Instituto Superior Técnico de Lisboa

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100% Renewable electricity in Portugal – Yes it is possible

Lisbon, November 4TH 2020

TÉCNICO LISBOA

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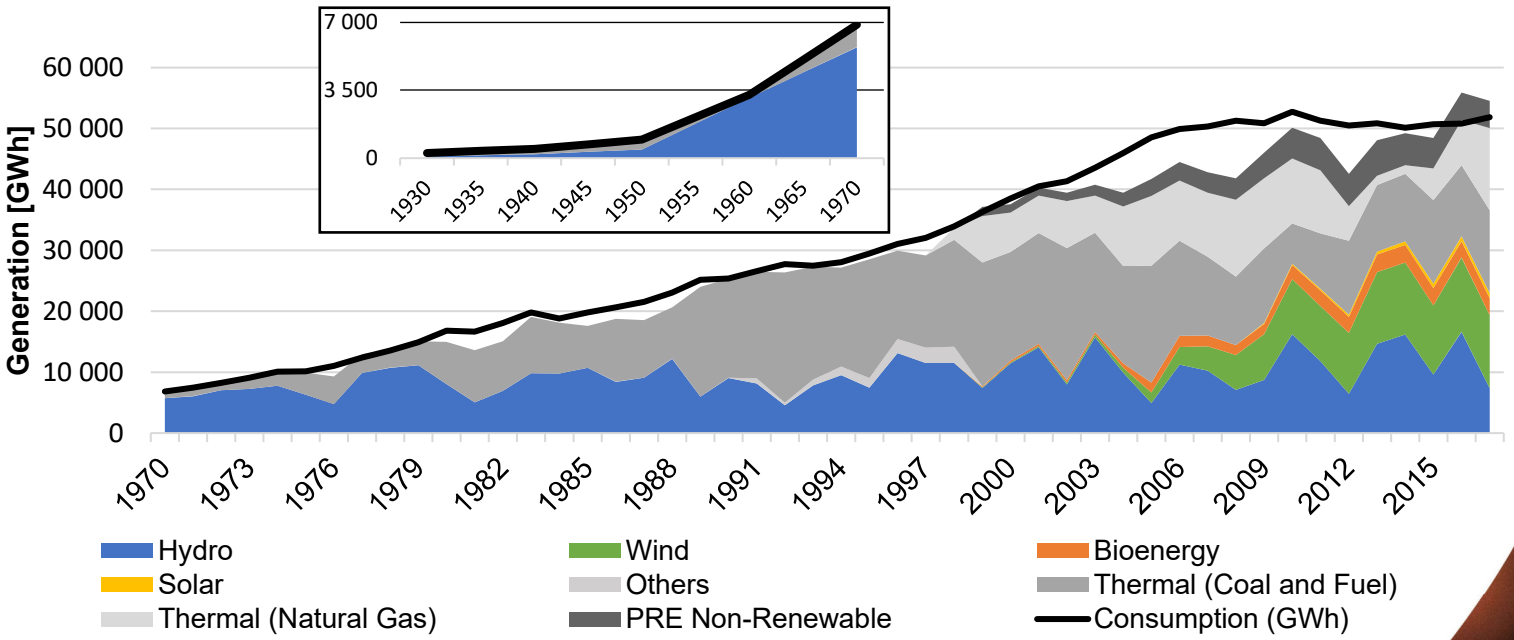
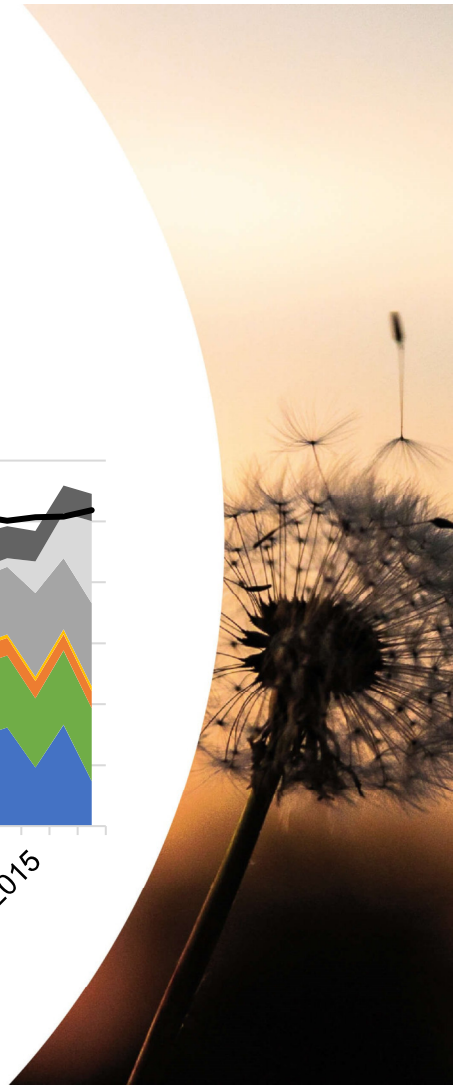
Renewable Energy in Portugal

Renewable Energy in Portugal

Evolution of the Portuguese electricity mix

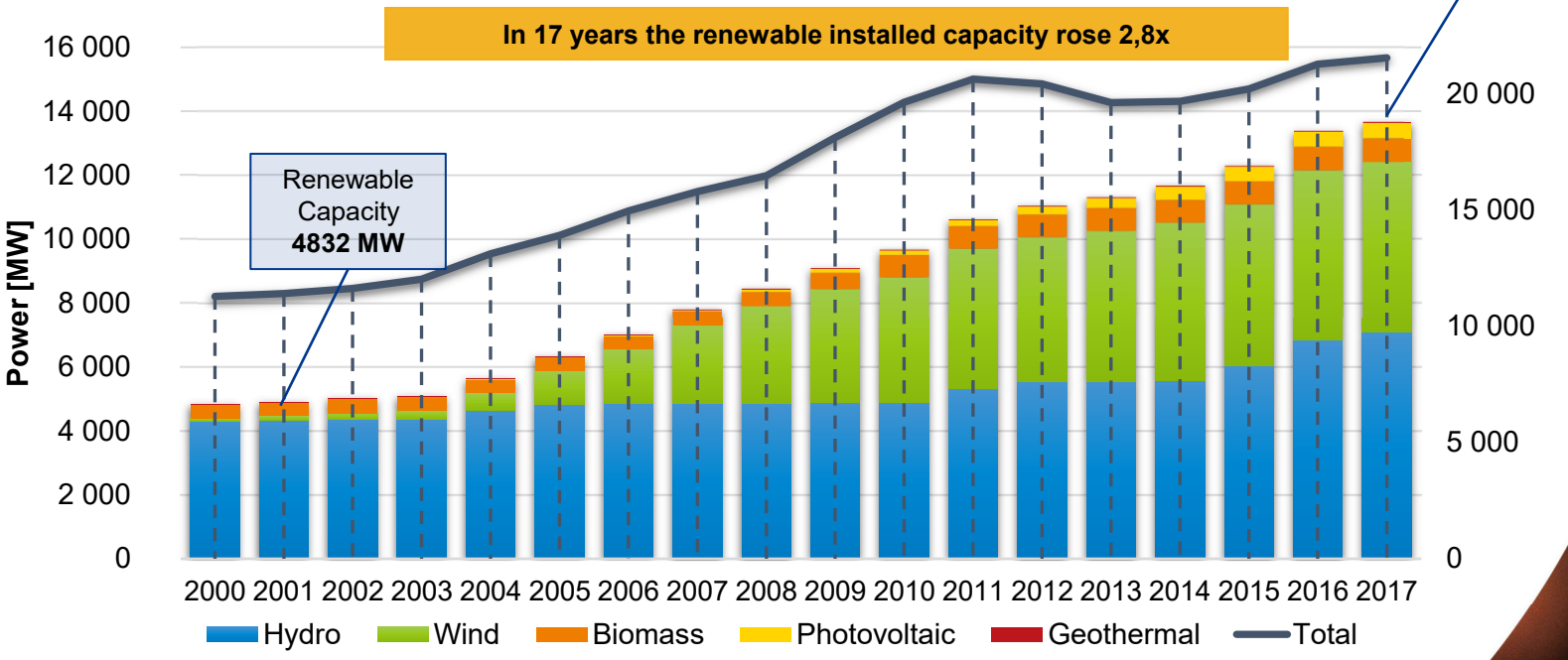


Source: REN, EDP; APREN's analysis

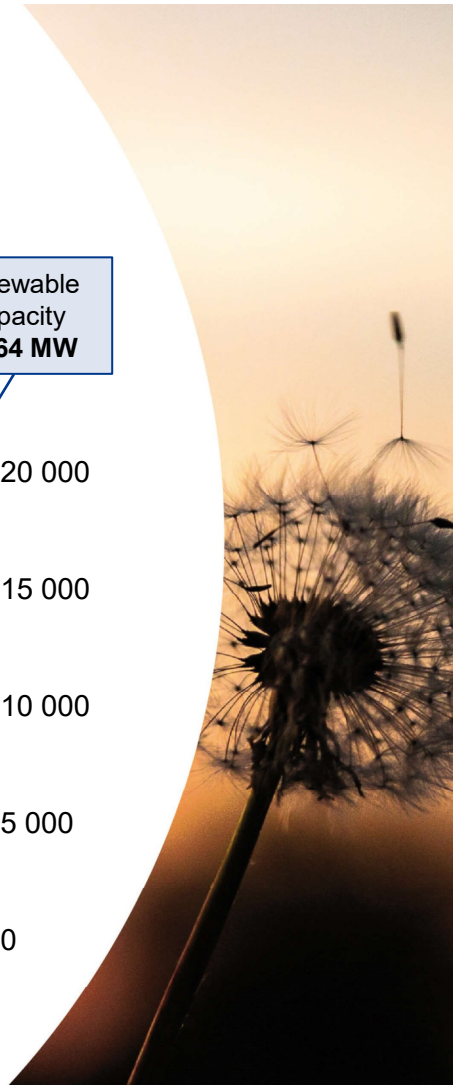


Renewable Energy in Portugal

Installed Capacity in Portugal

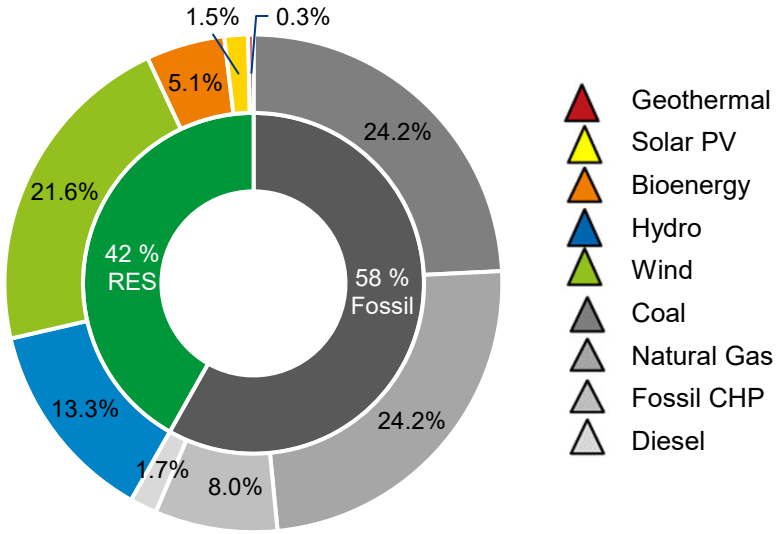


Source: DGEG; APREN's analysis



Renewable Energy in Portugal

2017 National Electricity Production by Energy Source

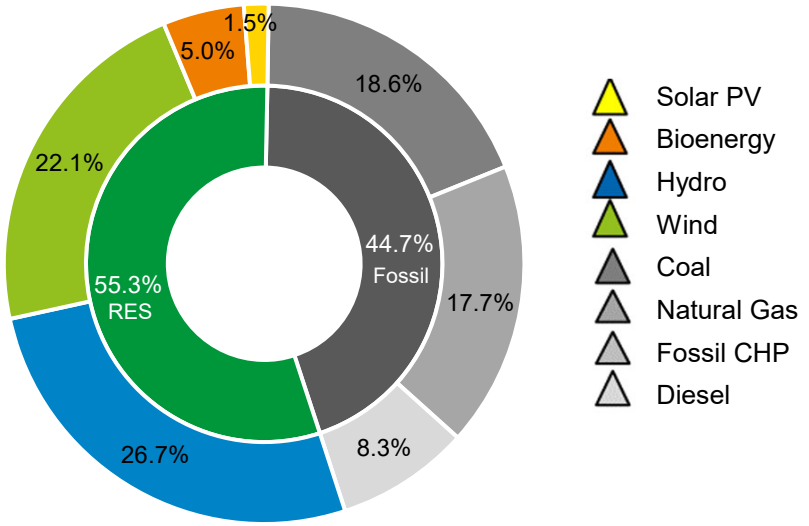


- In 2017 renewable energies represented 42% of the overall national electricity production.
- Concerning the energy electricity consumption, renewables represented 46% (renewables – 23.504 GWh, consumption - 51.297 GWh)

