The challenges of a changing energy landscape

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Agenda

1 A changing energy landscape

2 Challenges and opportunities in the Electricity sector

3 Portugal's strategy for the electricity sector

Questions

1. Which **country/region** is the **top energy consumer in the world**?
    a) China
    b) USA
    c) European Union

2. What was the **percentage of renewables** in the **Portuguese generation mix** in ‘15?
    a) ~10%
    b) ~30%
    c) ~50%

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1 **A changing energy landscape**

2 Challenges and opportunities in the European Electricity sector

3 Portugal's strategy for the electricity sector

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1 **A changing energy landscape**

a **The map of energy is changing**

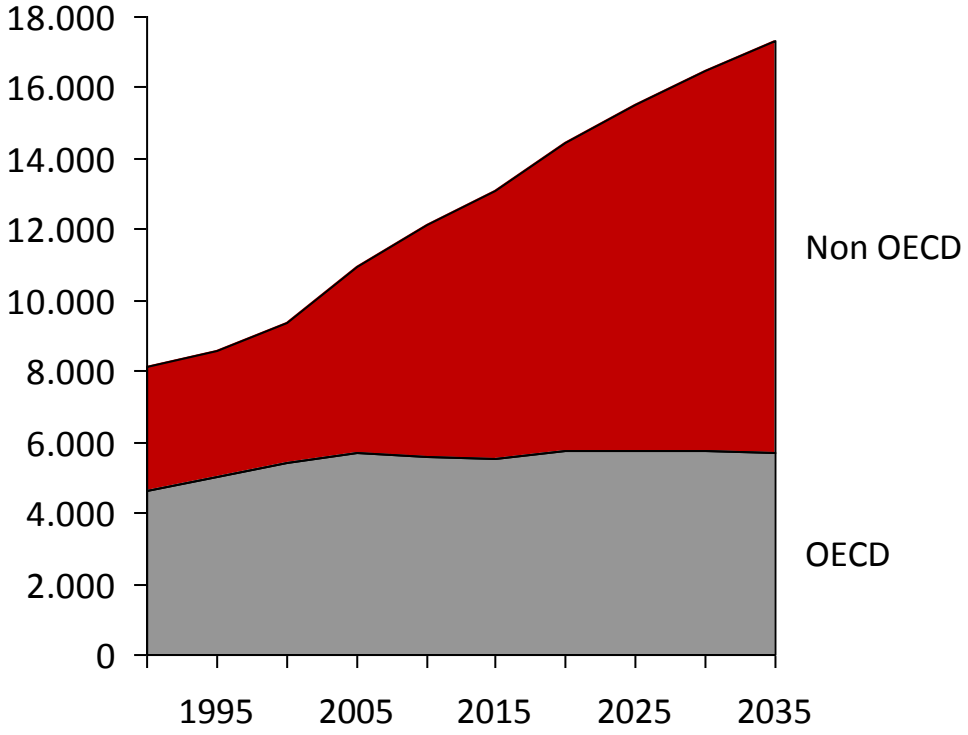
Efforts to tackle climate change still fall short of its target

The role of electricity in demand is increasing

Global energy demand is expected to evolve at two speeds: flat growth in the OECD and strong growth in non-OECD, pushed by China and India

