro combined cycle power plant is expected to close in 2029).

Thus, in 2030, avoided imports should reach ~2.7 billion euros, about 5.2x higher than the 2020 figure.

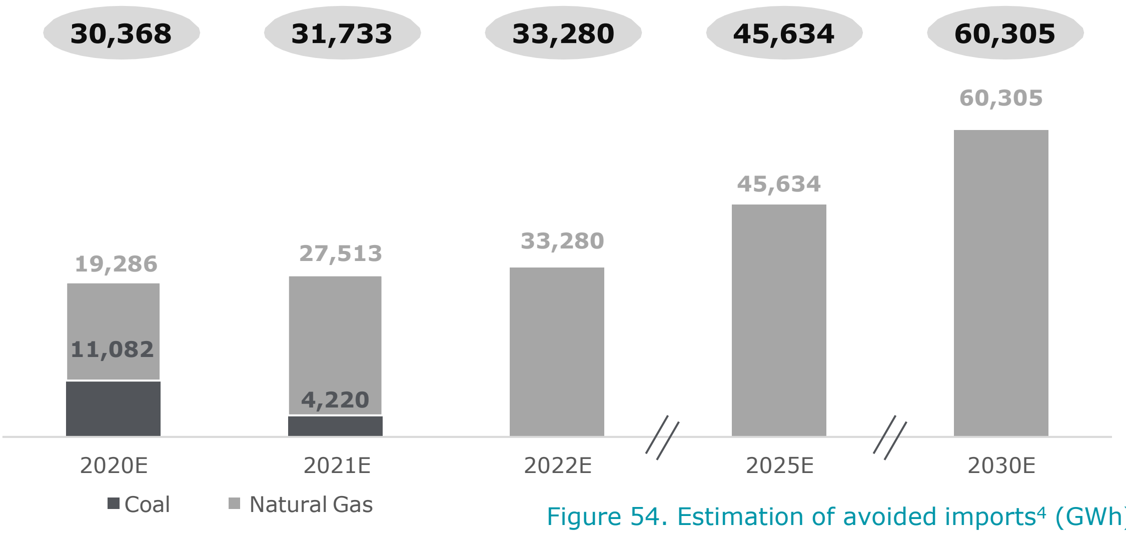

Figure 54. Estimation of avoided imports[4] (GWh)

Source: DGEG, Deloitte Analysis

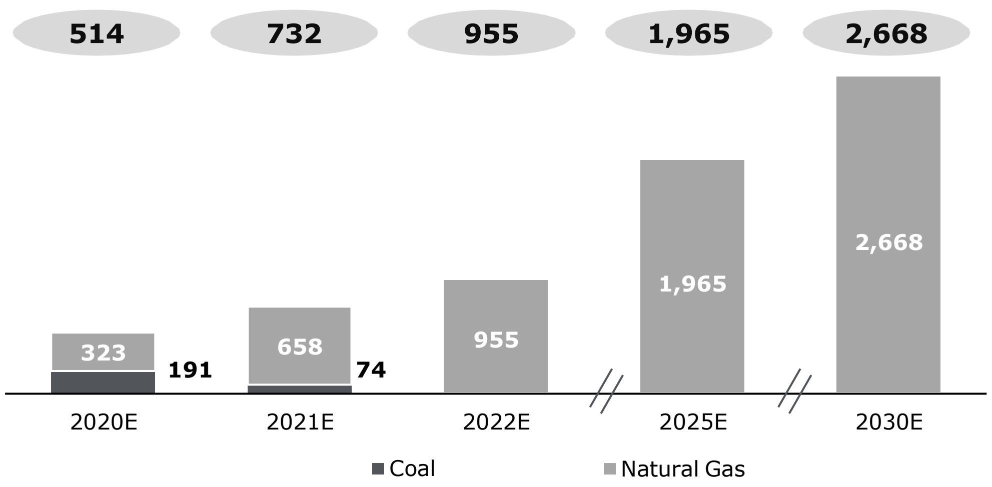

Figure 55. Estimated total import costs avoided by type of fossil fuel (M€)

Source: DGEG, Deloitte Analysis

[4] Assuming an annual equivalent number of hours at full capacity of 8.000 hours

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IMPACT ON ENERGY DEPENDENCY

Impact of RES on energy dependency – NECP 2030 Scenario

The incentive on electricity production from endogenous and renewable sources will tend to reduce external energy dependency by more than 22 p.p. by 2030

In 2020, energy dependence is estimated to have reached its lowest level in recent years, largely due to the reduction in electricity consumption as a result of the pandemic situation.

By 2030 it is estimated that RES production levels will reduce the energy dependency value to 67.8%. This value is representative of the weight that renewable energies have in reducing energy dependency: the higher the RES production, the lower the external energy dependency.

If there were no renewables in 2030, the energy dependency rate would be expected to reach 90.3%, 22.4 p.p. higher than the estimated value with RES.

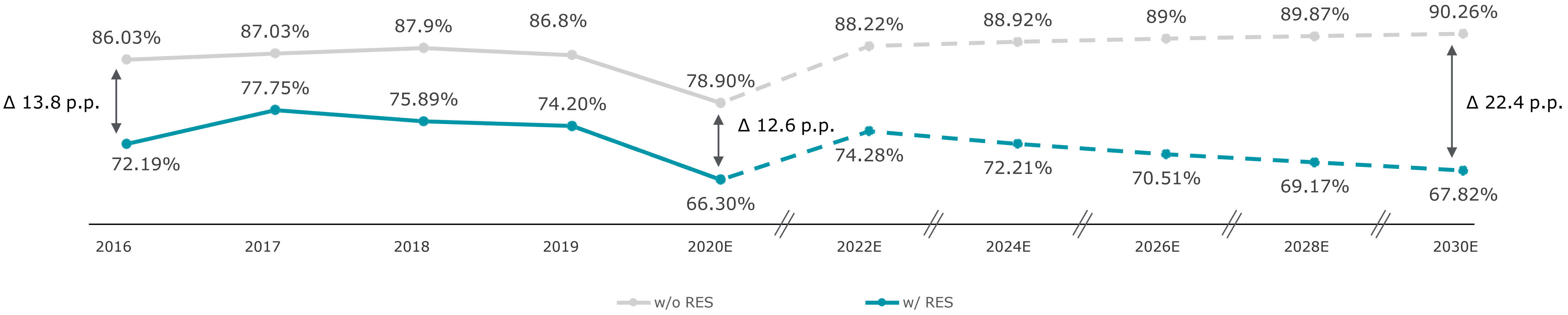

Figure 56. Impact on the evolution of the energy dependency rate (real rate vs. estimated rate w/o renewables)

Source: DGEG, Deloitte Analysis

Note: The historical values (2016-2019) were adjusted according to the revisions made by DGEG to the Synthetic Energy Balance, compared to that available in 2018

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Impact of the sector on energy dependency

Findings

- Between 2016 and 2020, the production of renewable electricity saved about 4.1 billion euros in imports of coal and natural gas;
- With the increase in electricity production through RES defined in the NECP 2030, the volume of fossil fuel imports avoided will also increase until 2030, when the import of about 60 TWh will be avoided;
- The incentive on electricity production from endogenous and renewable sources will tend to reduce external energy dependency by more than 22 p.p. by 2030.