Source: REN, EDA, EEM; APREN's analysis

Renewable Energy in Portugal

2018 Electricity Production by Energy Source in mainland Portugal

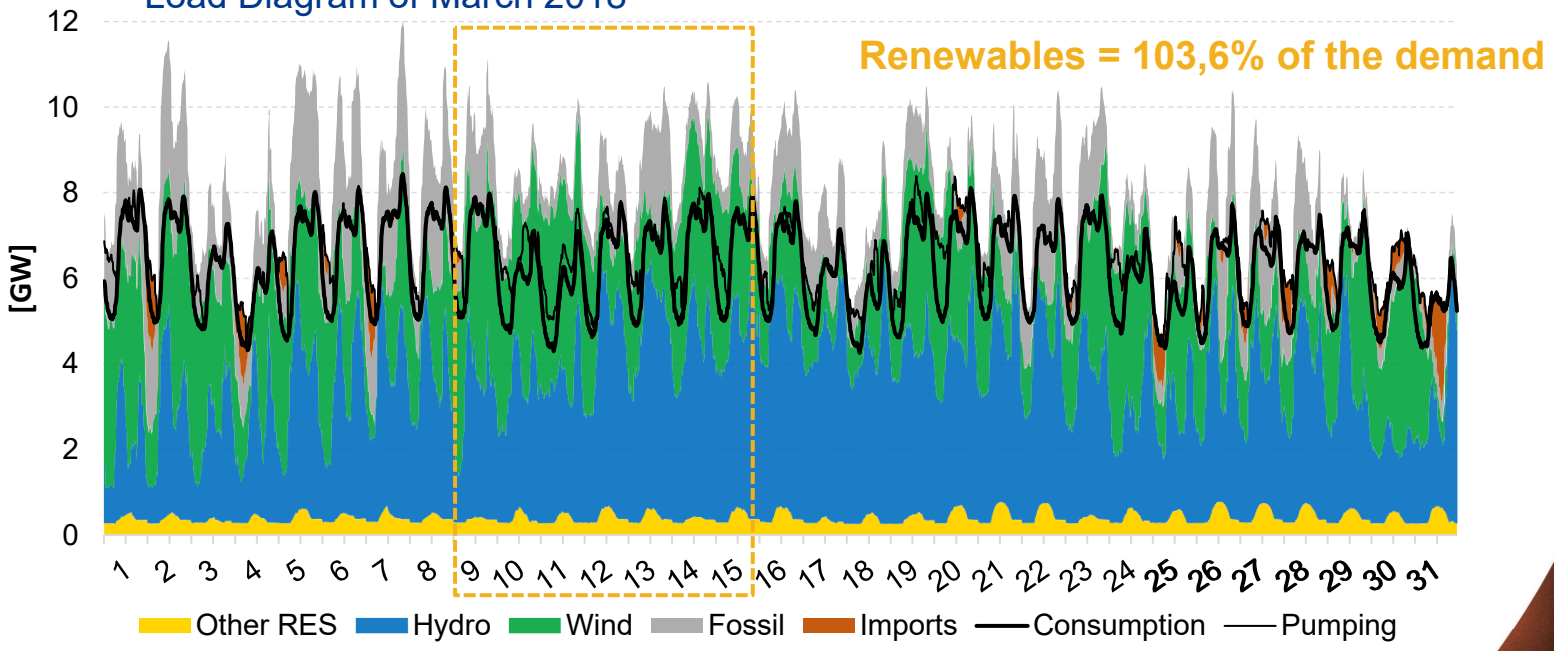


- In the first semester of 2018, renewable electricity represented 55,3% (20.710 GWh) of the overall electricity production in mainland Portugal (37.451 GWh).

Source: REN; APREN's analysis

Renewable Energy in Portugal

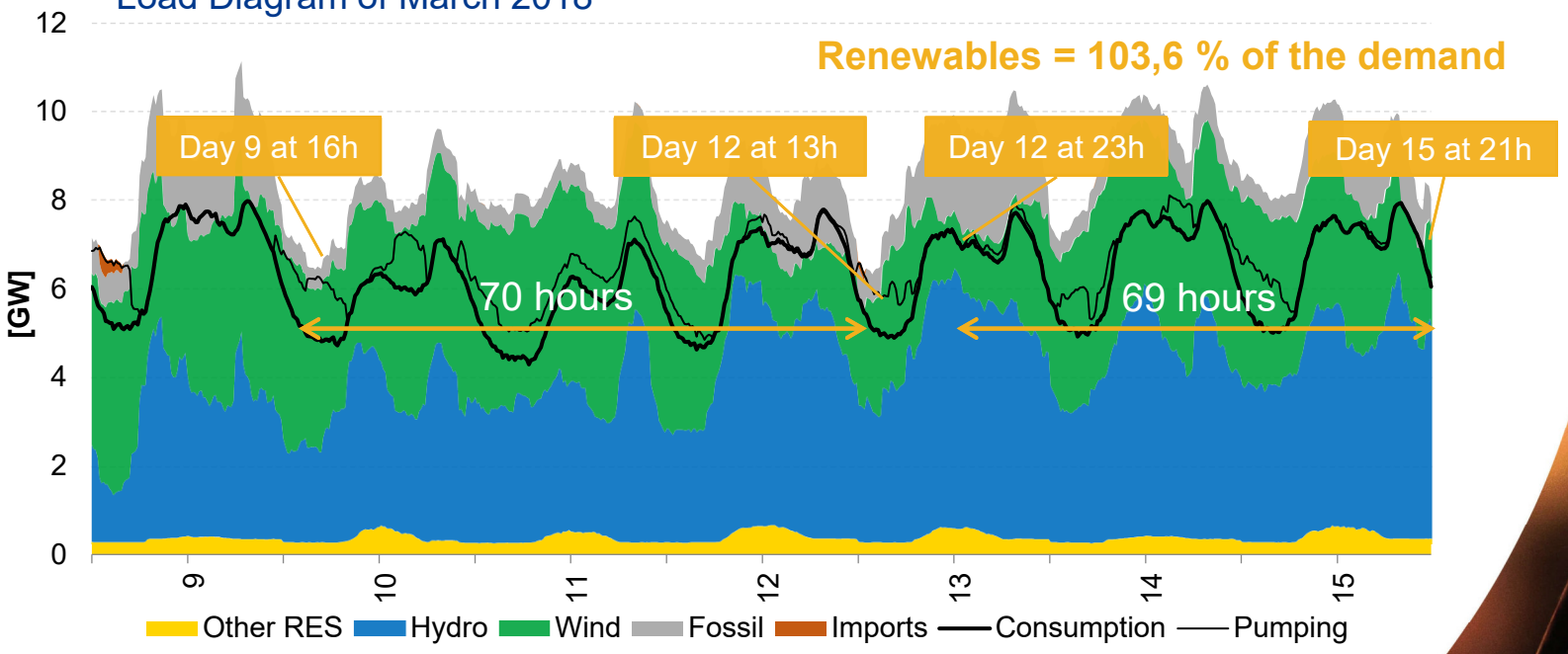
Load Diagram of March 2018



Source: REN; APREN's analysis

Renewable Energy in Portugal

Load Diagram of March 2018



Source: REN; APREN's analysis

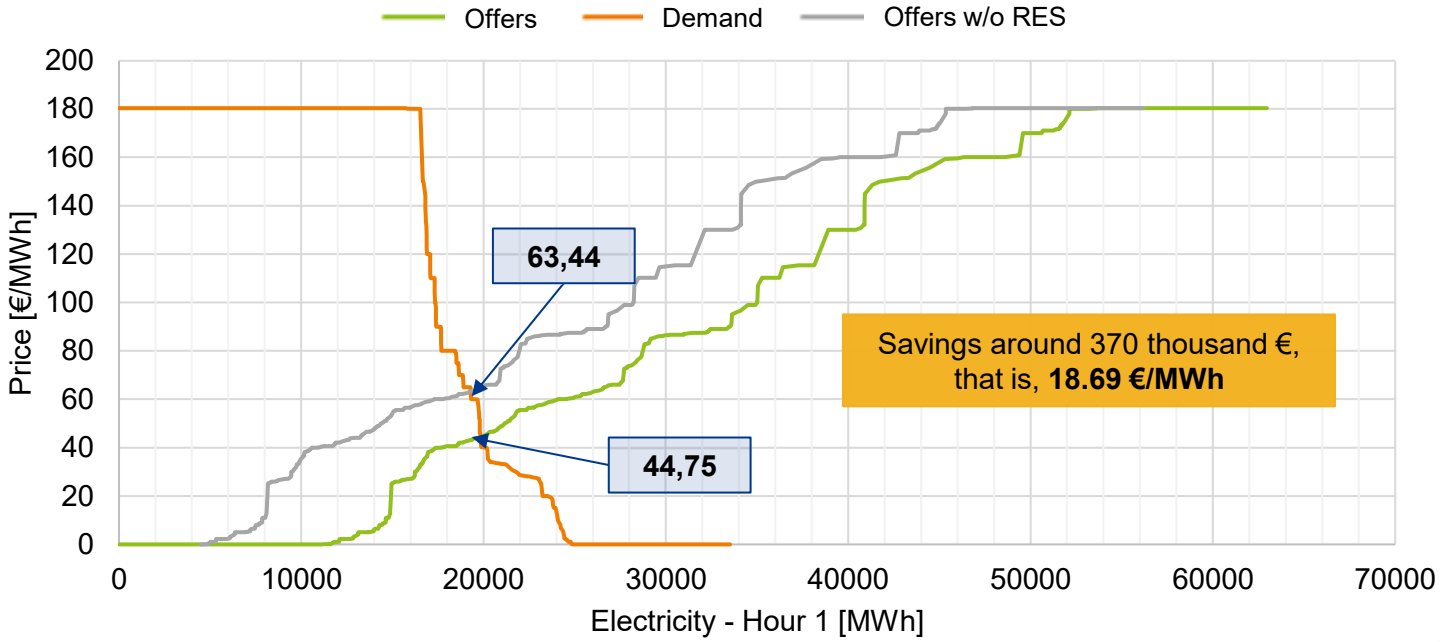
Renewable Energy in Portugal

Electricity System with 100% RES

Source: CNN

Renewable Energy in Portugal

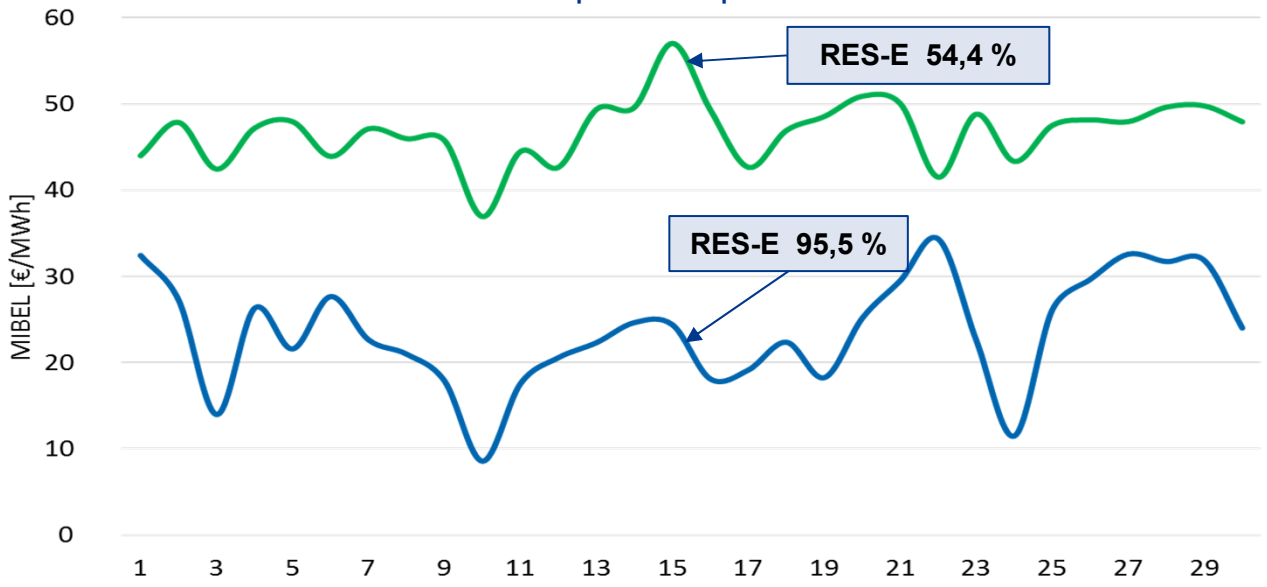
The Iberian Electricity Market (MIBEL) – Real Case January 1st 2016