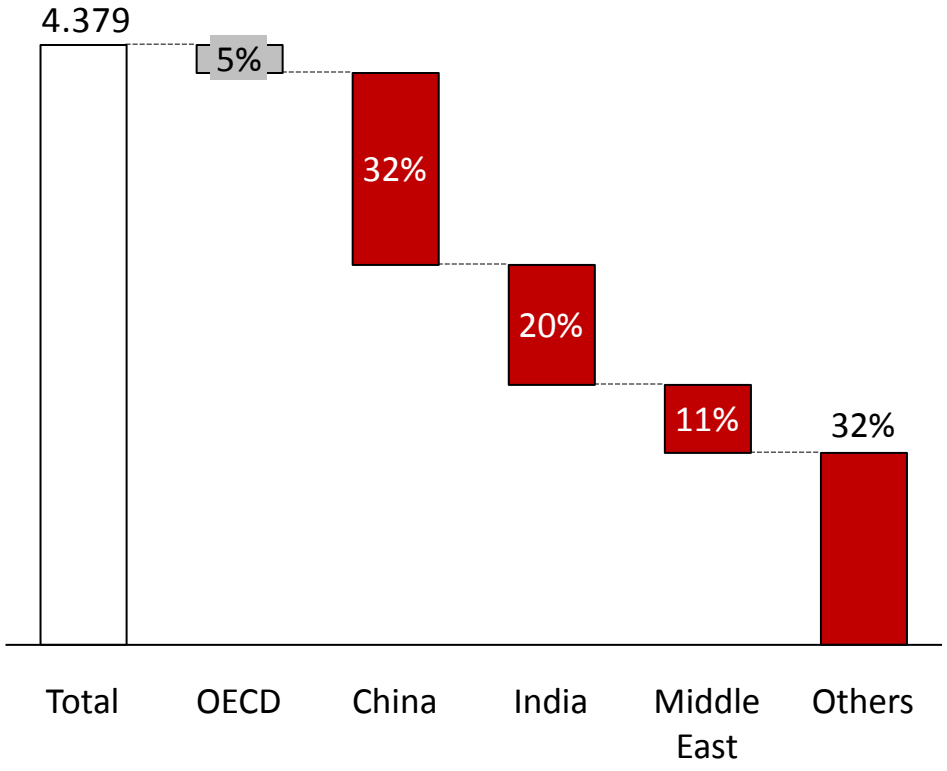
Primary energy demand

Mtoe, 1990-2015



Consumption growth per geography

Mtoe, 2014-2035

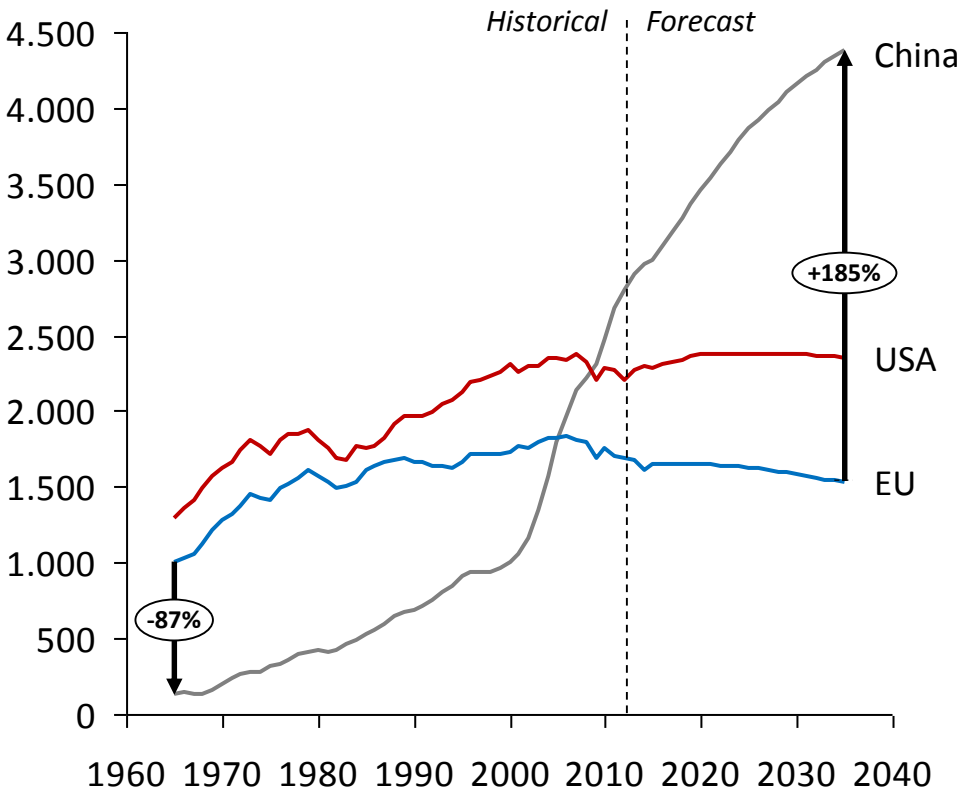


Source: BP Energy Outlook 2035

Consumption growth in China has been outstanding: in the past decade it added two times the EU's total growth in 35 years

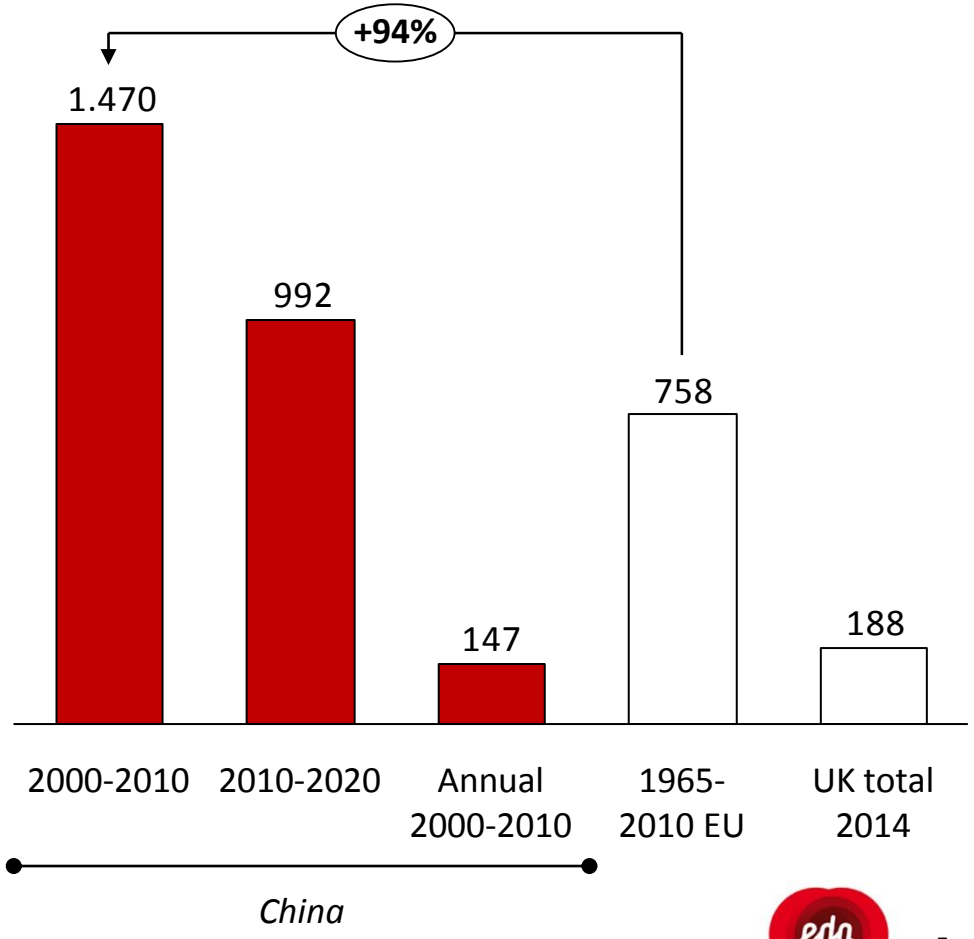
Primary energy demand

Mtoe, 1965-2035



Consumption growth

Mtoe



Source: BP Energy Outlook 2035

Huge disparities in energy consumption levels still subside: a New York inhabitant consumes 40x more electricity than one in Sub-Saharan Africa

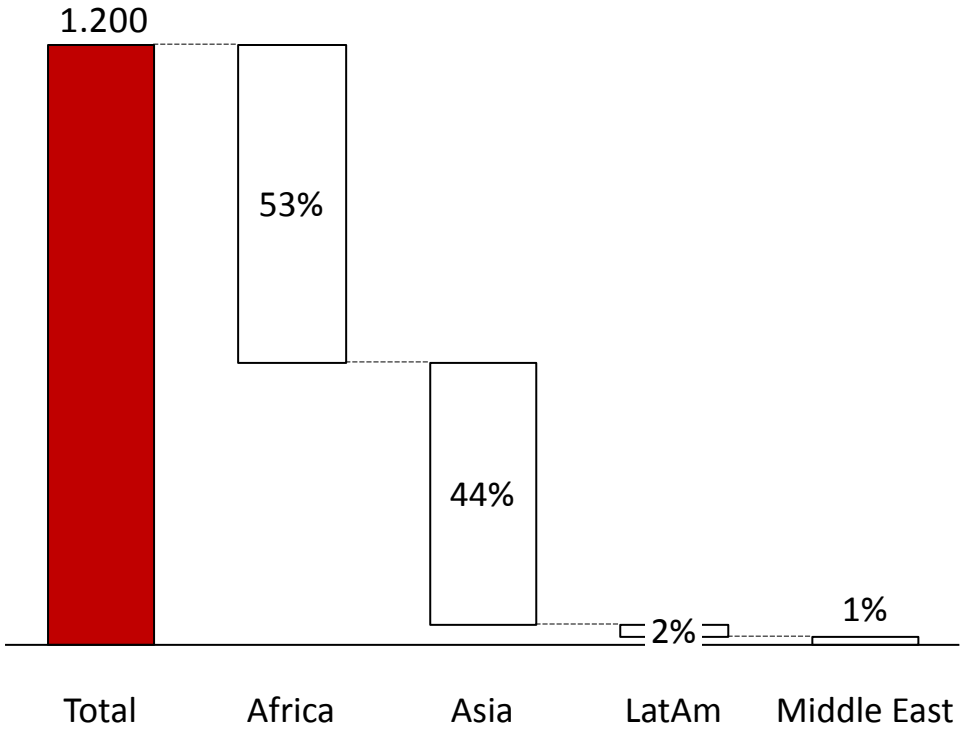
Residential electricity consumption in New York and Sub-Saharan Africa