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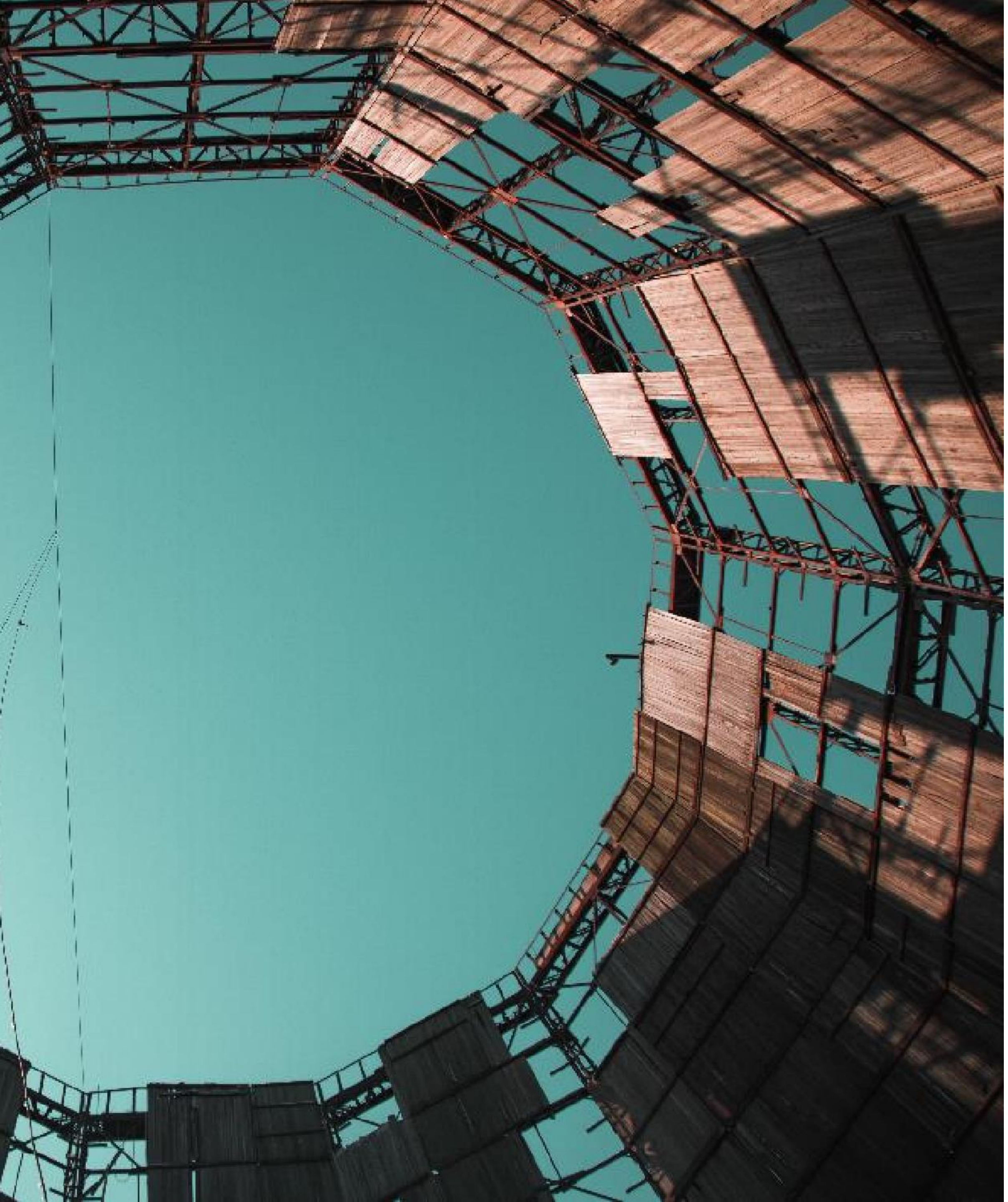

8. Impact of Green H_2 and Increased Climate Ambition

Impact of Green H_2 and increased climate ambition

Installed capacity in 2030 considering green H_2 and increased climate ambition

Two alternative scenarios were analysed which consider additions to the installed capacity of RES envisioning a reduction of GHG emissions of 55% compared to 1990 and the implementation of EN-H2

Up to this chapter, the results have been presented in a single perspective of the implementation of the NECP 2030. However, this scenario does not include the role of green hydrogen (H_2) in the decarbonization of sectors which direct electrification is not a cost-effective option, and also does not fit the new climate ambition of the European Union, which aims a reduction of GHG emissions of 55% compared to 1990.

Considering the implementation of EN-H2, assuming an installed capacity of electrolysis of 2.5 GW, and based on an increased Portuguese ambition of 55% reduction of GHG compared to 1990 values, estimates were made of the socio-economic and environmental impact in 2030 of two scenarios developed by CENSE – FCT NOVA, using the TIMES-PT model, which consider different production volumes of green H_2 and, consequently, different needs for additional capacity for electricity generation from renewable sources. These impacts will be presented as additional to the impacts described in the previous chapters of this document.

It should be noted that the model simulates the energy system, from a cost-effectiveness perspective, and that it is an exclusively national model, which does not explicitly consider the external market, making it necessary to allocate a unit export cost to H_2.

It is from this perspective that **two distinct scenarios have been analysed**, being **differentiated by the export price of H_2**, both in line with IRENA's forecasts for 2030, namely:

- **Baseline Scenario,** which assumes an H_2 cost in the international market of 1.4-2.0 \$/kg in 2030, being in line with the sector and export objectives and targets mirrored in EN-H2.
- **Export Scenario,** which assumes a higher unit value for H_2 of 3.0-3.5 \$/kg in the international market, leading to a stronger increase in global demand for green H_2.

In both scenarios, the imposition of a minimum installed capacity of 2.5 GW of electrolysis was placed, without inhibiting that there is an increase of the same if it is considered cost-effective by the model to achieve climate ambition.