Source: OMIE; APREN's analysis

Electricity Market

The influence of RES in the market price – April 2011 and 2016



Average Price for April 2011 = **46,85 €/MWh**
Average Price for April 2016 = **23,50 €/MWh**

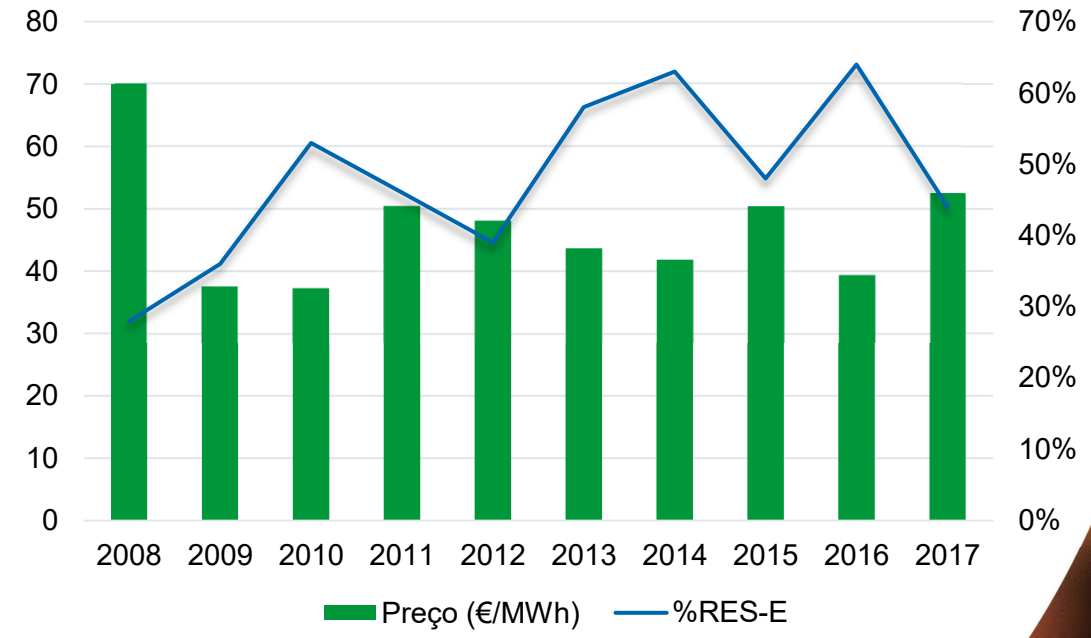
Source: REN, OMIE; APREN's analysis

The Iberian Electricity Market (MIBEL)

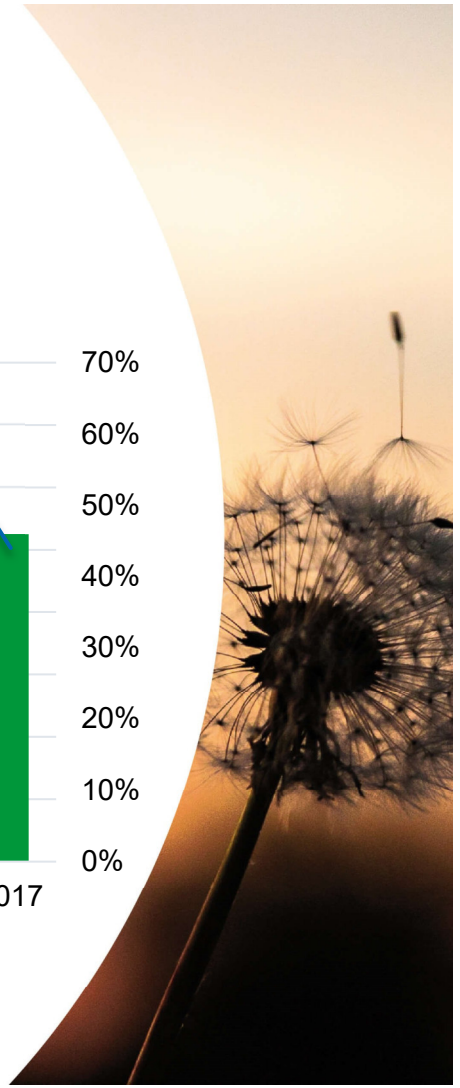
Historical Data

Year	MIBEL's Price [€/MWh]	% RES-E
2008	69,98	28%
2009	37,63	36%
2010	37,32	53%
2011	50,45	46%
2012	48,07	39%
2013	43,64	58%
2014	41,85	63%
2015	50,37	48%
2016	39,38	64%
2017	52,50	44%

Source: REN, OMIE; APREN's analysis



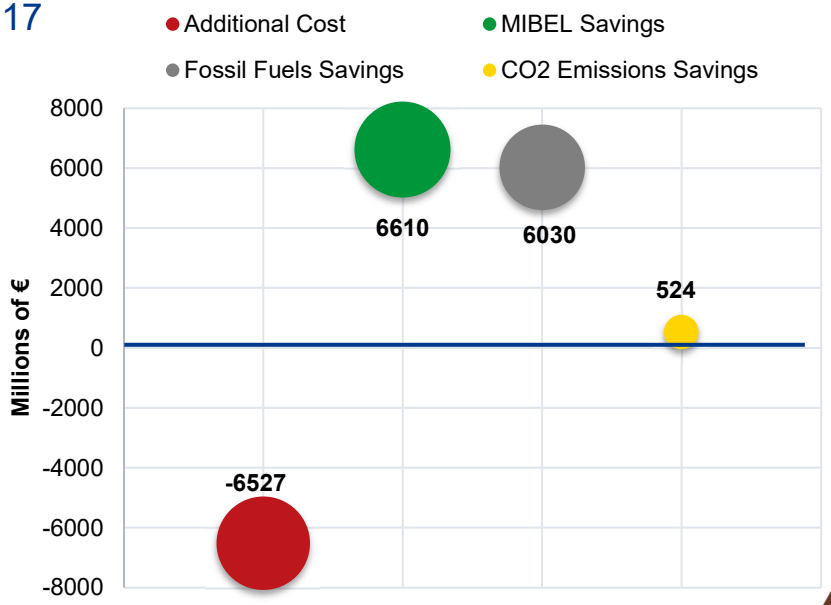
In the wholesale electricity market, an increase in the use of Renewable Electricity is expected to lead to a contraction in the price of electricity

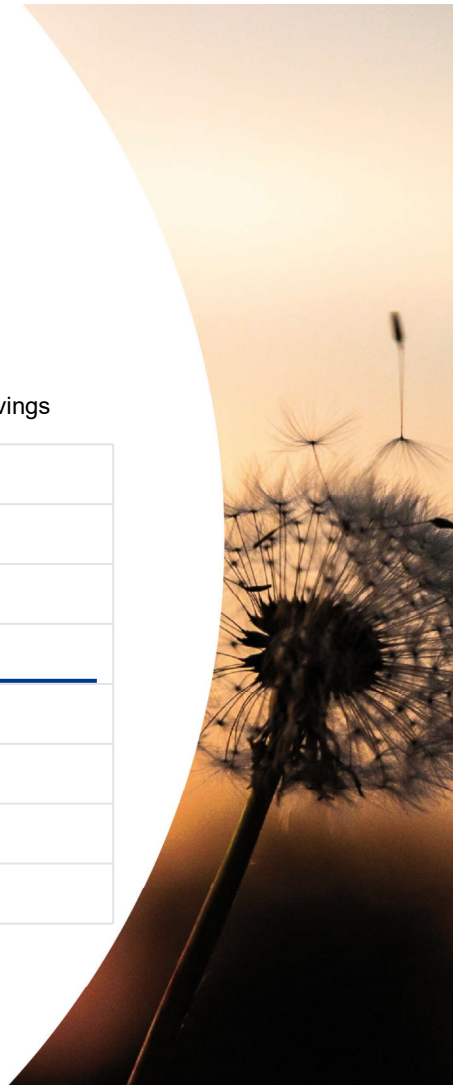


Renewables' Economic Benefits

Cumulative values from 2010 to 2017

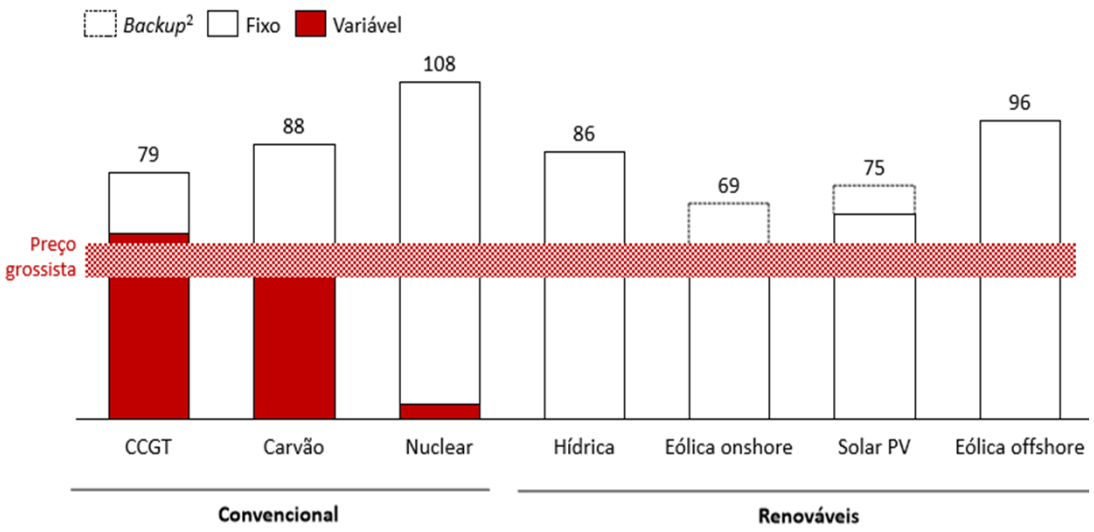
- The impact of renewable electricity on the Spot Market due to the merit order was 6 610 M€ between 2010 and 2017;
- The reduction on the imports of fossil resources resulted in a saving of 6,030 M€ in the energy bill;
- The savings from emission licenses were 524 M€;
- These savings outweigh the costs related to renewables (-6 527 M€).





Evolution of RES Technologies Costs

Custos nivelados de produção de electricidade no Sul da Europa[1]
€$_{16}$/MWh, 2016