	New York State (US)		Sub-Saharan Africa
Population	~20 Million People		~800 Million People
			
Consumption/ capita	2.000 kWh/capita		50 kWh/capita
Total consumption	**40 TWh/year**	=	**40 TWh/year**

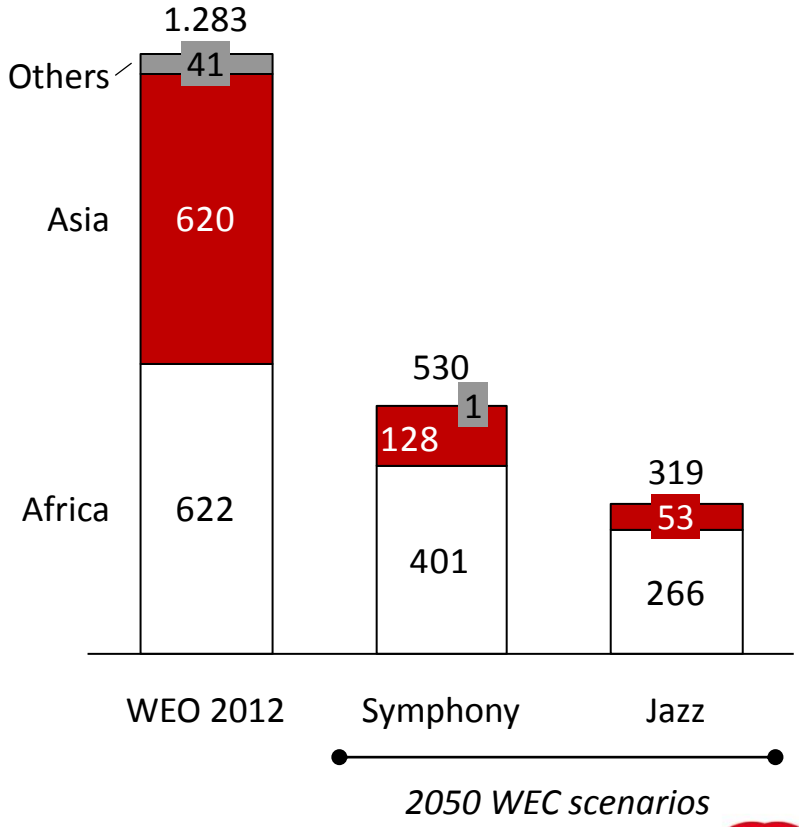
Source: IEA, WEC

Currently, 1.2 billion people still lack access to electricity, but demand growth in non-OECD should drive millions out of energy poverty

Population without access to electricity
Millions, 2013



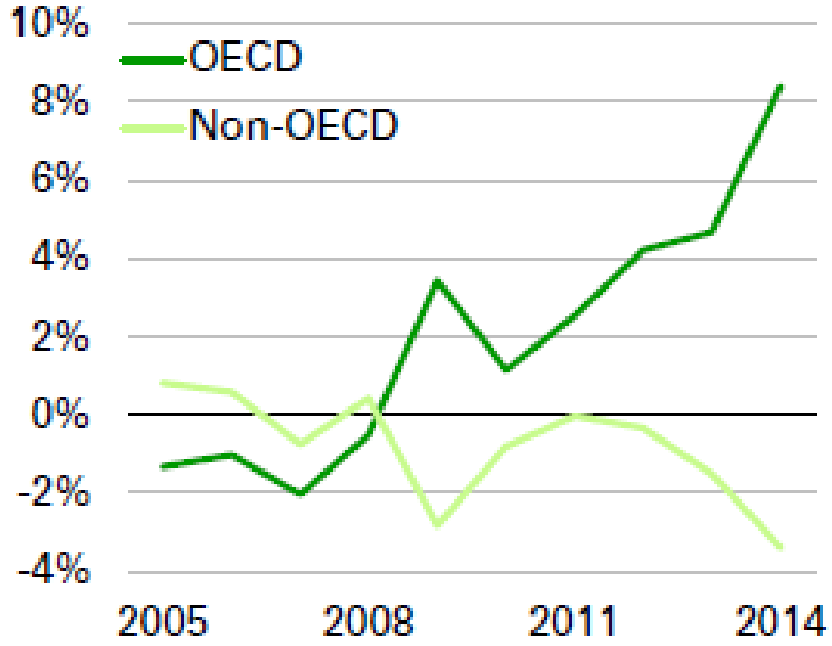
Population without access to electricity
Millions, 2012 and 2050



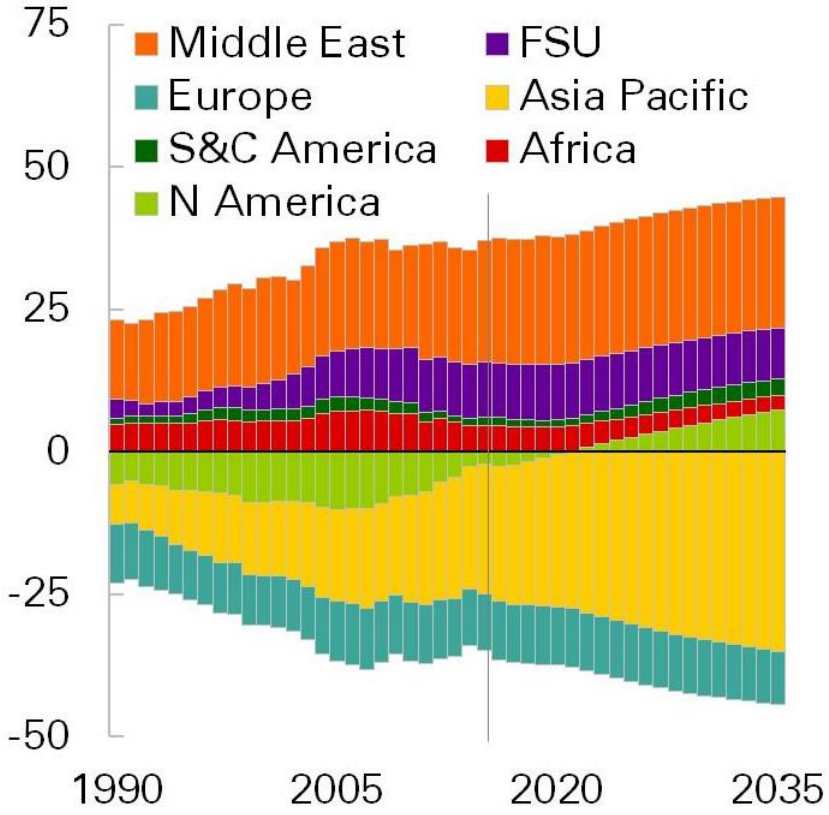
Source: IEA, WEC

Demand will grow faster than supply in non-OECD, eroding its net exporter position; energy will increasingly flow from West to East