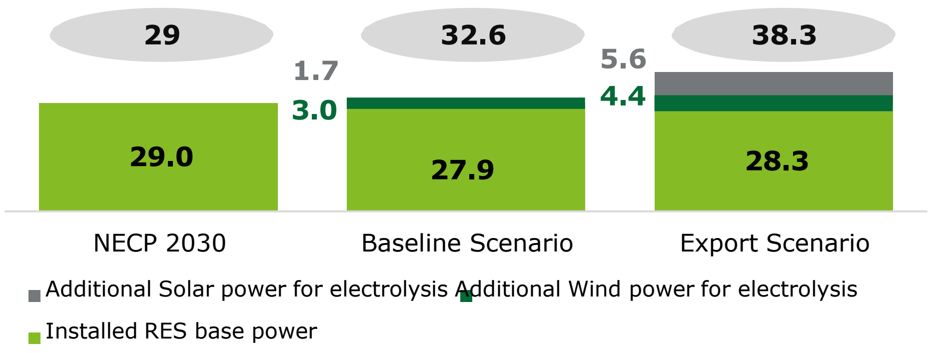

Figure 57. Installed power in 2030 (GW) for the 2 alternative scenarios

Source: CENSE – FCT NOVA, IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi.

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ECONOMIC/SOCIAL IMPACT

Contribution to GDP and Employment in 2030 considering green H_2 and increased climate ambition

The increase in RES production capacity from the Baseline and Export scenarios could add between 2 and 6.5 billion euros to the GDP in 2030. In terms of employment, the increase could represent between 24 and 83 thousand jobs in 2030

Impact on GDP

The increase in renewable generation capacity estimated in **the Baseline Scenario could add around 2 billion euros to the GDP in 2030**. In the **Export Scenario**, this value would amount to **6.5 billion euros**, more than 50% of the impact of the NECP scenario.

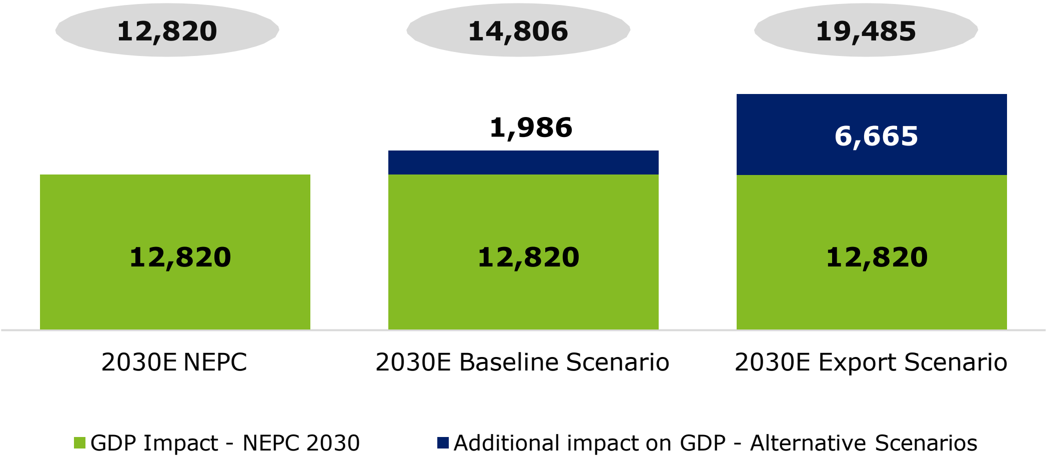

Figure 59. Estimated contribution to GDP (M€) with the Baseline Scenario and Export Scenario Source: APREN Analysis, Deloitte Analysis

Impact on employment

As for impact of the Baseline and Export scenarios on employment generation resulting from renewable electricity production in 2030, the **Baseline Scenario could add a total of about 24 thousand jobs in that year**. In the case of the **Export Scenario, the increase would be about 83 thousand jobs** in the sector in 2030.

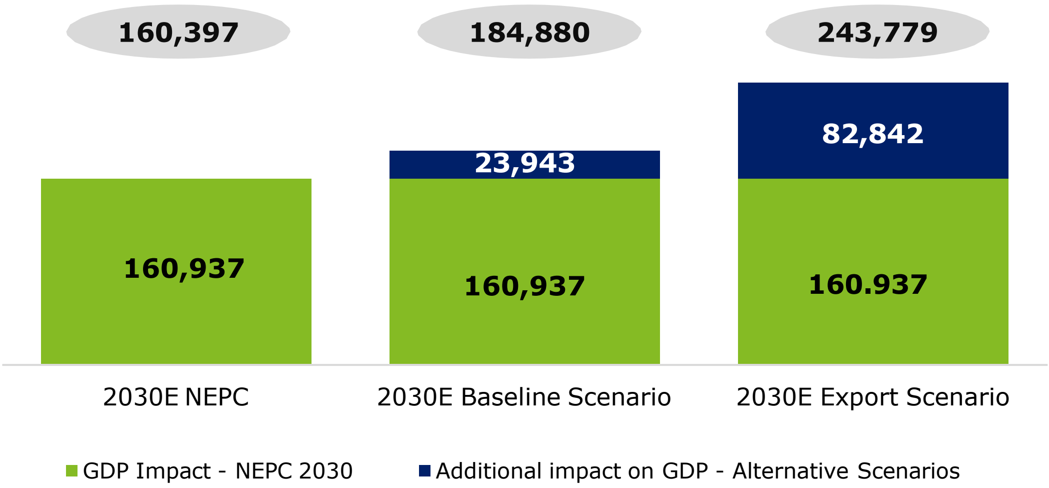

Figure 60. Estimated contribution of RES to national employment with the Baseline Scenario and Export Scenario

Source: APREN Analysis, Deloitte Analysis

Contribution of RES to Social Security and IRS in 2030 considering green H_2 and increased climate ambition

In 2030, green H_2 could add to the impact resulting from the NECP 2030 between 243 and 842 million euros for Social Security, and between 201 and 698 million euros for the IRS

Impact on IRS

In the same context, it is estimated that **by 2030 additional employees resulting from the incorporation of green H_2 could generate between 201 and 698 million euros additional IRS.**

Impact on Social Security

Assuming that the average monthly base remuneration of employees in the sector remains the same (2,087 €, in 2019, adjusted for inflation), it is estimated that in 2030 **additional employees resulting from the incorporation of green H_2 will be able to contribute an additional between 243 and 842 million euros for Social Security**.