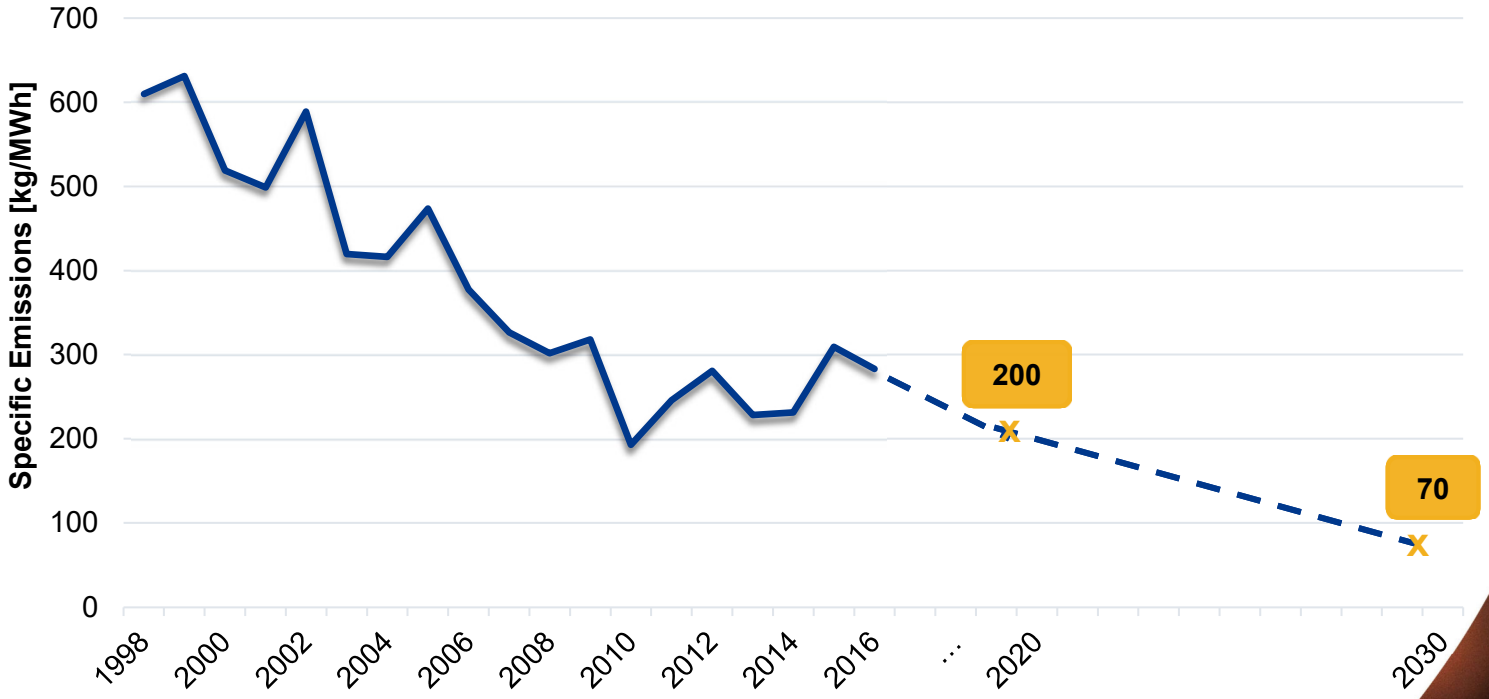


Source: EDP; APREN's analysis

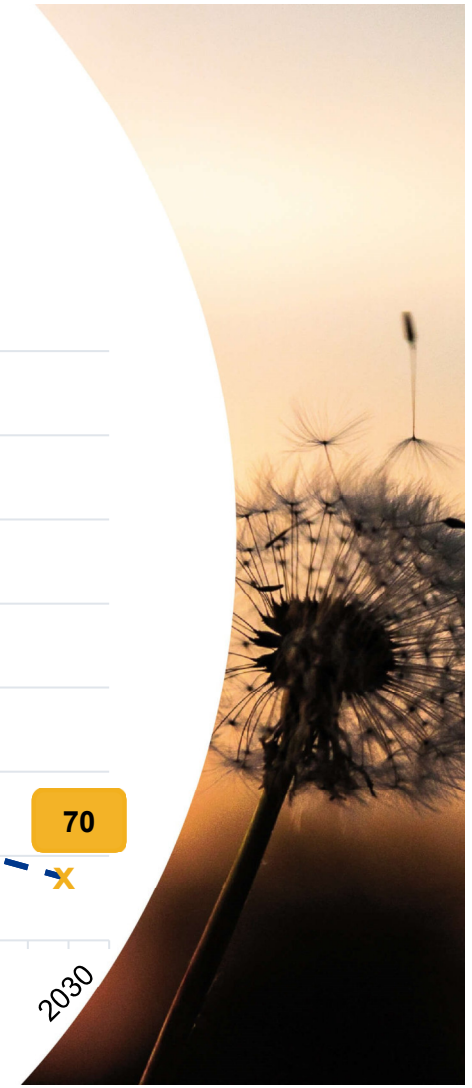
- The electricity market is making a transition from power plants with huge variable costs to power plants with low variable costs.

The marginal market becomes inadequate for RES.

Decarbonization of the Electric Sector

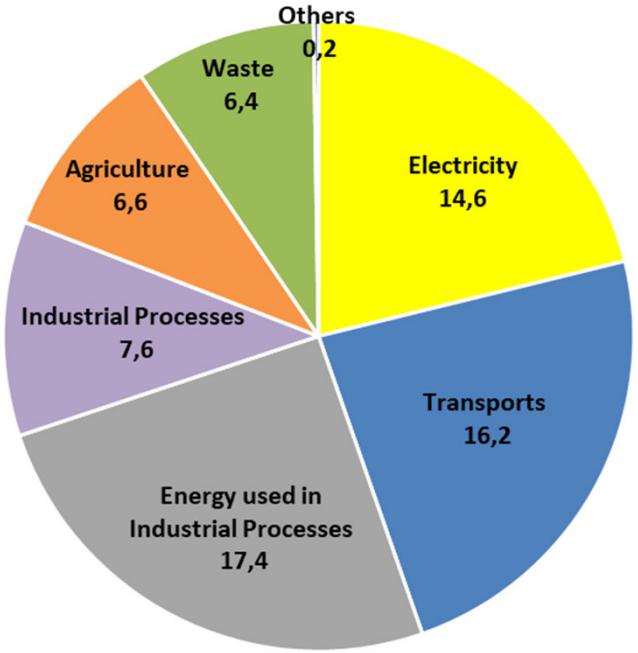


Source: REN, ERSE, Deloitte; APREN's analysis



Decarbonization of the Electric Sector

Sectoral Emissions



Total	Forests Absortion (without fires)	Net Values
69	8	61

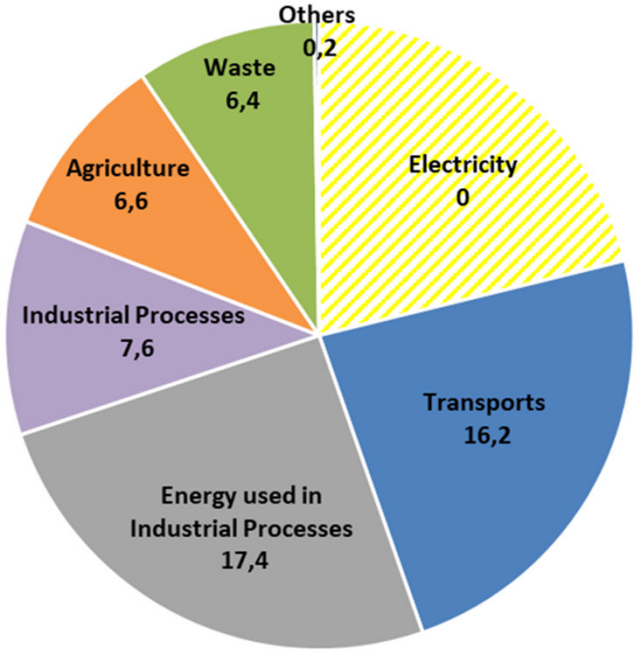
Units - Megatonnes

Note: Electricity Sector Emissions refer to 2015 and 2016's average

Source: Emissions Inventory 2017; APREN's analysis

Decarbonization of the Electric Sector

Sectoral Emissions – 100% RES-E



Source: Emissions Inventory 2017; APREN's analysis

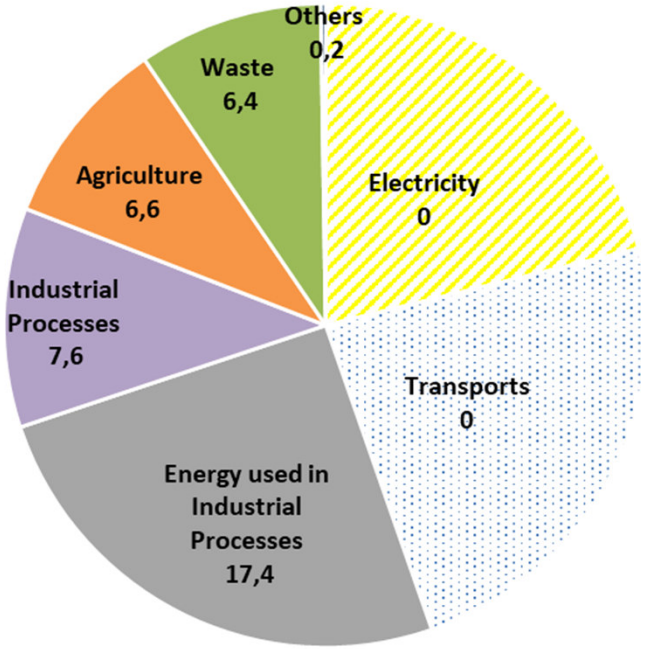
Total	Forests Absortion (without fires)	Net Values
54,4	8	46,4

Units - Megatonnes

Note: Electricity Sector Emissions refer to 2015 and 2016's average

Decarbonization of the Electric Sector

Sectoral Emissions – 100% RES-E and 0% CO_2 Emissions in Transport



Total	Forests Absortion (without fires)	Net Values
38,2	8	30,2

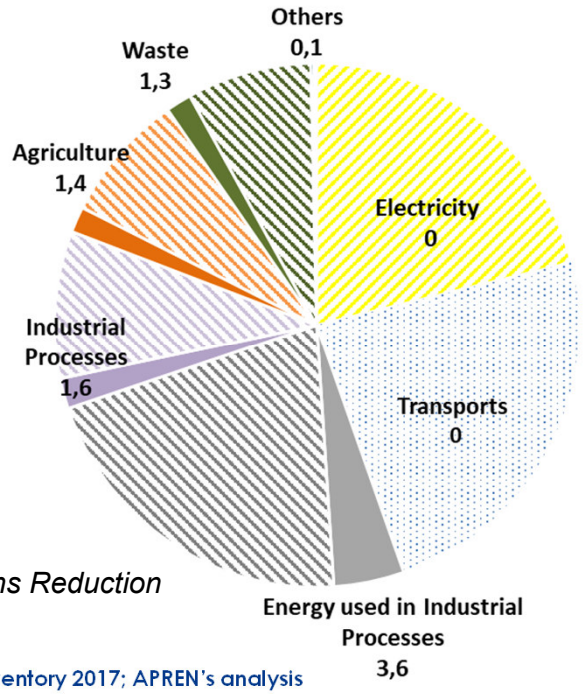
Units - Megatonnes

Note: Electricity Sector Emissions refer to 2015 and 2016's average

Source: Emissions Inventory 2017; APREN's analysis

Decarbonization of the Electric Sector

Sectoral Emissions – Total Decarbonization



Legend:

Emissions Reduction

Source: Emissions Inventory 2017; APREN's analysis

Total	Forests Absortion (without fires)	Net Values
8	8	0

Units - Megatonnes

Note: Electricity Sector Emissions refer to 2015 and 2016's average

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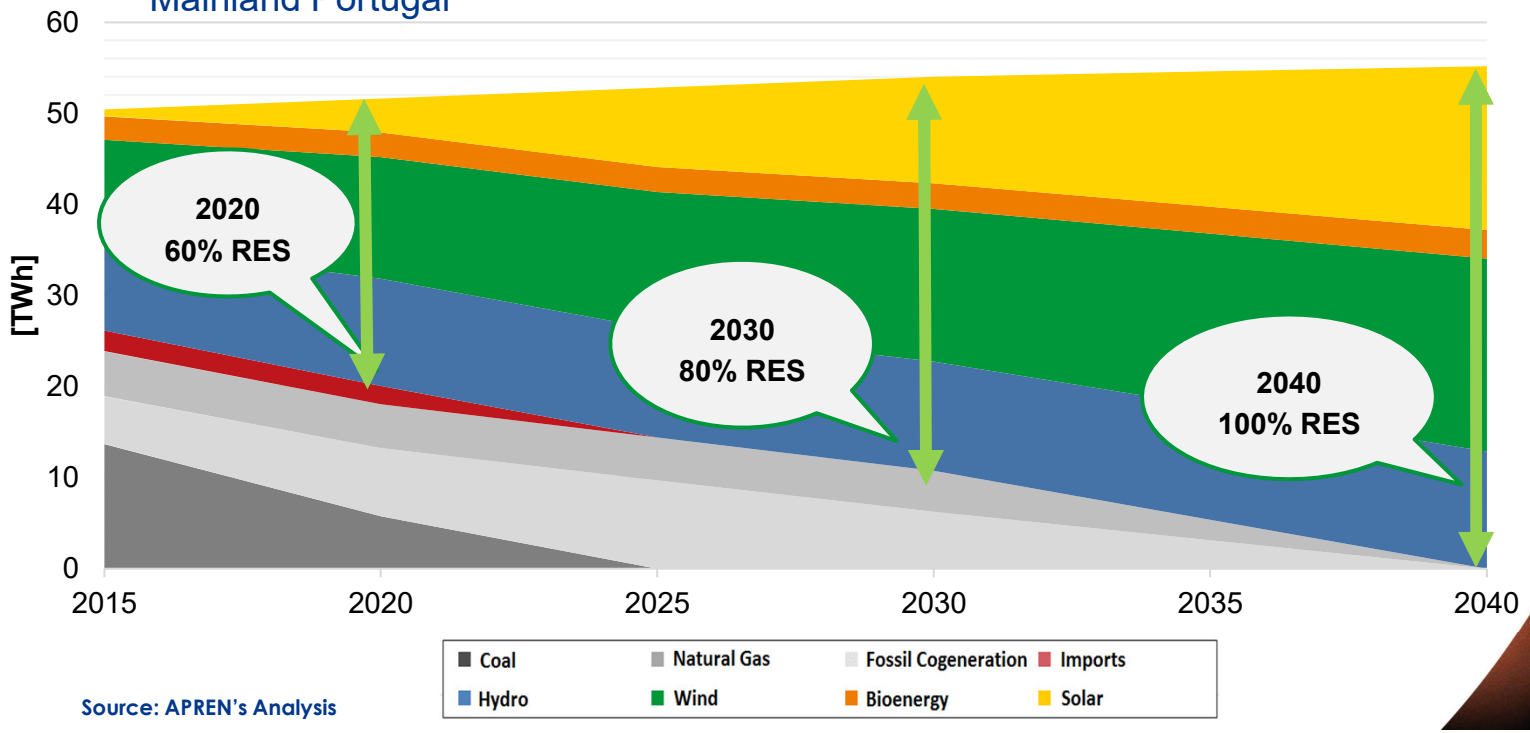
Electricity Sector Outlook