Change in net energy balance
Cumulative from 2004, % of consumption



Primary Energy net balances[1]
Mb/d, 1990-2035



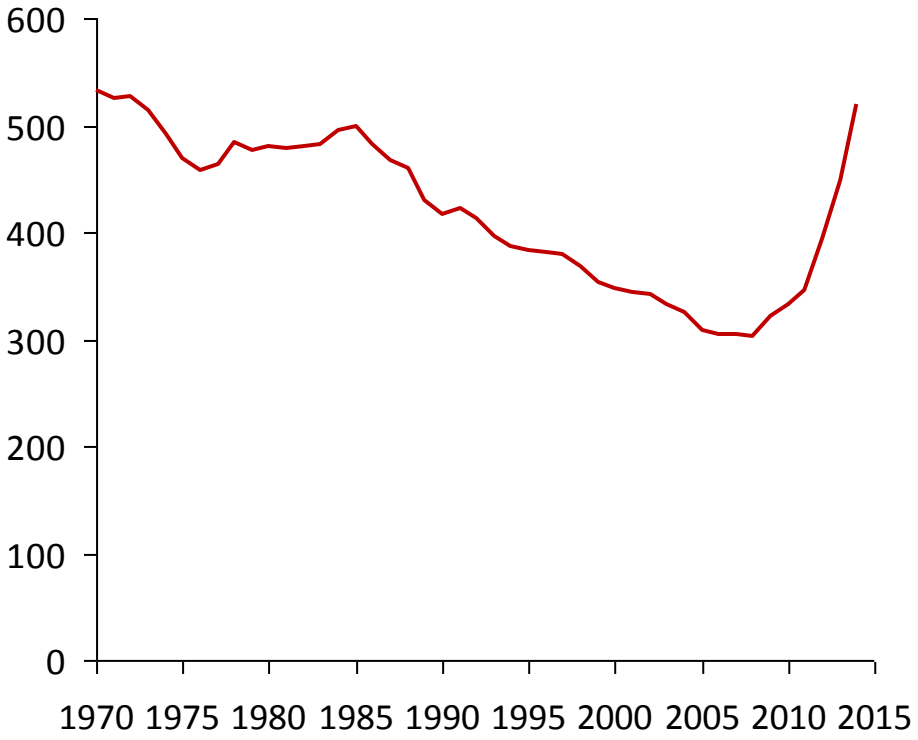
1. FSU – Former Soviet Union

Source: BP Statistical Review 2014, BP Energy Outlook 2035

The US is a showcase of this trend: spectacular increases in oil and gas production, pushed by tight oil and shale gas, reduce its import needs…