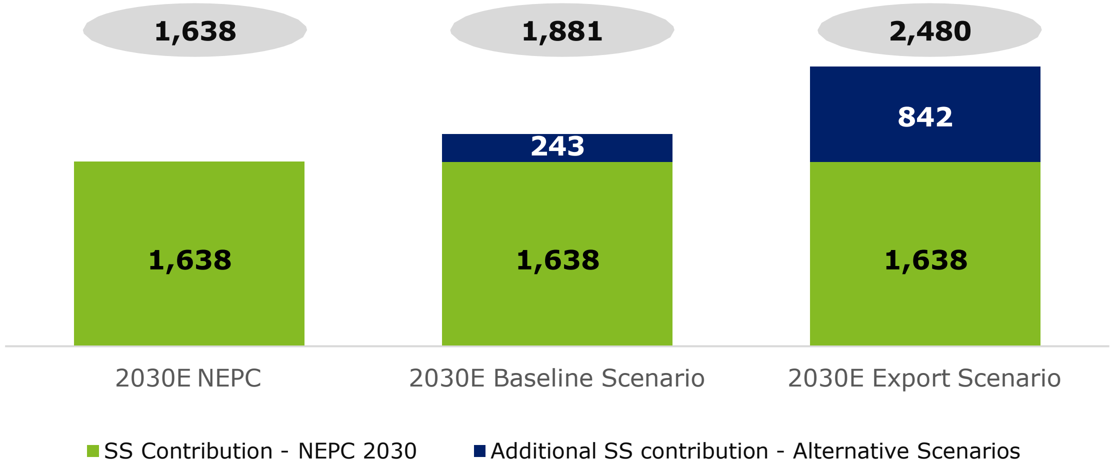

Figure 61. Estimated contribution to Social Security (M€) for the Baseline Scenario and Export Scenario

Source: APREN Analysis, Deloitte Analysis

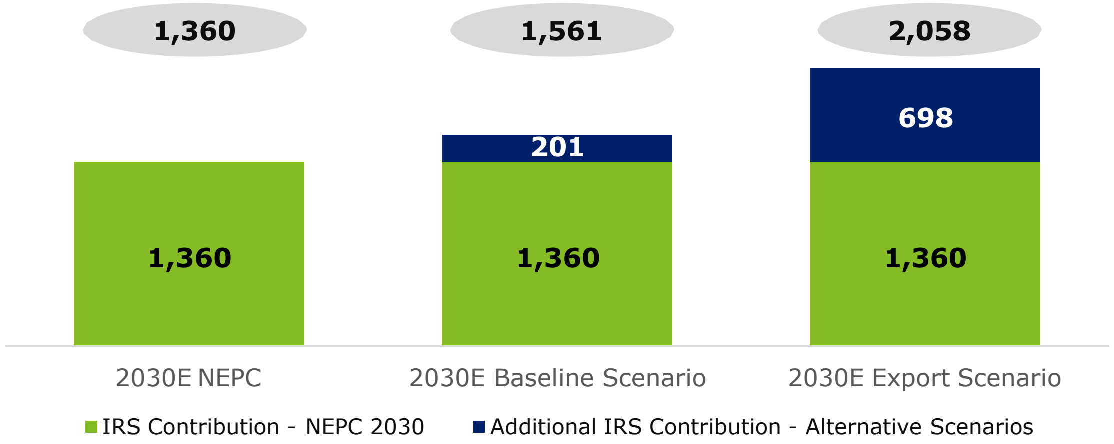

Figure 62. Estimated contribution to the IRS (M€) for the Baseline Scenario and Export Scenario

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CIT and VAT in the Renewables sector in 2030 considering green H_2 and increased climate ambition

In 2030, the Baseline and Export scenarios could contribute an additional between 81 and 165 million euros for CIT, and between 350 million and 1.1 billion euros of net VAT contribution

Impact on CIT

Regarding the contribution to **CIT**, it is estimated that in 2030, with the emergence of green H_2, the RES sector **could add between 81 and 165 million euros in that year.**

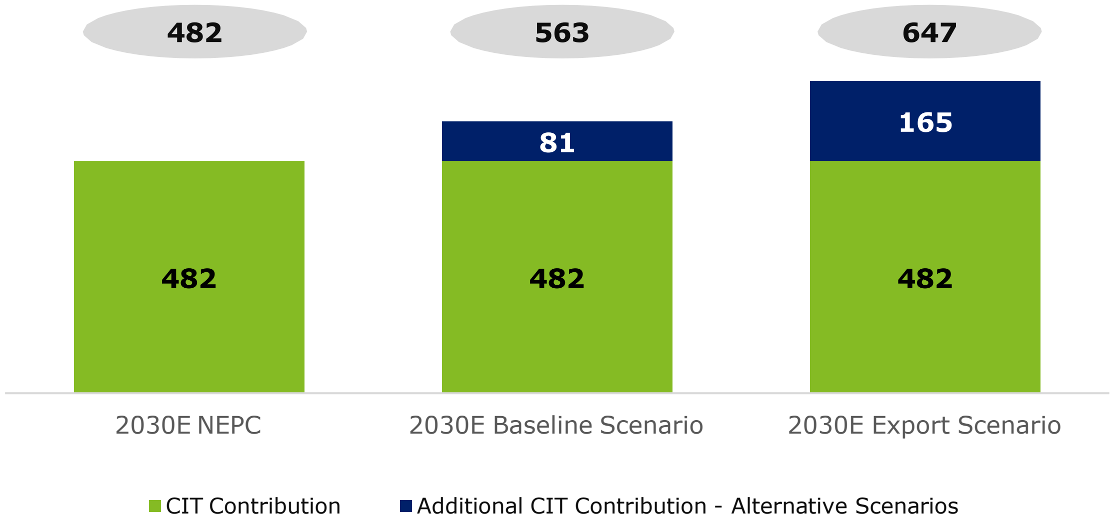

Figure 63. Estimation of the contribution to CIT (M€) with the Baseline Scenario and Export Scenario Source: APREN Analysis, Deloitte Analysis

Impact on VAT

As for **VAT**, it is estimated that in 2030, **green H_2 could generate an increase in the net contribution of this tax between 350 million and 1.1 billion euros.**

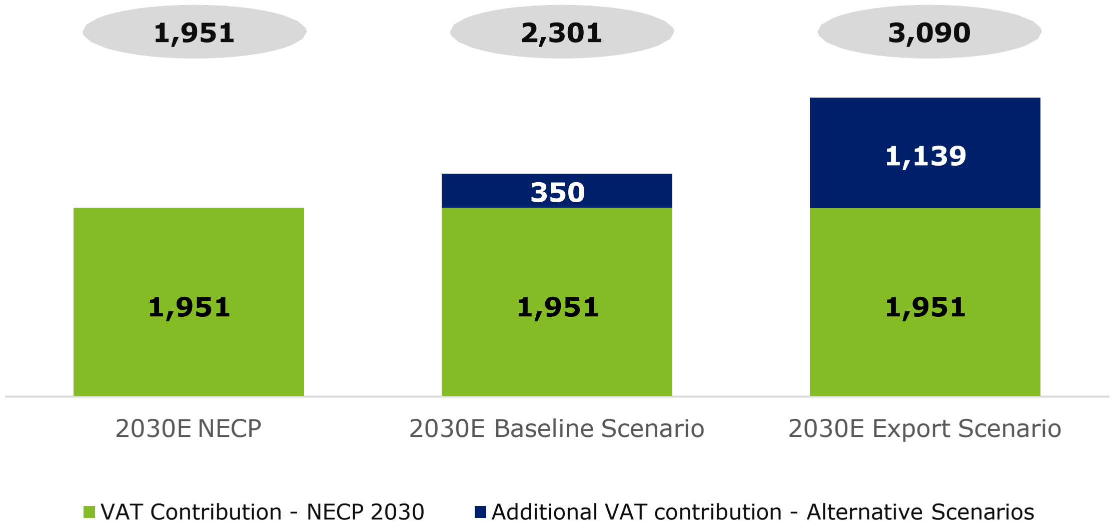

Figure 64. Estimate of net contribution to VAT (M€) with the Baseline Scenario and Export Scenario Source: APREN Analysis, Deloitte Analysis