Electricity Sector Outlook

Mainland Portugal



Source: APREN's Analysis

Electricity Sector Outlook

Mainland Portugal

2016

Consumption	% Renewable in Consumption	Renewable Electricity [normalized]	Wind	Hydro	Solar	Biomass	RES Total
51 TWh	55 %	28 TWh	5.2 GW	6.8 GW	0.4 GW	0.7 GW	13.2 GW

2030*

Consumption	% Renewable in Consumption	Renewable Electricity [normalized]	Wind	Hydro	Solar	Biomass	RES Total
54 TWh	80 %	43,2 TWh	7 GW	8,4 GW	6,6 GW	0.8 GW	22,9 GW

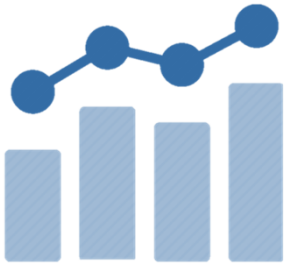
* Needs to be actualized with the last forecasts

Electricity Sector Outlook

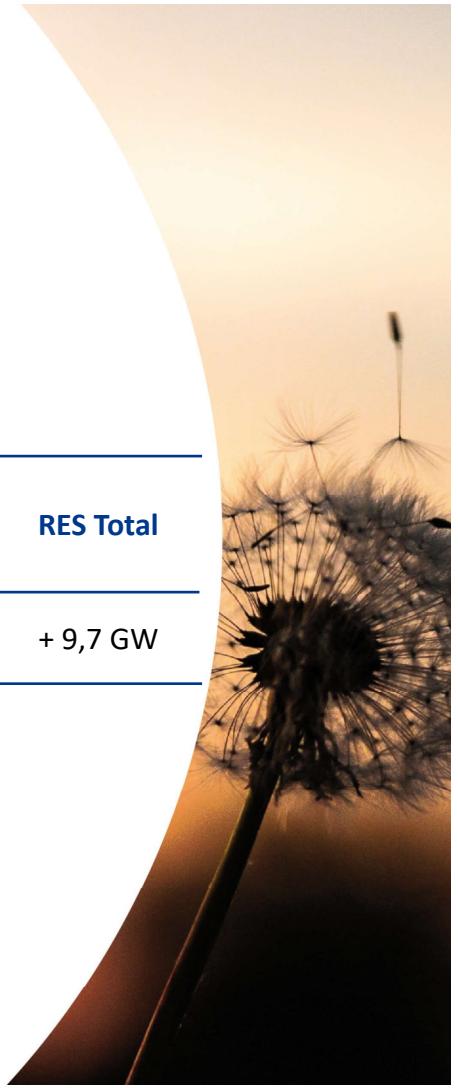
Mainland Portugal

2016-2030

Consumption	% Renewable in Consumption	Renewable Electricity [normalized]	Wind	Hydro	Solar	Biomass	RES Total
+ 3 TWh	+ 25 %	+ 15,2 TWh	+ 1,8 GW	+ 1,6 GW	+ 6,2 GW	+ 0.1 GW	+ 9,7 GW



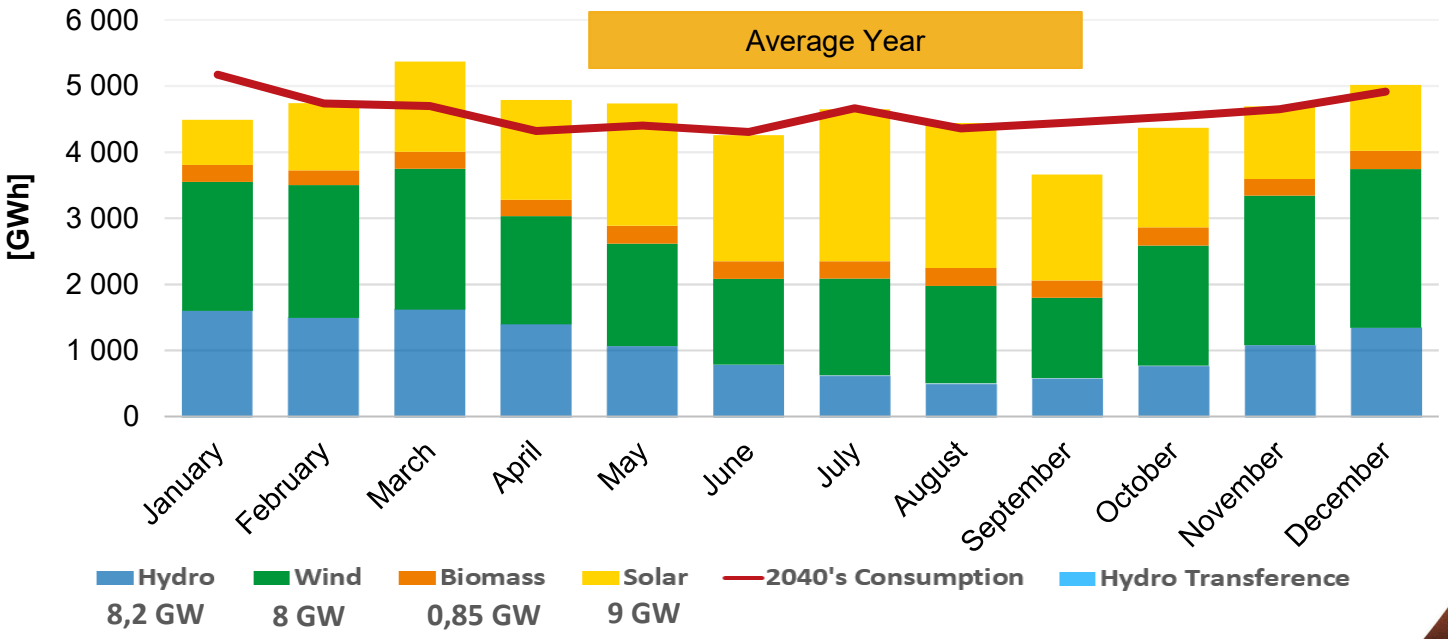
- **Increase in consumption**
- **Increase in renewable capacity**

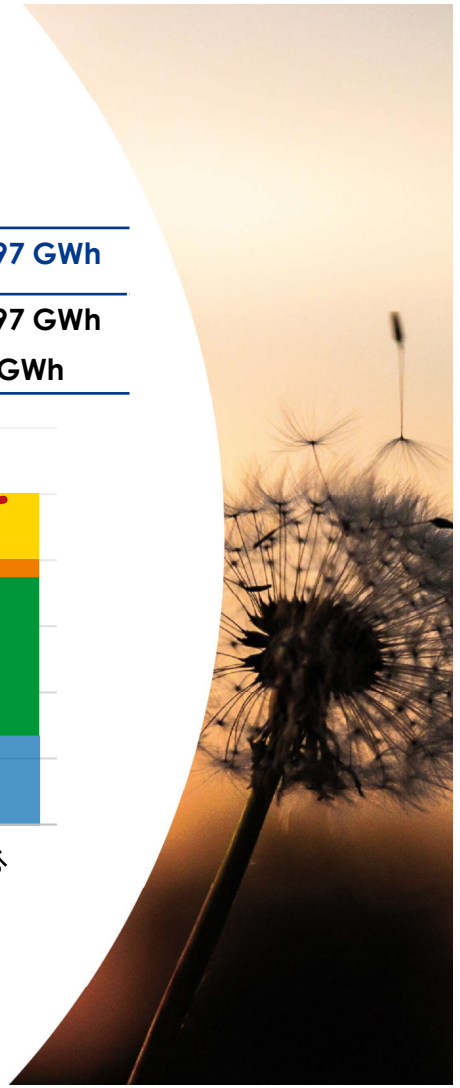


Outlook of the Electricity Sector in 2040

100% Renewable in net values – Mainland Portugal

Consumption	55 197 GWh
Generation	55 197 GWh
Balance	0 GWh





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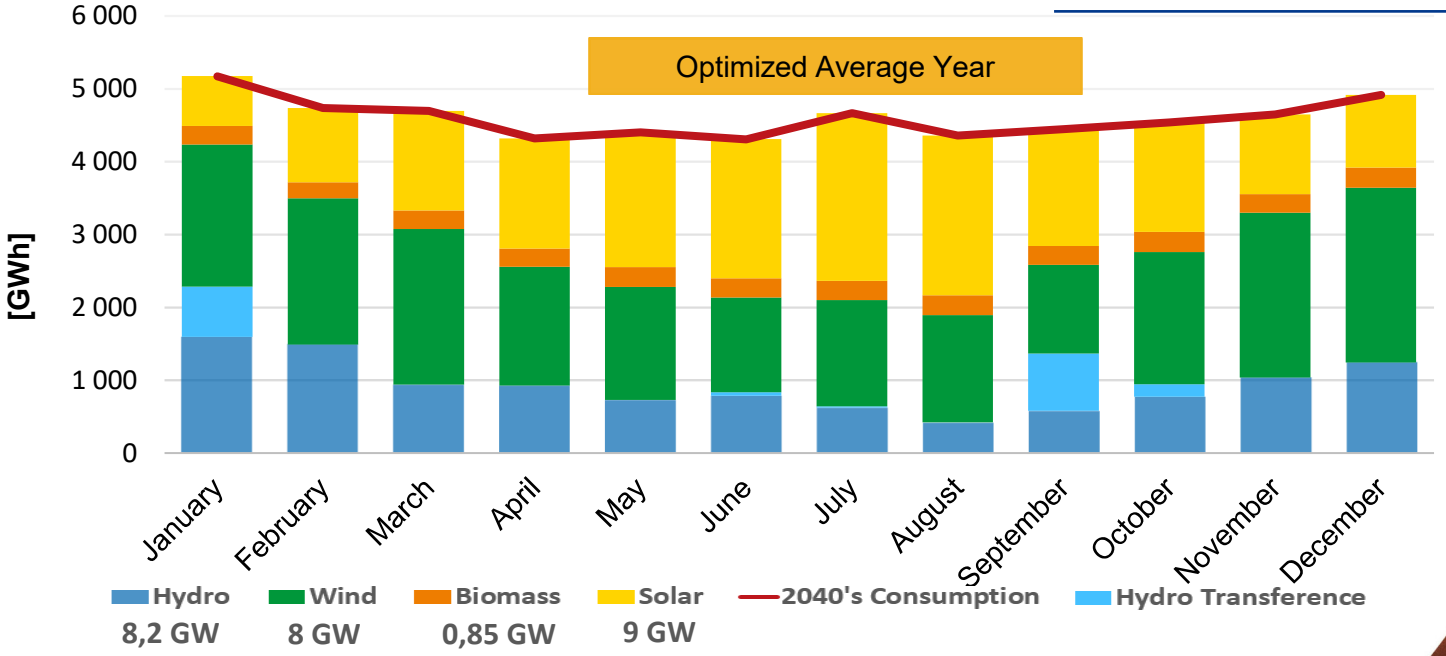
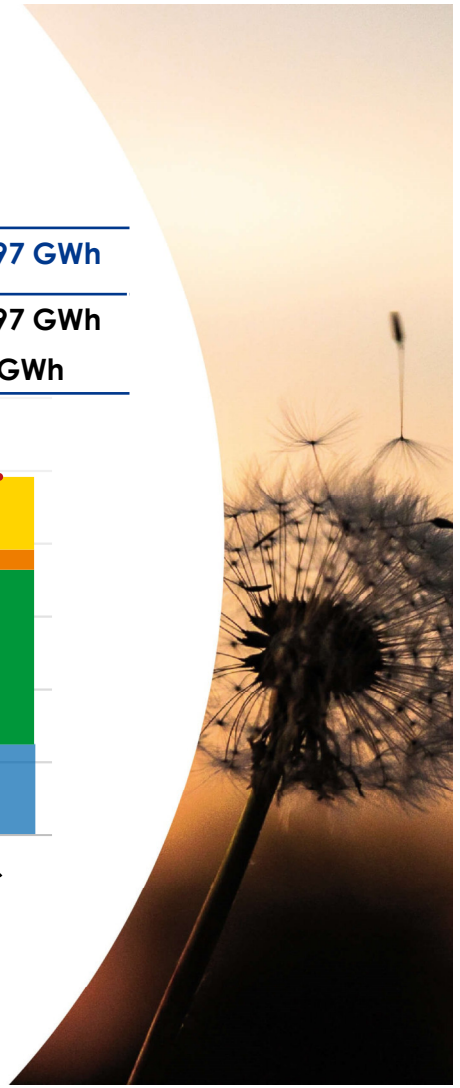