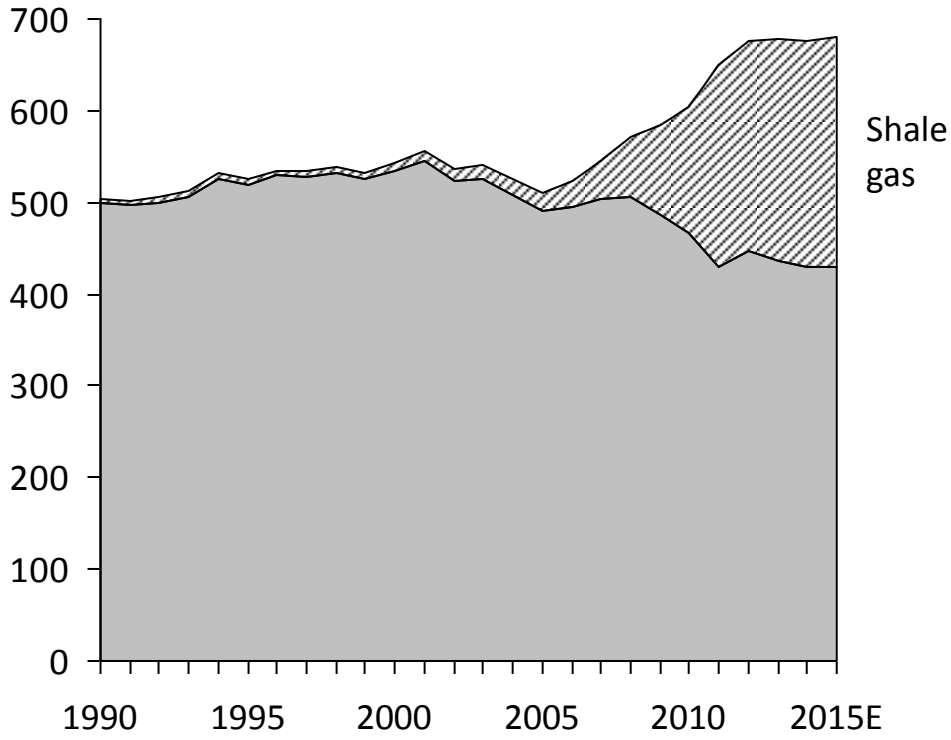
US oil production

Million tonnes, 1965-2014



US gas production

Bcm, 1970-2013

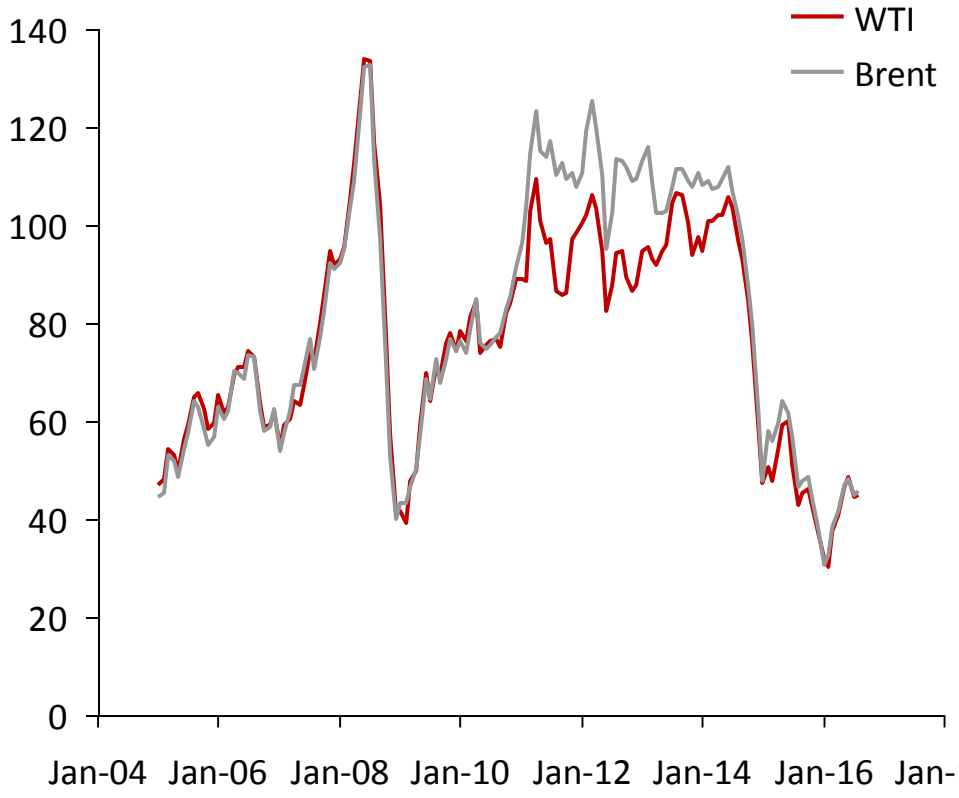


Source: BP Statistical review 2014, EIA

…which had a significant impact in the global commodity markets

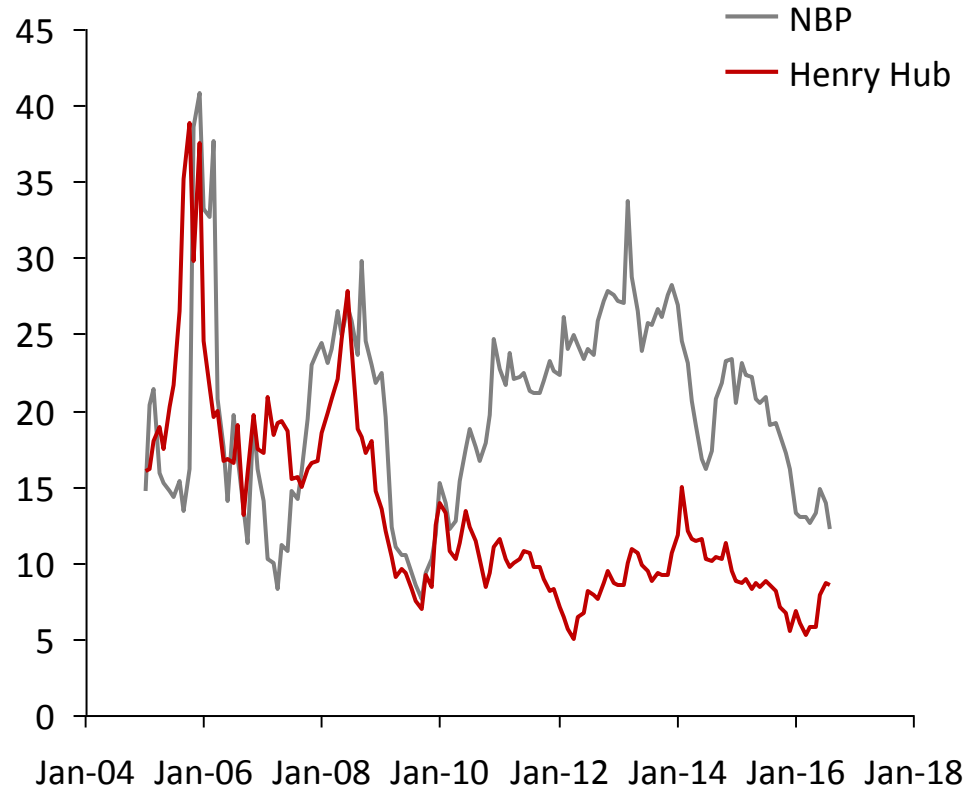
Oil price

$/bbl, Jan 2005 – Aug 2016



Gas price

€/MWht, Jan 2005 - Aug 2016



Source: Reuters

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1 **A changing energy landscape**

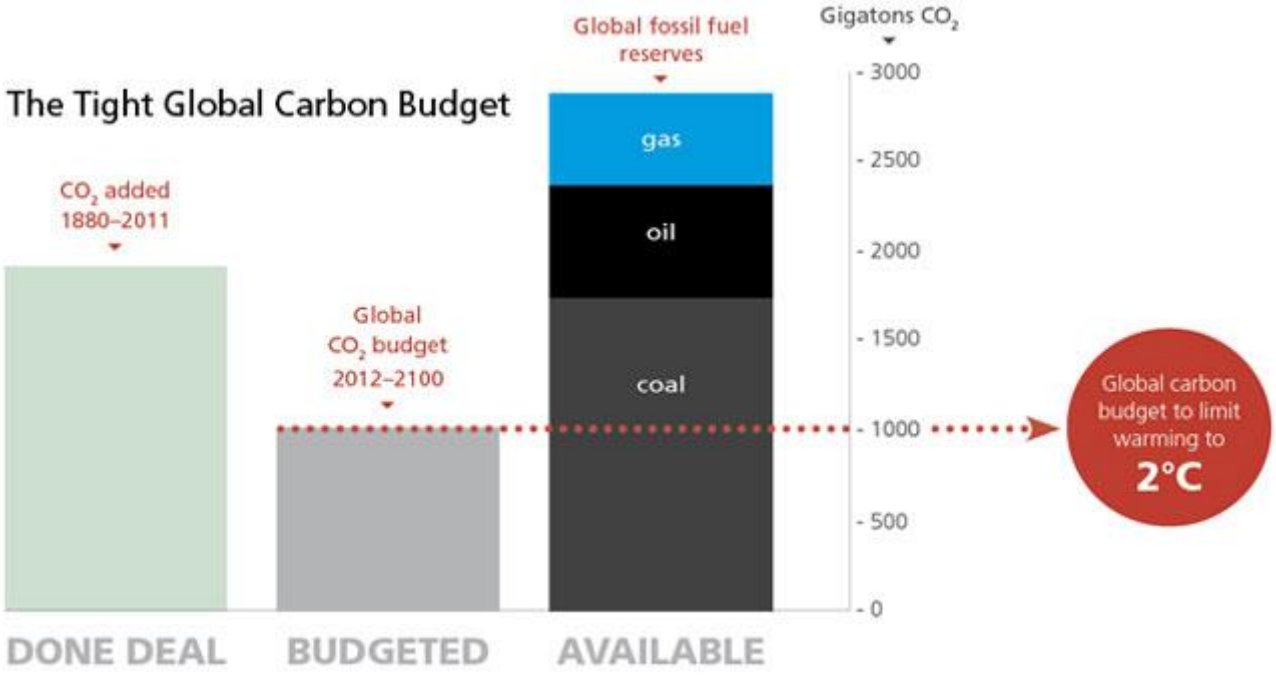
The map of energy is changing

b **Efforts to tackle climate change still fall short of its target**

The role of electricity in demand is increasing

To limit the global warming to 2ºC, known fossil fuel reserves need to stay underground