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Private investment in RES in 2030 considering green H_2 and increased climate ambition

Private investment in RES based power plants is expected to increase between 4.3 and 8 billion euros in the period 2020-2030 as a result of the different scenarios analysed by the impact of green H_2 and increased climate ambition

With the incorporation of green H_2 and increased climate ambition, **direct private investment** in RES based power plants for the **period 2020-2030 could increase between 4.3 and 8 billion euros.**

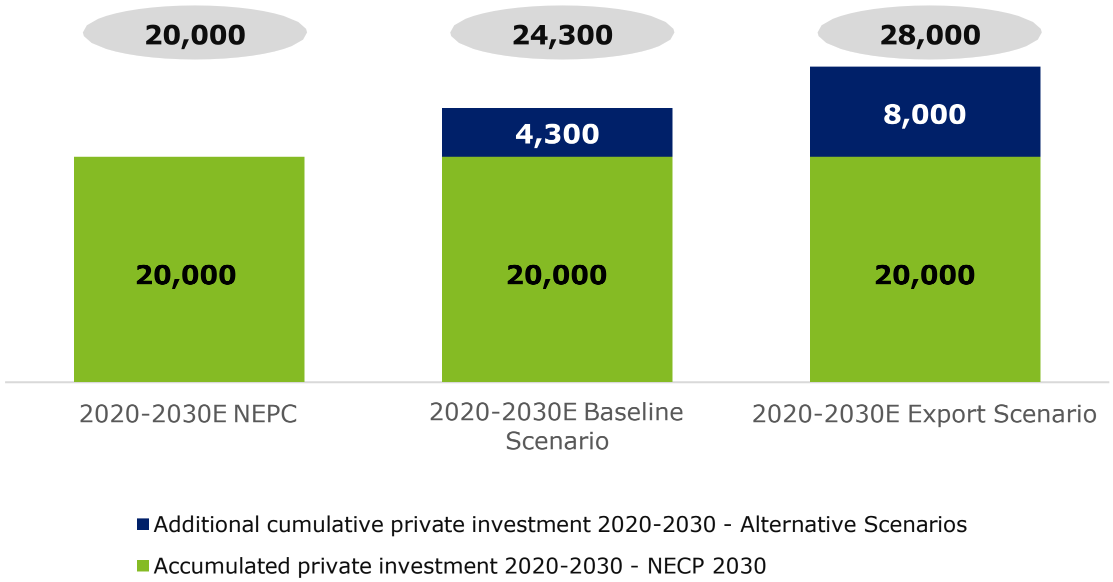

Figure 65. Estimate of the increase in direct private investment in RES based power plants (M€) with the Baseline Scenario and Export Scenario Source: APREN Analysis, Deloitte Analysis

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Reduction of emissions resulting from Green H_2 and increased climate ambition

The new scenarios that reflect the impact of green H_2 and increased climate ambition result in a reduction in global emissions in 2030 of 60.1 $MtCO_2$-eq compared to 2005, 4.7% more than forecast in the NECP 2030

As previously mentioned, the new alternative scenarios were calculated in a perspective of increased climate ambition, both aiming at a GHG reduction of 55% in 2030 when compared to 1990, equivalent to a 65% reduction for the energy system when compared to 2005. It should be noted that the Export Scenario, which differs from the Baseline Scenario regarding the total green H_2 for export, does not translate into an increase in emissions reduction, since exports are not accounted for in the total emissions of the exporting country in order to achieve the climate target.

This new scenario, more ambitious than the one transcribed in the NECP 2030, which aims to reduce GHG emissions between 45% and 55%, excluding land and forest change emissions compared to 2005, results in an increased emission reduction potential.

In both scenarios of greater climate ambition, **a reduction in global GHG emissions is achieved in 2030 equivalent to 60.1 $MtCO_2$-eq compared to 2005**, an increase of 4.7% compared to the most ambitious NECP 2030 scenario.

Looking exclusively at the energy system, the new scenarios result in a **reduction in emissions in 2030 quantified by 41.6 Mt CO_2-eq compared to 2005**, an additional 4.3% compared to the most ambitious NECP 2030 scenario.

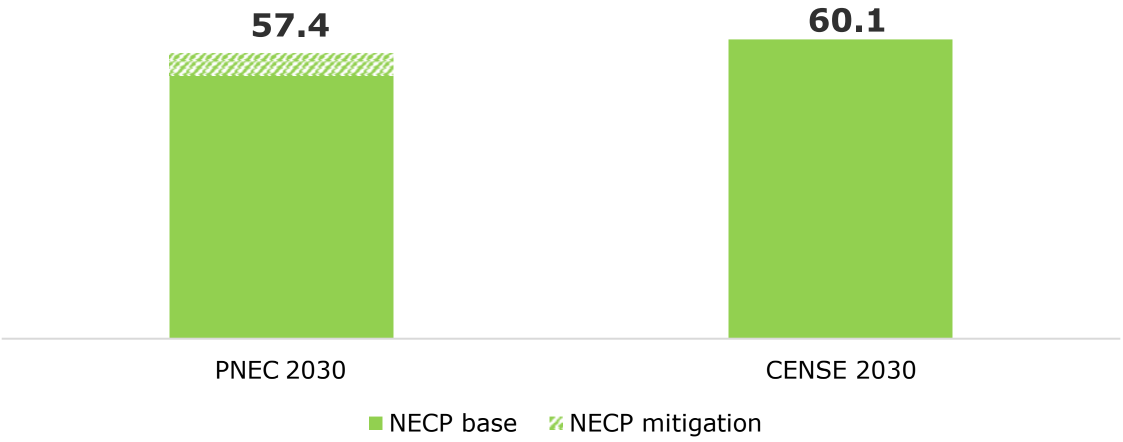

Figure 66. Overall reduction of GHG emissions compared to 2005 by the Scenarios of NECP 2030 and CENSE, with increased climate ambition ($MtCO_2$-eq)
Source: CENSE - FCT NOVA, PNEC 2030, NIR, APREN Analysis