- Vol. of water needed for pumped stor. = 3.000 hm^3



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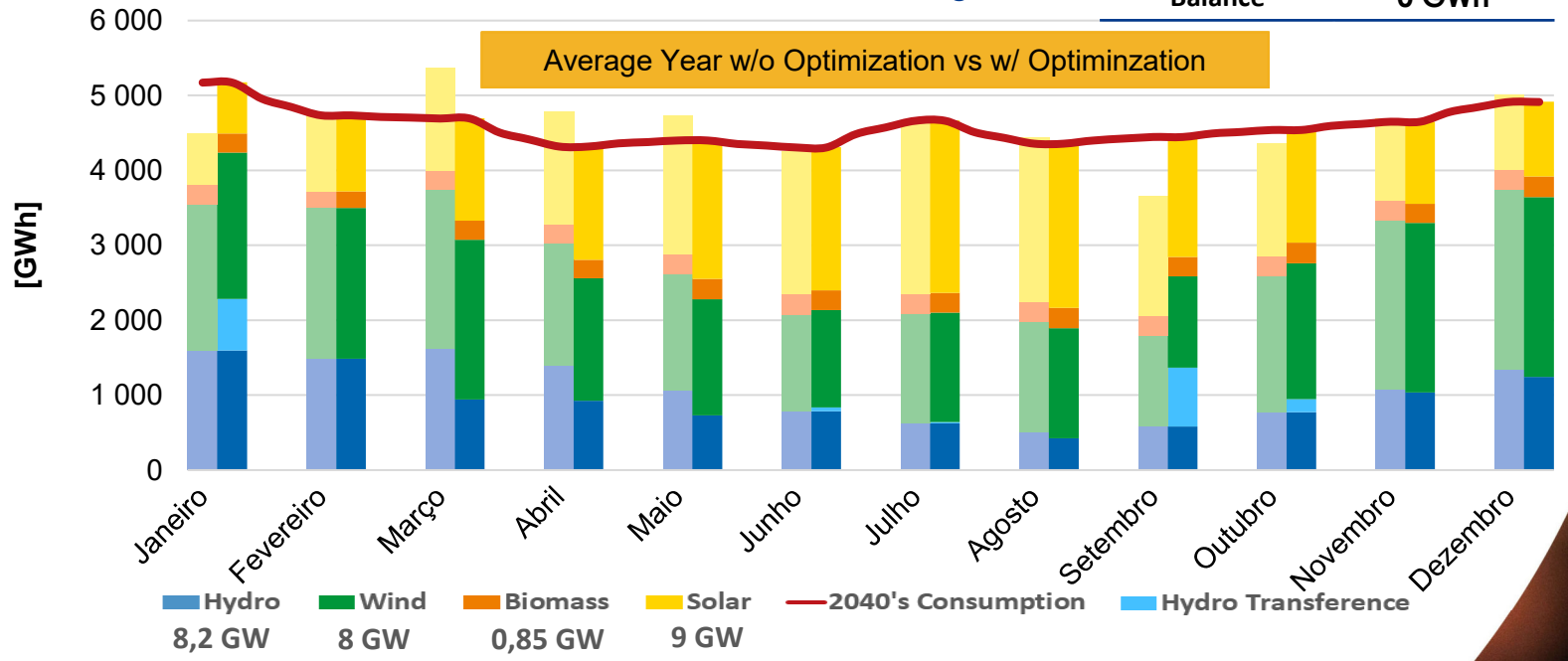

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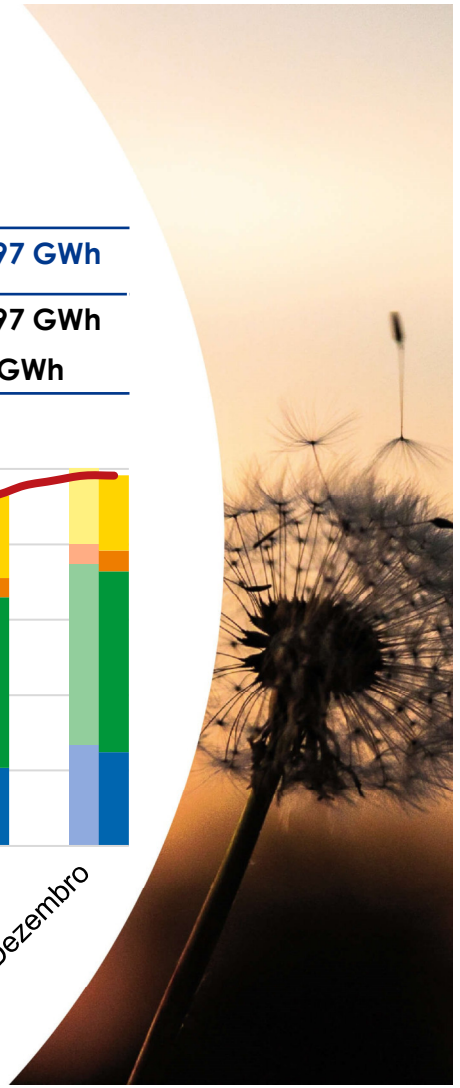
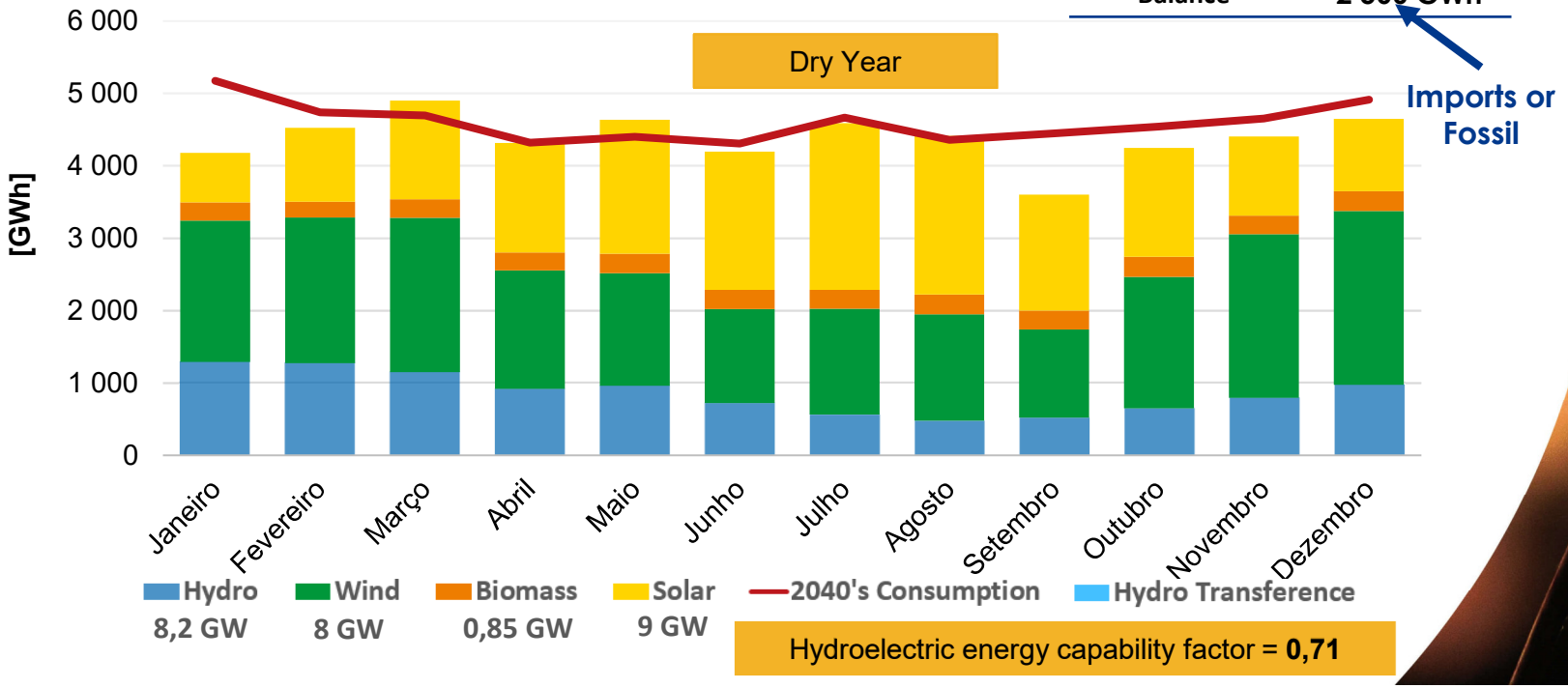


Outlook of the Electricity Sector in 2040

100% Renewable in net values – Mainland Portugal

Consumption	55 197 GWh
Generation	52 631 GWh
Balance	-2 566 GWh



Outlook of the Electricity Sector in 2040

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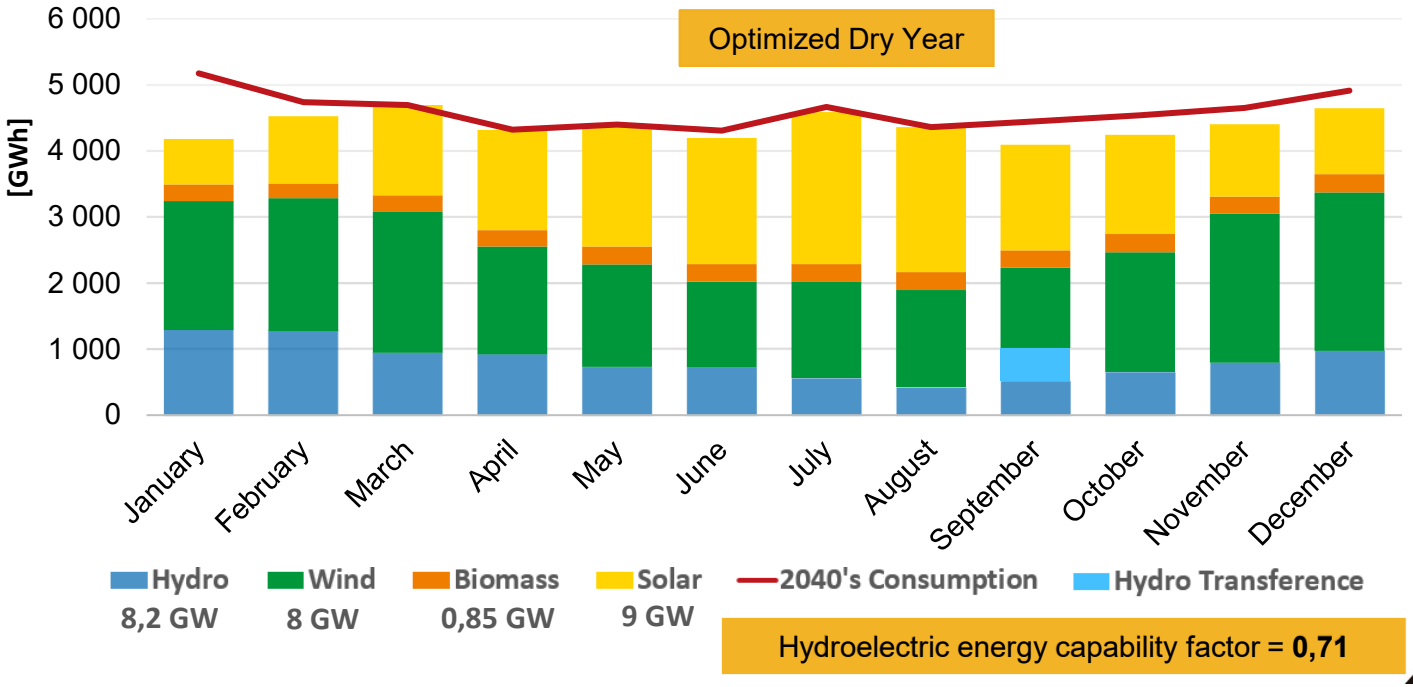
Imports or Fossil