The Carbon bubble



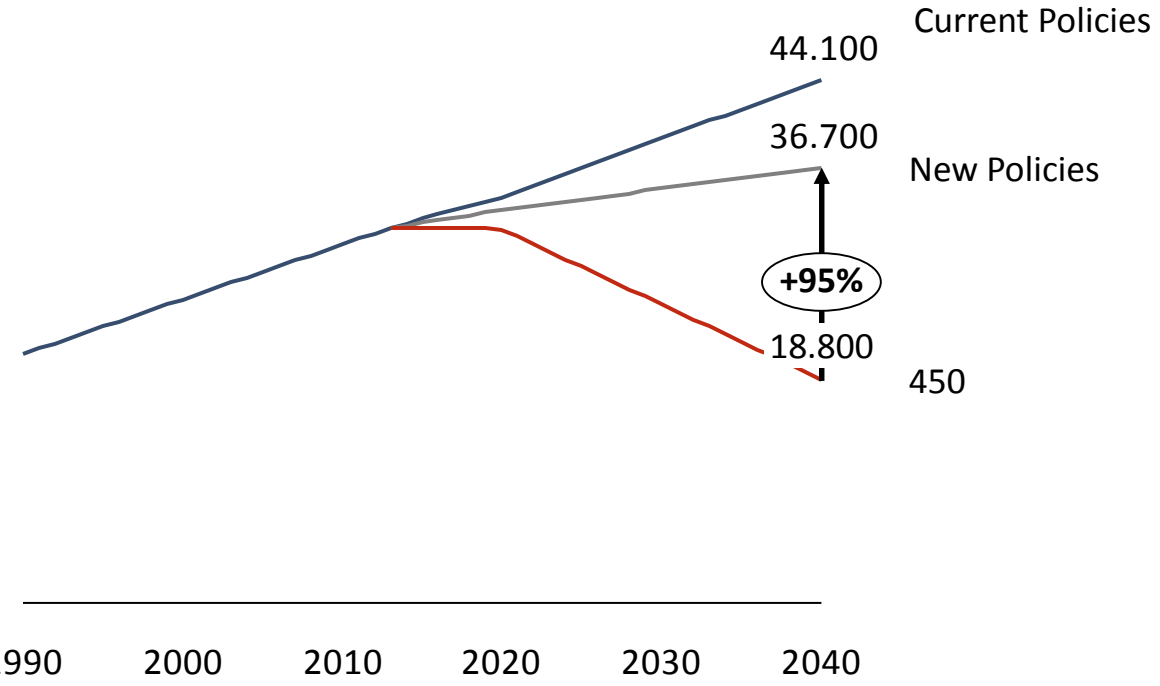
The Carbon Bubble dilemma: the World either overshoots the 2ºC limit, or fossil fuel listed companies are overvalued

Source: Conservation Magazine

However, emissions under IEA's base scenario use all the remaining carbon budget by 2040; adaptation measures will also be needed

Global CO_2 emissions

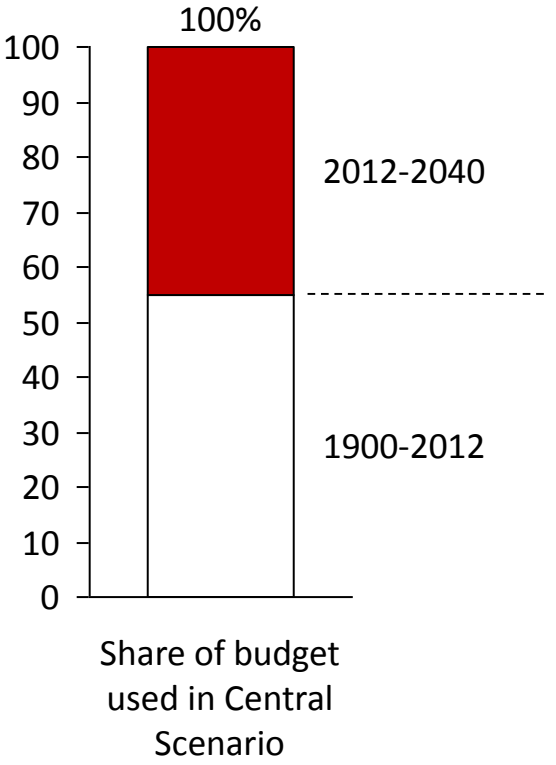
Gt, 1990-2040



IEA's 450 scenario is the only that considers the necessary measures to stabilize the increase in temperature to 2°C

Share of remaining carbon budget used under IEA's Base Scenario

%



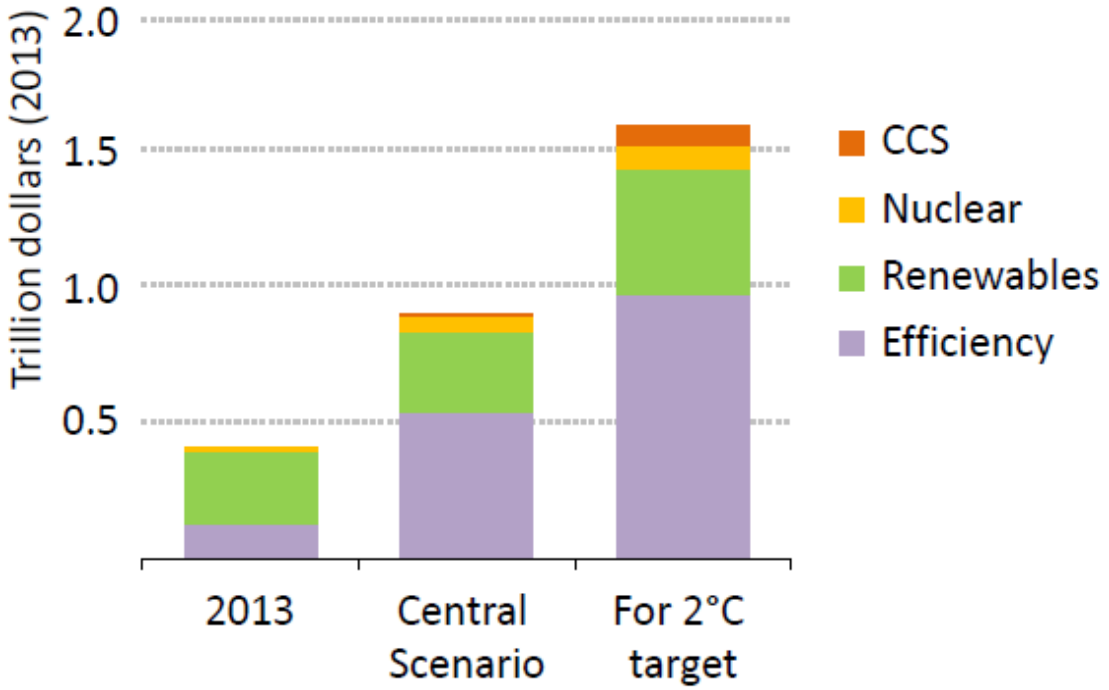
1. IEA – International Energy Agency

Source: IEA WEO 2015

Avoiding severe climate change requires a significant step up in low carbon investment, notably in improved efficiency and renewables