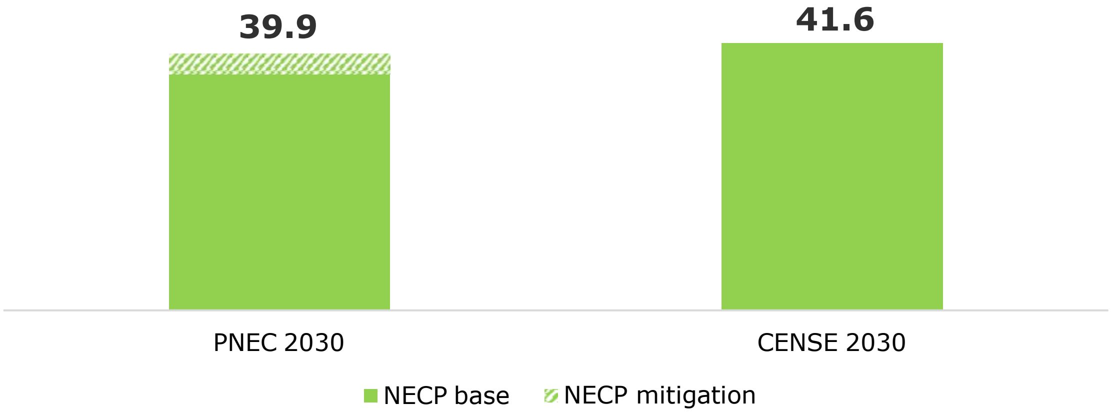

Figure 67. Reduction of GHG emissions in the energy system compared to 2005 by the scenarios of NECP 2030 and CENSE, with increased climate ambition ($MtCO_2$-eq)
Source: CENSE - FCT NOVA, PNEC 2030, NIR, APREN Analysis

Note: The two scenarios of NECP 2030 (NECP base and NECP mitigation) represent the emission reduction interval transcribed in the NECP, whose most ambitious scenario is a scenario of additional policies consistent with carbon neutrality.

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Scenarios considering the impact of green H_2 and the new climate ambition

Findings

- The increase in RES production capacity resulting from Baseline and Export scenarios could add between 2 and 6.5 billion euros to GDP in 2030. For employment, the increase could represent between 24 and 83 thousands jobs in 2030;
- In 2030, green H_2 could add to the impact resulting from the NECP 2030 between 243 and 842 million euros for Social Security, and between 201 and 698 million euros for the IRS;
- In 2030, Baseline and Export scenarios could contribute with an additional between 81 and 165 million euros for CIT, and between 350 million and 1.1 billion euros of net contribution to VAT;
- Direct private investment in RES based power plants is expected to increase between 4.3 and 8 billion euros in the period 2020 to 2030, as a result of the different analysed EN-H2 scenarios;
- The new scenarios that consider the impact of green H_2 and increased climate ambition result in an overall emissions reduction in 2030 of 60.1 $MtCO_2$-eq compared to 2005, 4.7% more than the forecast in the NECP 2030.

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Documents and links consulted

In the preparation of this report, the following documents were consulted:

- DGEG (2020), Balanço Energético Sintético 2020
- DGEG (2021), Estatísticas Rápidas Renováveis – maio de 2021
- DGEG (2021), Estatísticas Rápidas Combustíveis Fósseis – maio de 2021
- DGEG (2020), Relatório de Monitorização da Segurança de Abastecimento do Sistema Elétrico Nacional 2021-2040
- PNEC 2030 – Plano Nacional de Energia-Clima, 07-05-2019
- Roteiro para a Neutralidade Carbónica 2050, Resultados Preliminares – Versão para consulta pública; Vol1: Trajetórias para a neutralidade carbónica da Economia Portuguesa em 2050 | Opções Tecnológicas
- IRENA (2020) – Renewable Power Generation Costs in 2020
- IRENA (2020) – Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal

The following links have been used:

- Paris Agreement – consulted https://www.consilium.europa.eu/pt/policies/climate-change/timeline/
- ERSE – consulted https://www.erse.pt/media/heddnoqc/estrutura-tarif%C3%A1ria-se-2021.pdf
- National Energy and Climate Plan– consulted https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=0eada7c4-4f17-4d13-a879-6700f302b7e0

Additionally, the Pordata, SABI and Sendeco2 databases were consulted.

Data on the daily market price of electricity of market players, including ERSE, OMIE and REN, were also shared. A questionnaire was also prepared and shared with APREN members.

GLOSSARY

Acronyms

- **CIEG –** General Economic Interest Costs
- **CO_2 –** Carbon Dioxide
- **E -** Used for periods whose data are estimated (future estimates or lack of actual data)
- **RES –** Renewable Energy Sources
- **FIT –** *Feed-in-tariffs*
- **GEE –** Greenhouse Gas
- **GW -** Equal to 1,000 MW
- **GWh -** Gigawatt-hour; measure of electricity produced and corresponding to the amount of energy used to feed a charge with a power of one gigawatt for a period of one hour; 1 gigawatt = 1.000.000.000 watt
- **MIBEL –** Iberian Electricity Market
- **MW –** Megawatt; installed power measure for electricity production; 1 megawatt = 1.000.000 watt
- **LOTC -** Logistics Operation of Retailer Change
- **p.p. –** Percentage points
- **GDP –** Gross Domestic Product
- **SRP –**Special Regime Production
- **RFI** – Request For Information
- **RMSA -** Relatório de Monitorização da Segurança de Abastecimento do Sistema Elétrico Nacional
- **TWh** – Equal to 1.000 GWh
- **GVA –** Gross Value Added
- **ESS** – External Supplies and Services

APPENDIX

Methodological description

Comprehensive data collection through RFIs and databases

The contribution of the RES sector to GDP was based on data obtained through questionnaires to companies belonging to the sector, in order to ensure the widest possible scope of the data used in the study. To complement the information collected in the questionnaires, information was directly collected on the financial statements of companies that are part of the RES sector (databases and reports and accounts). The data collected allowed the following coverage as a percentage of the installed power:

Table 1 - Scope of data collection through questionnaires and databases

RES	Hydro	Wind	Solar	Bioenergy	Geothermal
Coverage of collected data (% installed power)	97	87	14	48	91

Input/ouput matrix for indirect GDP calculation

The input-output analysis methodology (Leontief coefficients) was developed by Wassily Leontief in 1936. The main use of this tool focuses on the interpretation of the interdependencies of the different sectors of the economy.

All industries purchase raw materials and/or services from other industries. These interactions between industries are reflected in tables of origin and destination, which indicate who produces and who uses the production of all sectors of the economy.

From the target table you can obtain the matrix of technical coefficients. This matrix expresses, as a percentage, the purchases made by one sector to the other industries. Each technical coefficient represents industry consumption and the quantity required to produce a product unit.

Methodological description

Direct and Indirect GVA Calculation

Direct GVA corresponds to the wealth generated by the sale of energy by renewable energy producers. This was calculated based on operating revenues, costs of goods sold and other operating costs of renewable energy producing companies, and these data were obtained via RFI from APREN members. Direct GVA can also be designated as the "direct contribution of RES to GDP".