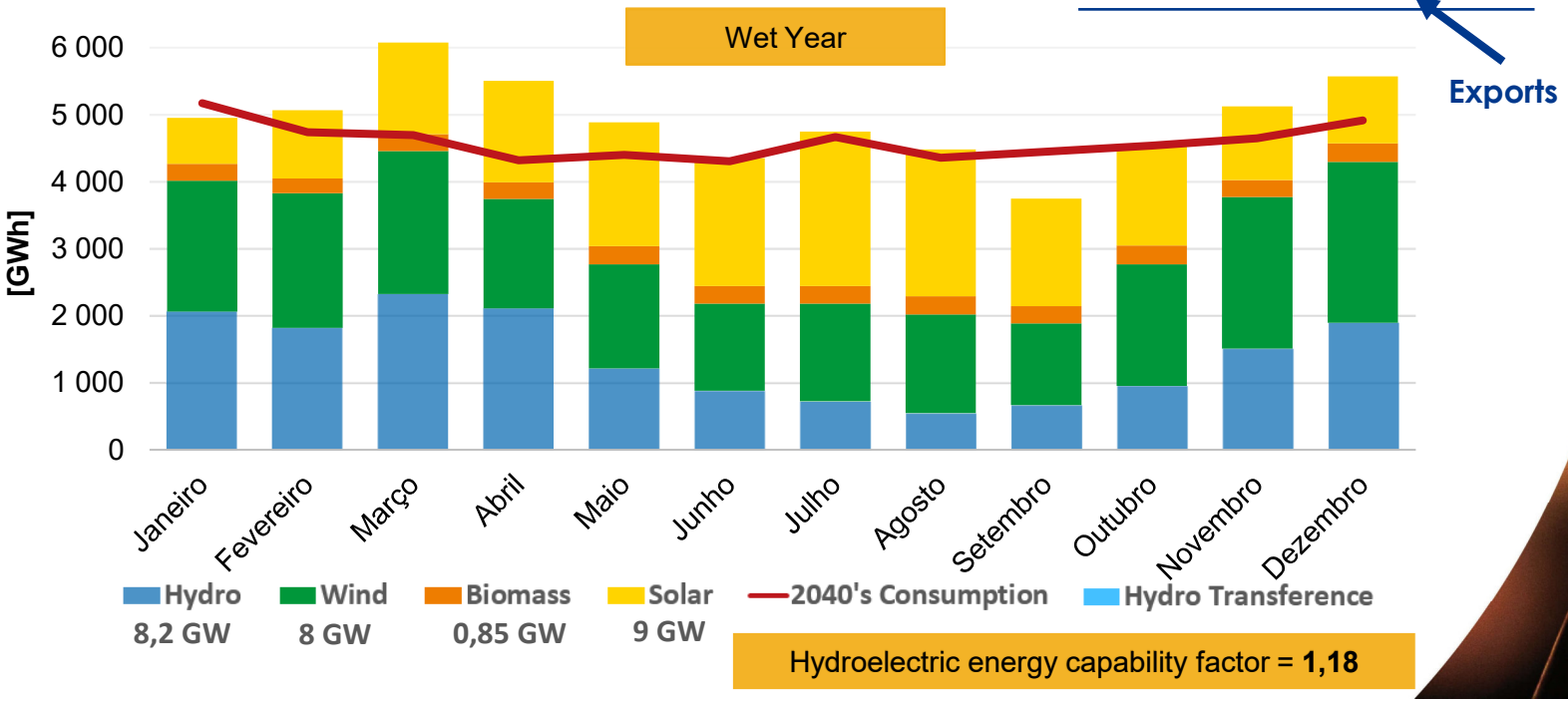
Hydroelectric energy capability factor = **0,71**

Outlook of the Electricity Sector in 2040

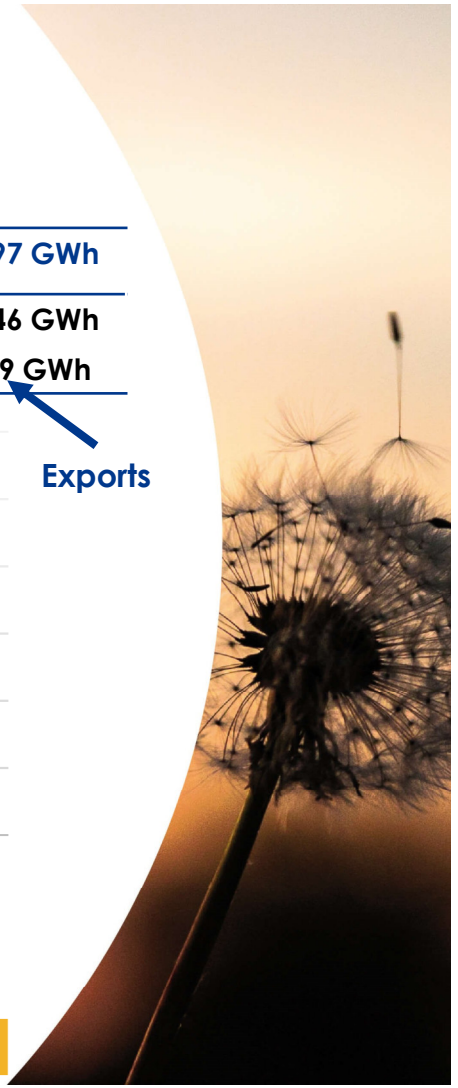
100% Renewable in net values – Mainland Portugal

Consumption	55 197 GWh
Generation	59 046 GWh
Balance	3 849 GWh

Exports



Hydroelectric energy capability factor = **1,18**



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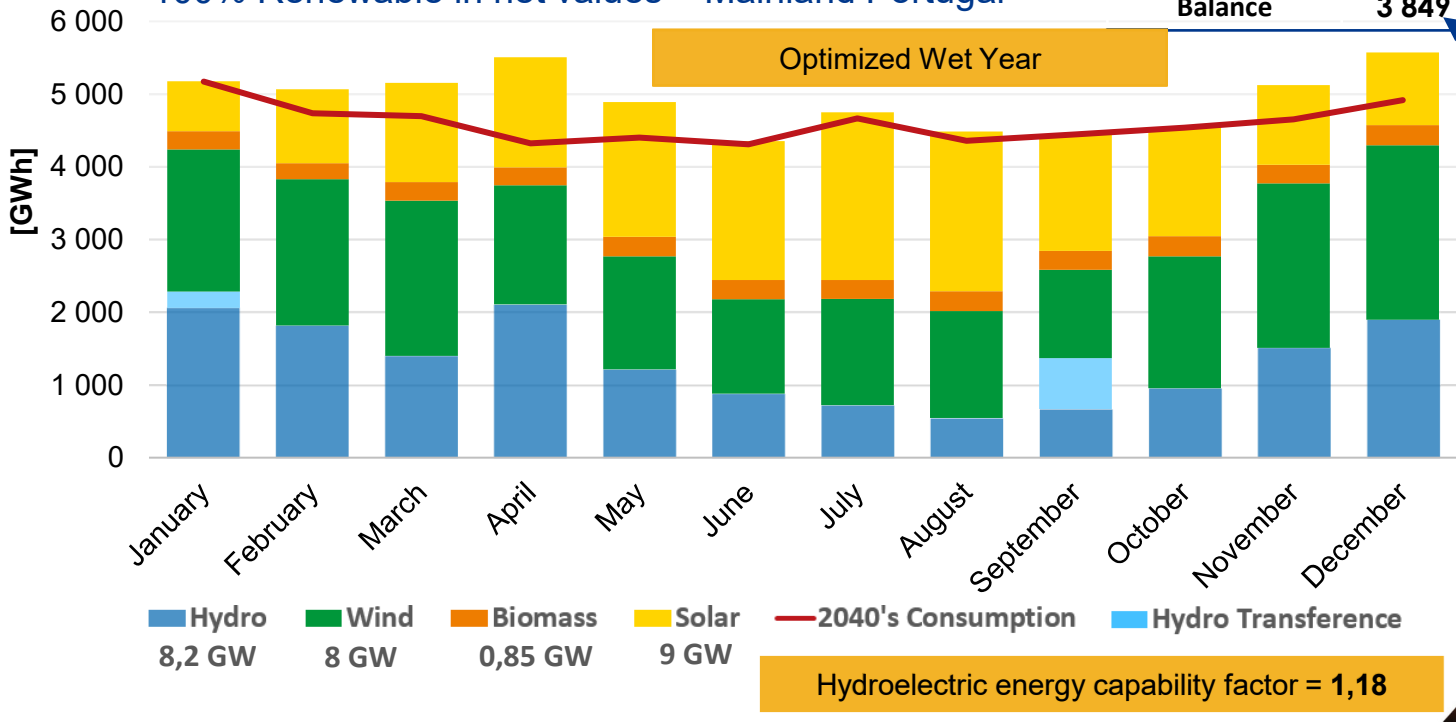

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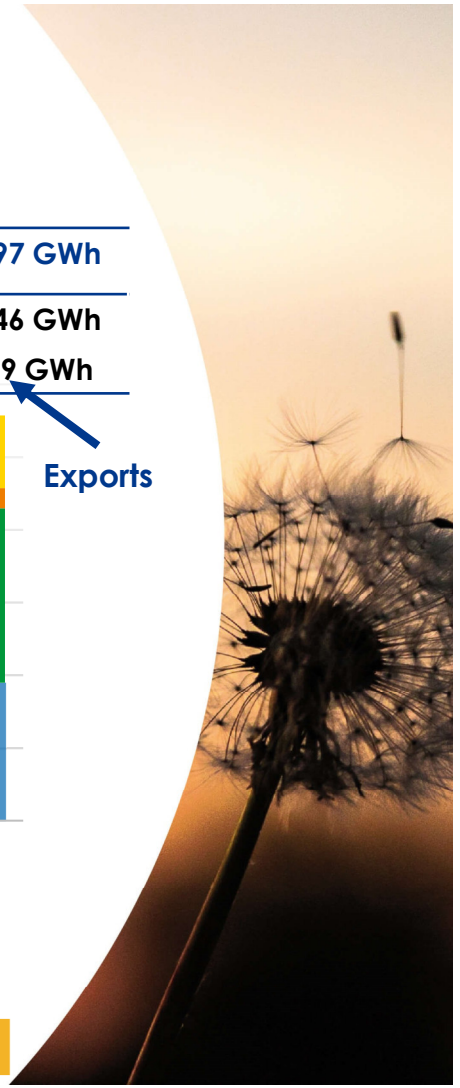

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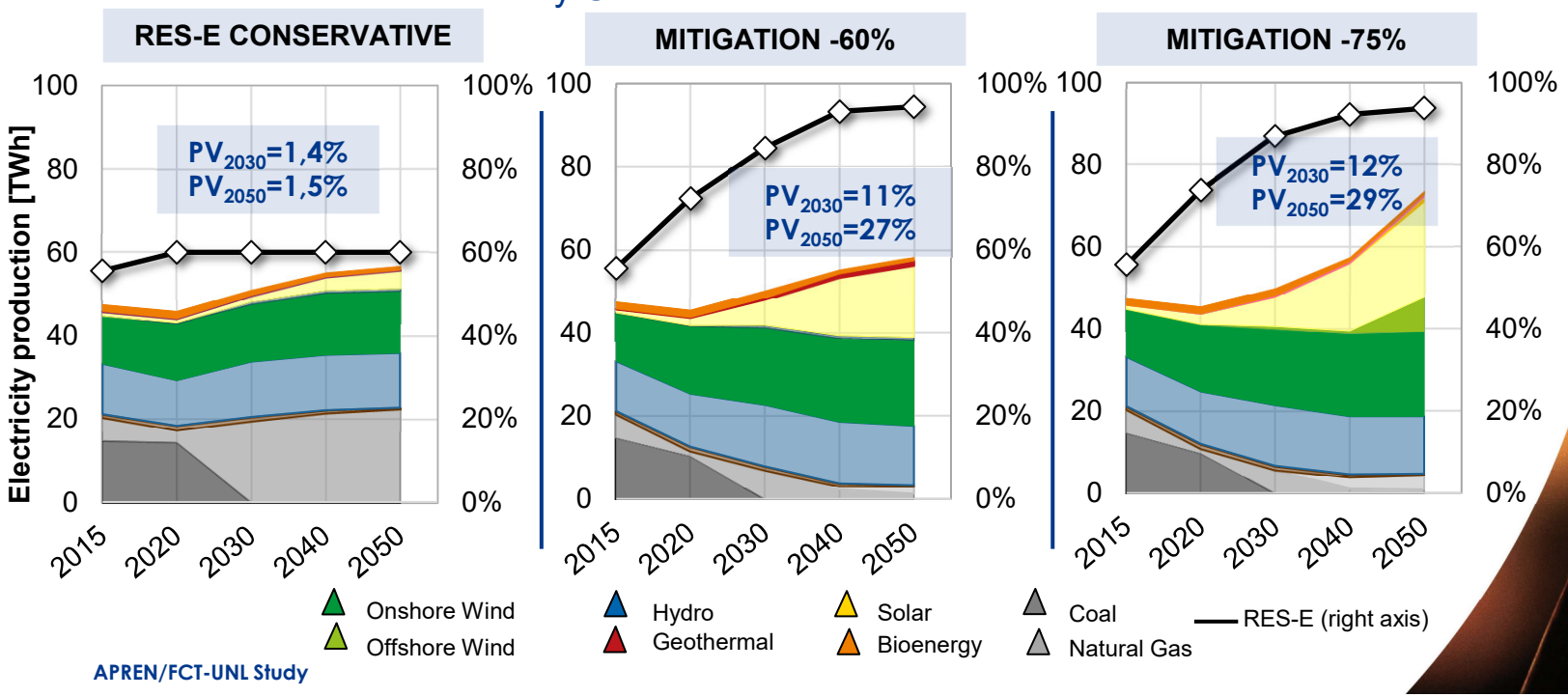
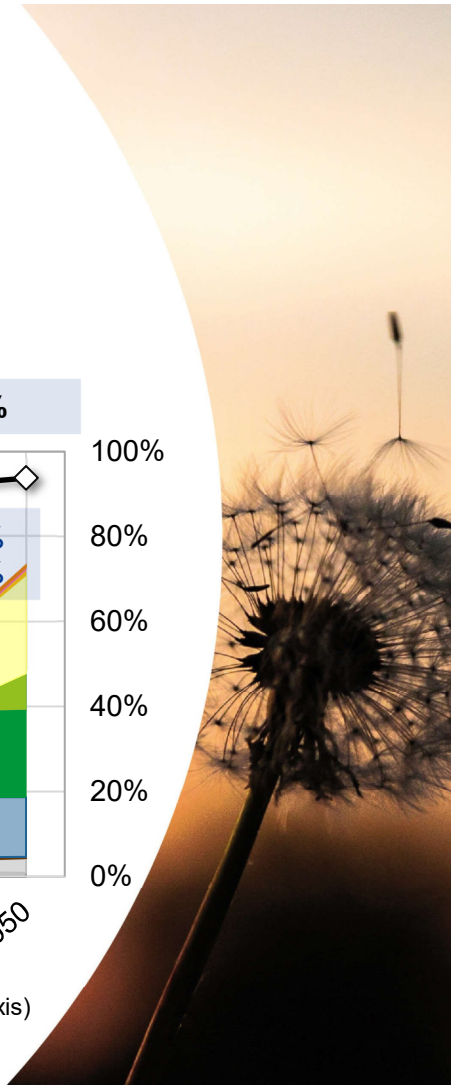
Renewable Electricity in the Portuguese Energy System until 2050