Average anual low carbon investment

Trillion dollars(2013), 2014-2040



Source: IEA – International Energy Agency

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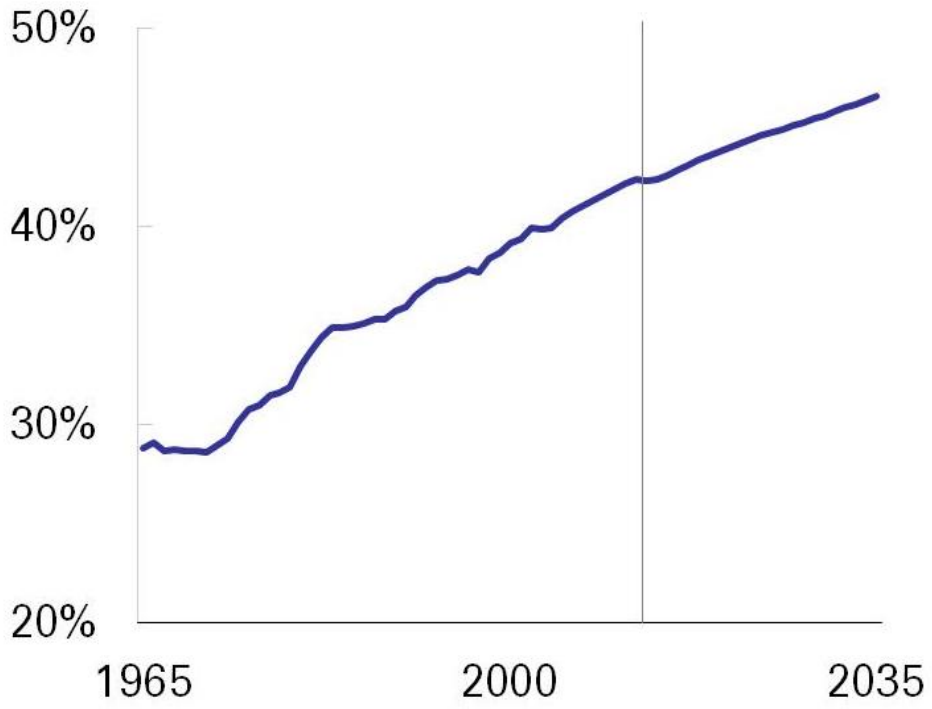
C **The role of electricity in demand is increasing**

Electricity as a final energy source has grown significantly in the past, and it should remain as the highest growth source in the future

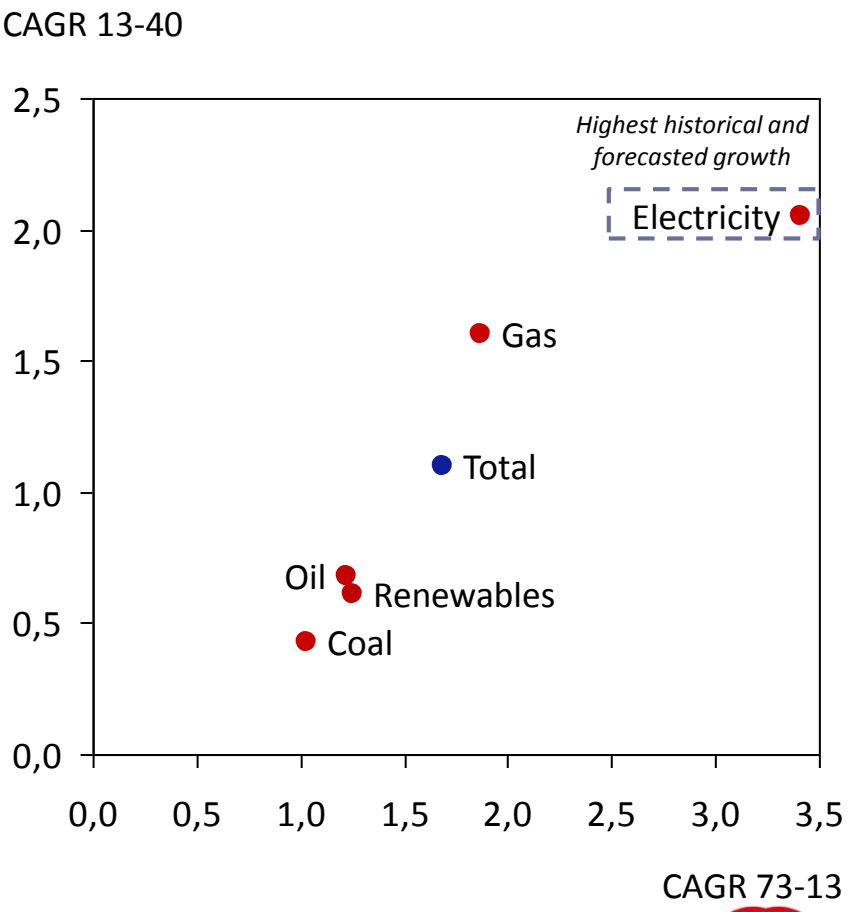
Inputs to electricity as a share of total primary energy