Indirect GVA corresponds to the wealth generated in the rest of the economy due to the activity of renewable energy producers. This was calculated based on the Direct GVA, to which is applied an input/output matrix specific to each type of RES. The Indirect GVA can also be designated as the "indirect contribution of RES to GDP".

Total Gross Value Added (also can be called "total contribution of RES to GDP") was calculated by summing up Direct and Indirect Gross Added Value.

Calculation of Direct and Indirect Employment

Direct Employment corresponds to the jobs created directly by the operation of renewable energy producers. This was calculated based on the volume of employees reported via RFI to APREN members.

Indirect Employment corresponds to the jobs generated in the rest of the economy due to the activity of renewable energy producers. This was calculated considering coefficients # jobs generated / € of GVA, which were applied to the Indirect GVA of each type of RES.

Total Employment was calculated using the sum of Direct and Indirect Employment.

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Methodological description

Calculation of Private Investment in RES

For the calculation of private investment in RES for the period 2011 to 2020, we used cost ratios / MW of new installed power of IRENA, specific for each type of RES. The evolution of the installed power for each type of RES was applied to these.

To estimate the private investment in RES by 2030, the cost ratios /MW of new installed power were used by 2030, specific for each type of RES, to which the evolution of the installed power contained in the NECP 2030 for each type of RES was applied.

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Methodological description

Environmental impact of the sector

In the chapter on the environmental impact of the RES sector, avoided CO_2 emissions are estimated. For this purpose, the following CO_2 emission factors per source of electricity generation were considered:

Table 2 - CO_2 emissions by electricity generation source (Ton/GWh)

Source	2016	2017	2018	2019	2020	2021-2030
Coal	995	892	920	933	933	933
Natural Gas	386	370	371	371	371	371

Table 3 - Price of CO_2 emission allowances (€/ton)

	2016	2017	2018	2019	2020	2030E
Price (€/t)	5.35	5.83	15.88	24.84	24.74	108

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APPENDIX

Methodological description

Impact of the sector on energy dependency

To calculate the costs avoided by reducing imports of fossil fuels, the following prices were taken into account:

Table 4 - Fossil fuel price

Source	2016	2017	2018	2019	2020	2030E
Coal (€/t)	50.85	75.76	80.30	58.91	47.87	69.62
Natural Gas (€/MMBtu)	4.16	5.05	6.53	4.29	2.46	6.49

Simplified Market Simulation

For the calculation of simplified market simulation, based on the data provided by OMIE, the quantity of renewable SRP placed on the market was replaced by the following electricity offerings with the highest price available.

The marginal saving per MWh in the market is the difference between the daily electricity market price effectively verified in a given period and the new balance between supply and demand with the entry of offers with a higher price, resulting from the withdrawal of Renewable SRP from the market.

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Methodological description

Hydrogen cost-effective potential calculation model

The Hydrogen study in Portugal – Assessment of the Impact of Green H_2 on the Electroproducer System, developed by CENSE-FCT NOVA, which aims to explore the cost-effective role of green H_2 in the national energy system by assuming a mitigation target in line with the new European ambition for the medium term and assess how H_2 will impact the national energy system, with emphasis on the electroproducer system, gave rise to the Baseline and Export Scenarios.

The potential cost-effectiveness of green H_2 was assessed through the TIMES_PT modeling tool, previously used in technical studies to support public policy, as was the case with studies supporting the 2050 Carbon Neutrality Roadmap, National Low Carbon Roadmap, Green Taxation Reform or the National Climate Change Program 2020/2030.

Whenever possible, the present study presents a comparative analysis between the potential effective cost of green H_2 and the basic support scenario for EN-H2.

The study is available for consultation upon request to APREN.

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APPENDIX

Individual characterization of each renewable energy source

Hydro

In the NECP 2030 scenario, the hydro installed capacity is estimated to increase by 1,408 MW between 2020 and 2030. For production, it is estimated that in 2030, this is equivalent to 14,598 GWh.

In alternative scenarios considering hydrogen, it is estimated that by 2030 the power is 8,540 MW, with a production of 14,754 GWh.

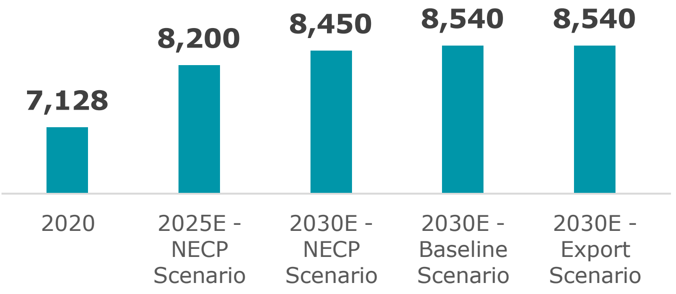

Figure 68. Hydro capacity (MW)

Source: DGEG, NECP 2030, Deloitte Analysis

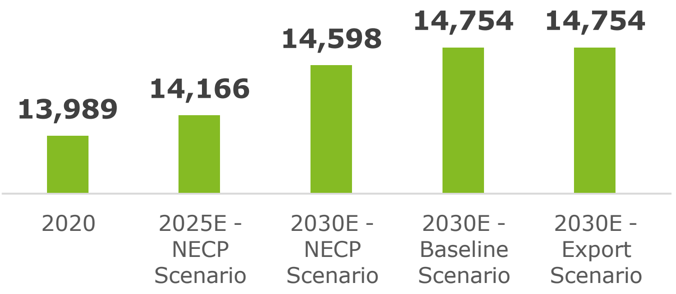

Figure 69. Hydro production (GWh)

Source: DGEG, NECP 2030, Deloitte Analysis

Wind

In the NECP 2030 scenario, wind power capacity is expected to increase by 3,822 MW between 2015 and 2030. For production, it is estimated that in 2030, this is equivalent to 32,400 GWh.

In alternative scenarios considering hydrogen, it is estimated that by 2030 the power is between 12,000 and 12,020 MW, with a production between 32,400 and 32,454 GWh.