Renewable Electricity in the Portuguese Energy System until 2050

Evolution of the Electricity Generation Mix

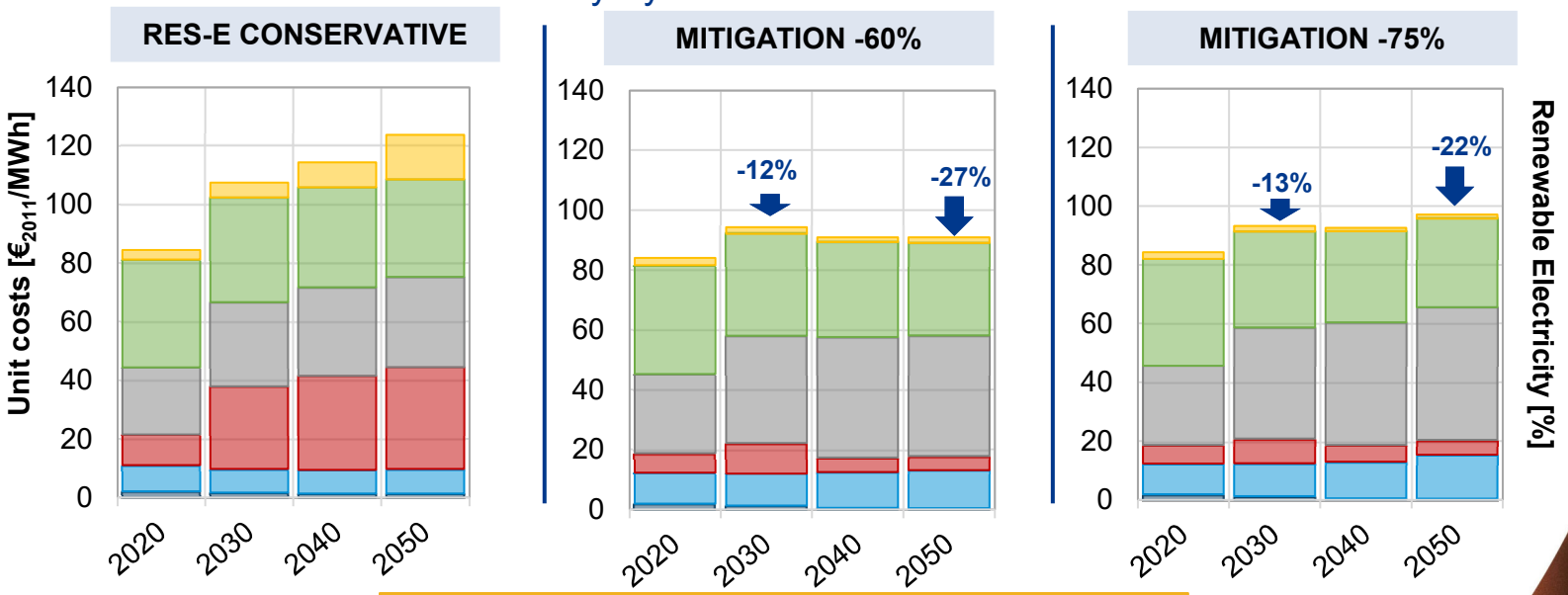


APREN/FCT-UNL Study



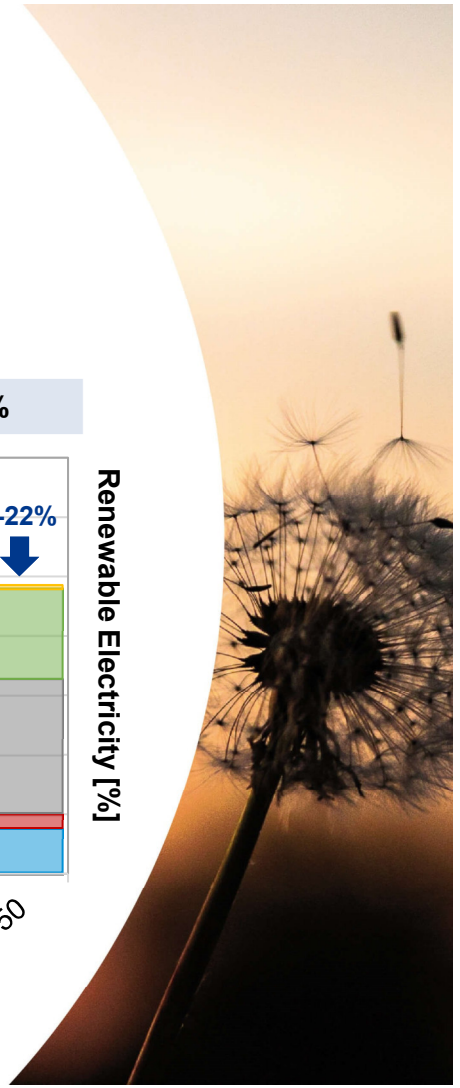
Renewable Electricity in the Portuguese Energy System until 2050

Unit Costs of the Electricity System



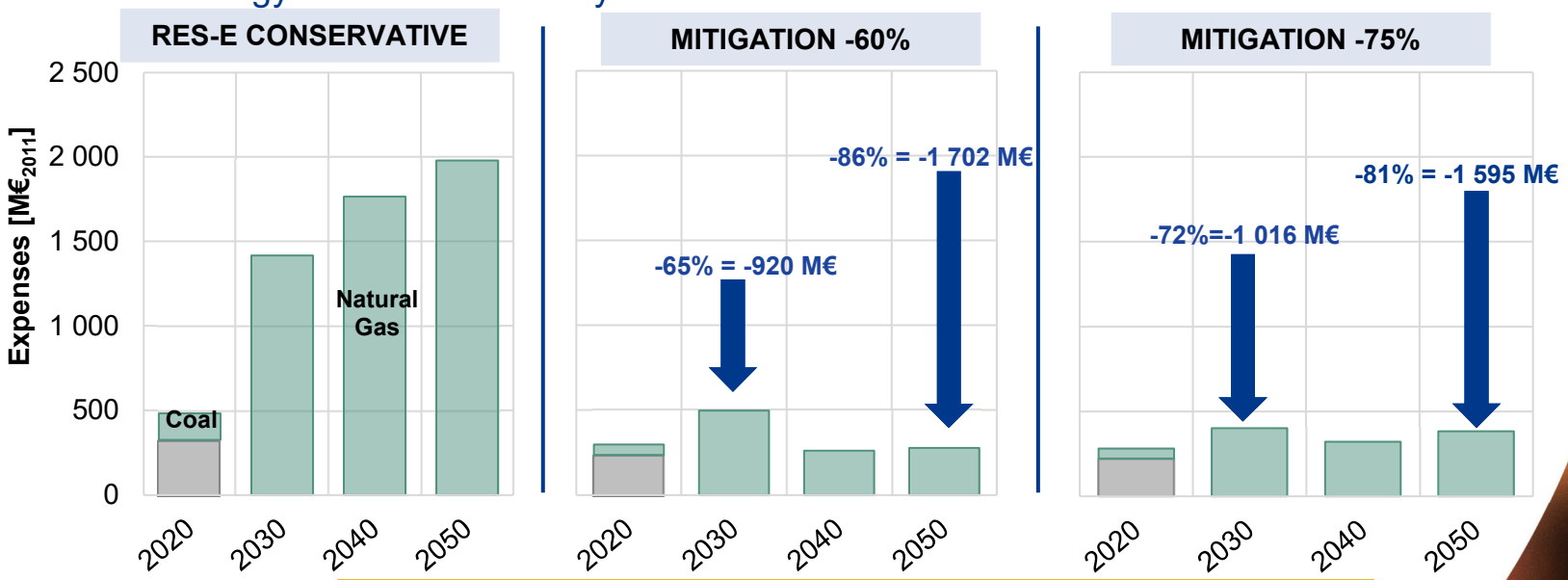
Scenarios with **strong utilization** of RES-E result in **lower unit costs** for the electric sector

APREN/FCT-UNL Study



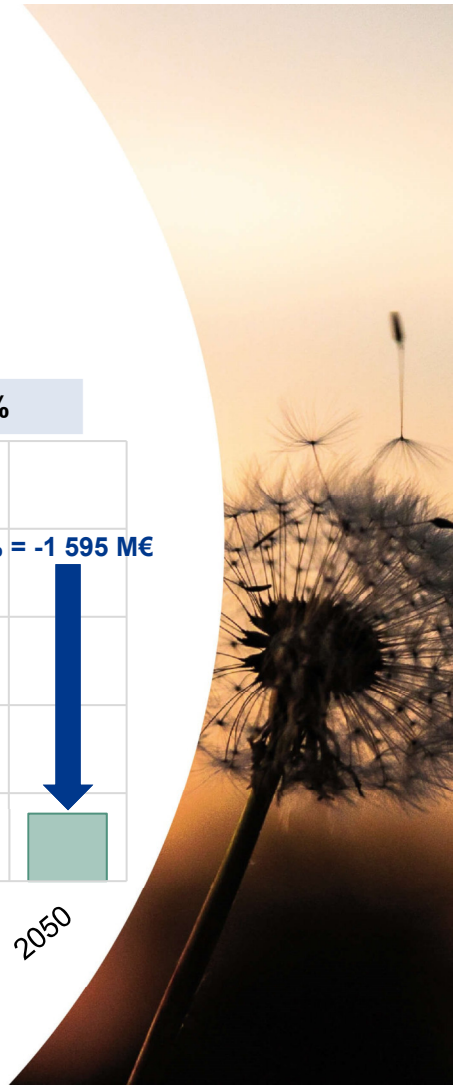
Renewable Electricity in the Portuguese Energy System until 2050

Energy Bill of the Electricity Sector



From 2030, the **savings** with the **energy bill** can reach values over **€ millions per year**, equivalent to 28% of the national energy import-export balance for 2015

APREN/FCT-UNL Study



YES IT IS POSSIBLE TO ACHIEVE A 100 %

RENEWABLE ELECTRICITY SYSTEM

HYDROELECTRIC ENERGY STORAGE

WILL BE ESSENTIAL TO REACH THAT GOAL

So…

LET'S DO IT!

Thank you!

For more information go to: www.apren.pt
Or send us an e-mail: dep.tecnico@apren.pt