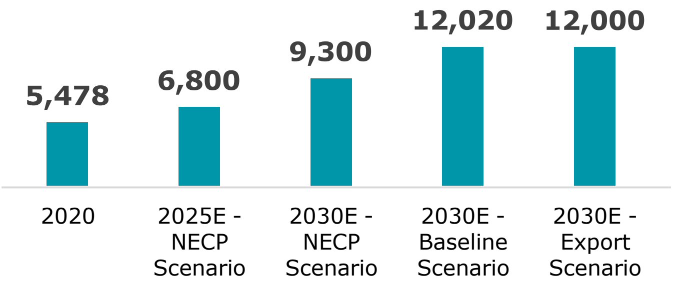

Figura 70. Wind power Capacity (MW)

Source: DGEG, NECP 2030, Deloitte Analysis

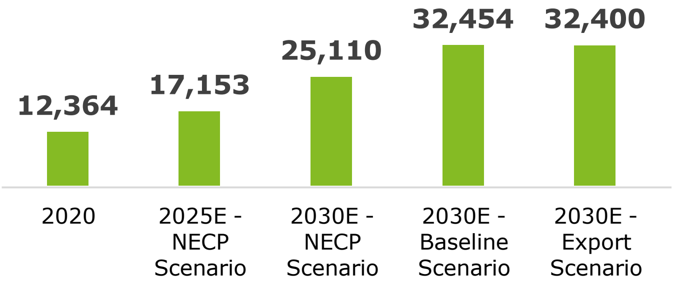

Figure 71. Wind power production (GWh)

Source: DGEG, NECP 2030, Deloitte Analysis

Individual characterization of each renewable energy source

Solar

In the NECP 2030 scenario, capacity is estimated to increase by 7,700 MW between 2020 and 2030, given the focus on decentralized solar. For production, it is estimated that in 2030, this is equivalent to 17,670 GWh.

In alternative scenarios considering hydrogen, it is estimated that by 2030 the power is between 10,870 and 16,600 MW, with a production between 20,653 and 31,540 GWh.

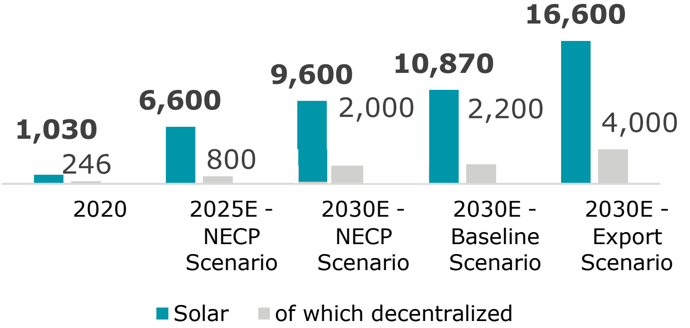

Figure 72. Solar capacity (MW)

Source: DGEG, NECP 2030, Deloitte Analysis

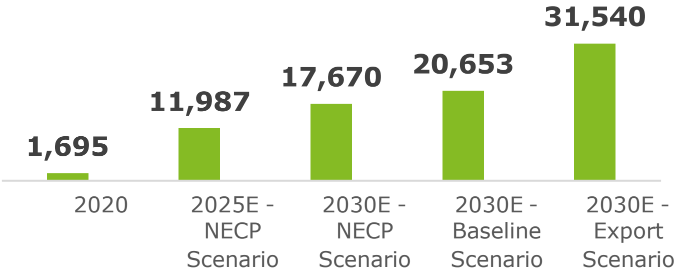

Figure 73. Solar Production (GWh)

Source: DGEG, NECP 2030, Deloitte Analysis

Bioenergy

In the NECP 2030 scenario, bioenergy installed capacity is estimated to increase by 258 MW between 2020 and 2030. For production, it is estimated that in 2030, this is equivalent to 3,997 GWh.

In alternative scenarios considering hydrogen, it is estimated that by 2030 the power is between 1,050 and 1,060 MW, with a production between 4,444 and 4,490 GWh.

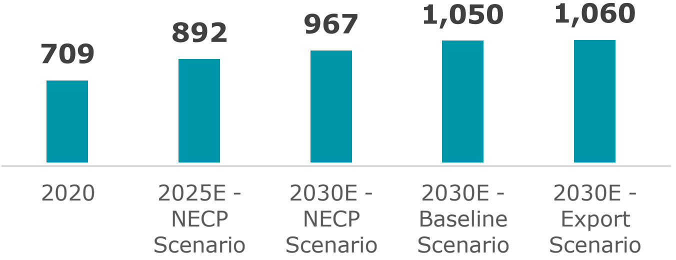

Figure 74. Bioenergy capacity (MW)

Source: DGEG, NECP 2030, Deloitte Analysis

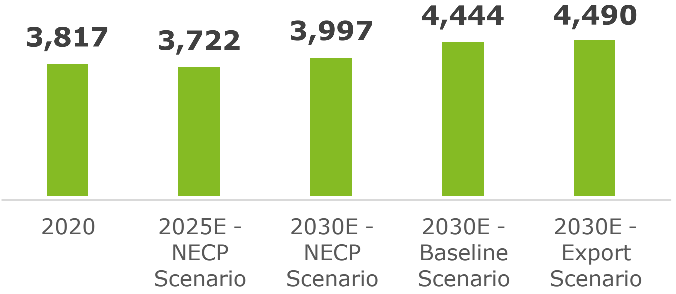

Figure 75. Bioenergy Production (GWh)

Source: DGEG, NECP 2030, Deloitte Analysis

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Individual characterization of each renewable energy source

Geothermal

In the NECP 2030 scenario, geothermal installed capacity is expected to increase by 266 MW between 2020 and 2030. For production, it is estimated that in 2030, this is equivalent to 642 GWh.

In alternative scenarios considering hydrogen, the same estimate remains at the level of power and production.

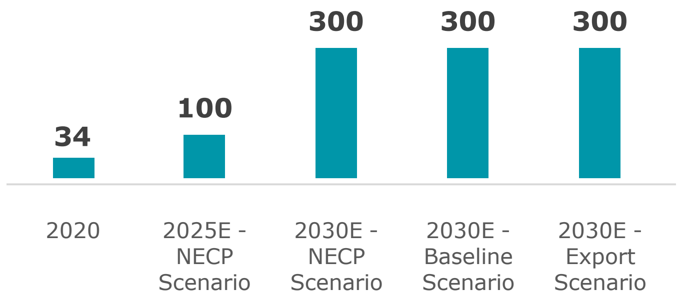

Figure 76. Geothermal capacity (MW)

Source: DGEG, NECP 2030, Deloitte Analysis

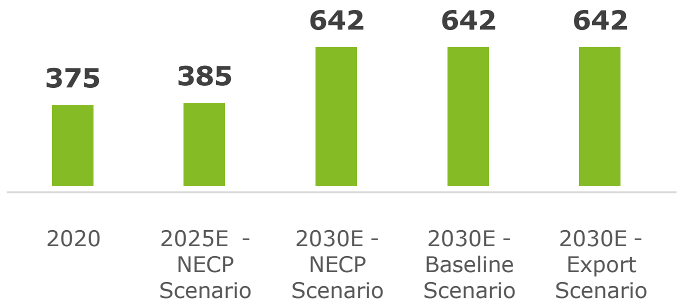

Figure 77. Geothermal production (GWh)

Source: DGEG, NECP 2030, Deloitte Analysis