%, 1965-2035



Final energy CAGR by fuel type

%

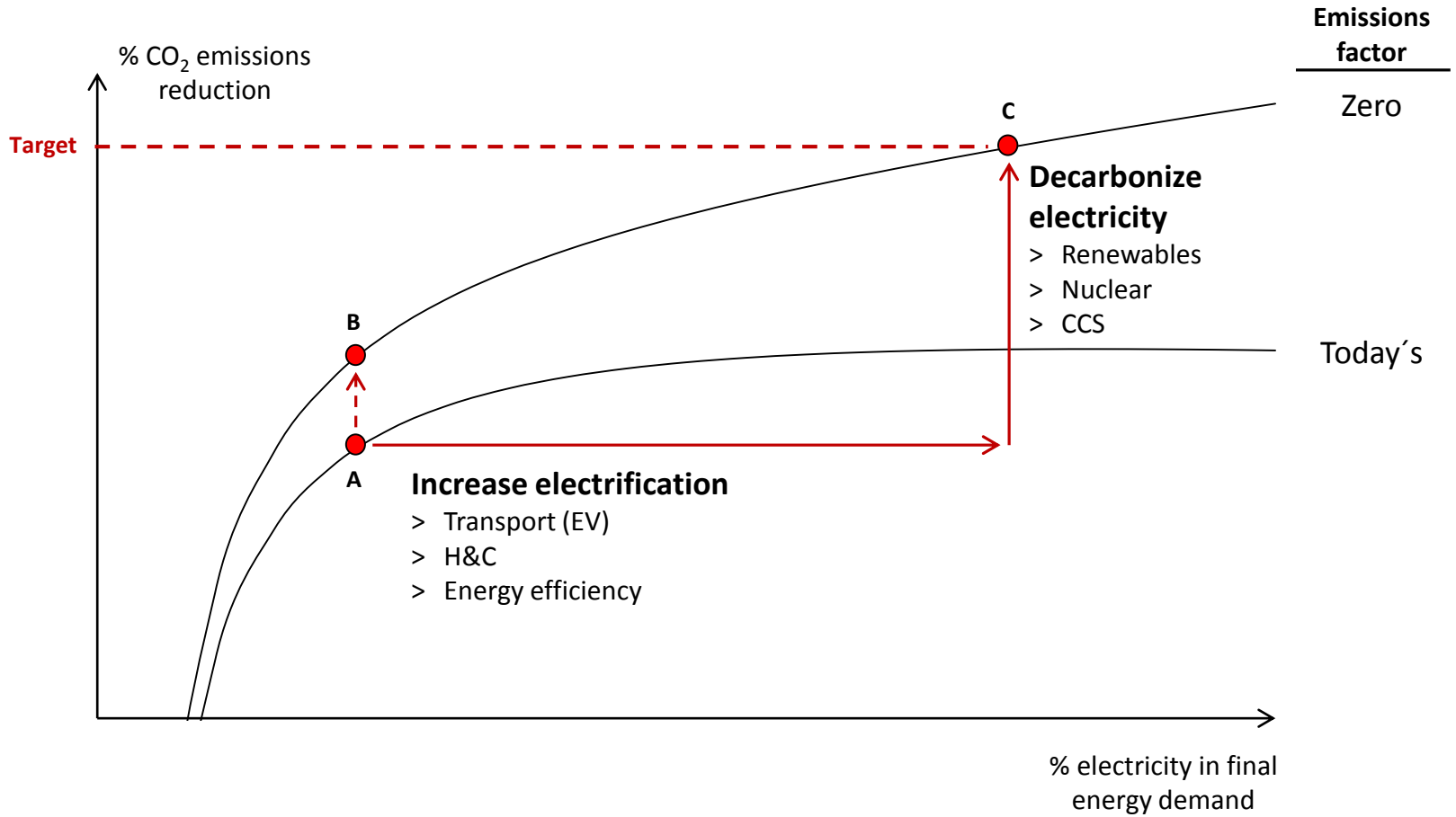


Source: BP Statistical review 2014, IEA WEO 2015

Indeed, strongly reducing emissions implies increasing electrification of energy demand, besides decarbonizing the power sector

Emissions reduction as a function of the share of electricity in final energy demand

%

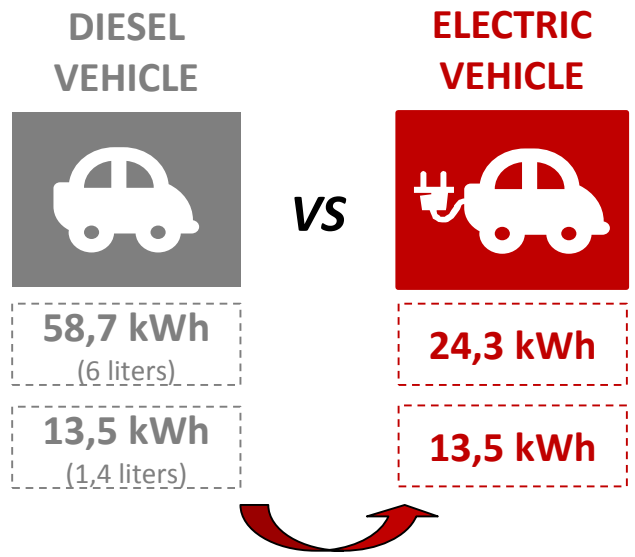


Source: EDP analysis

Through the electrification of transports and H&C, overall energy consumption decreases due to higher efficiency of electric techs

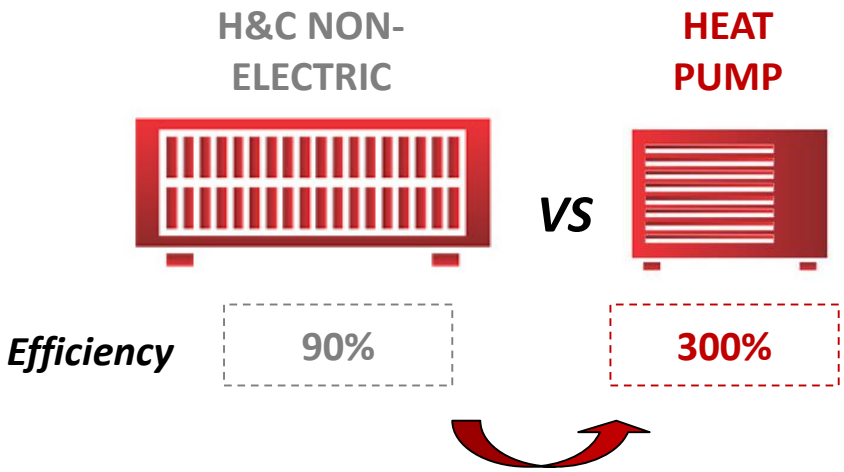
Transport Electrification[1]

Average for 100 km



Electric vehicles 2,5x more efficient

Heating & Cooling Electrification



Heat pump 3x more efficient than non-electric technologies

1. It is assumed a primary energy/final energy ratio of 68% for generation and 91% for transport and distribution

Source: Deloitte, EDP analysis

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The context that presided over the last significant change in the industry (liberalization in the 90's) has dramatically changed

	Generation	Grids and downstream
1990's	> Depreciated assets > Dash-for-gas era > Low and stable fuel prices > Few renewables	> Increased consumption > Grid expansion
Today	> Need to ensure investment in low carbon techs (capex intensive) > Very volatile fuel prices > High share of renewables > Thermal increasingly needed for back-up	> Stagnated consumption > Replacement and upgrade of grids > Energy efficiency > Distributed generation and storage

Source: EDP analysis

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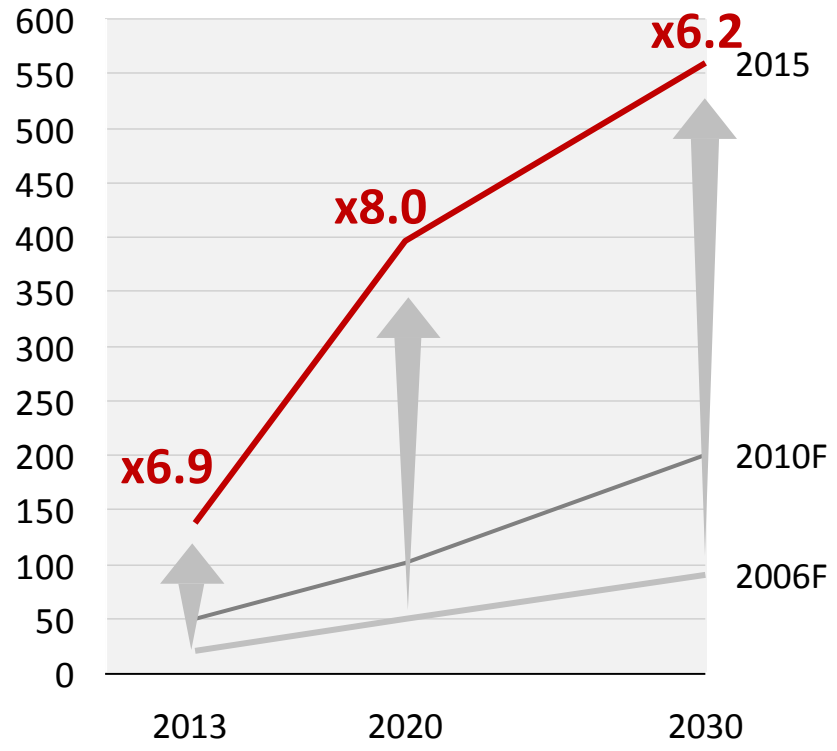
Source: EDP analysis

The uptake of RES has been consistently revised upwards...

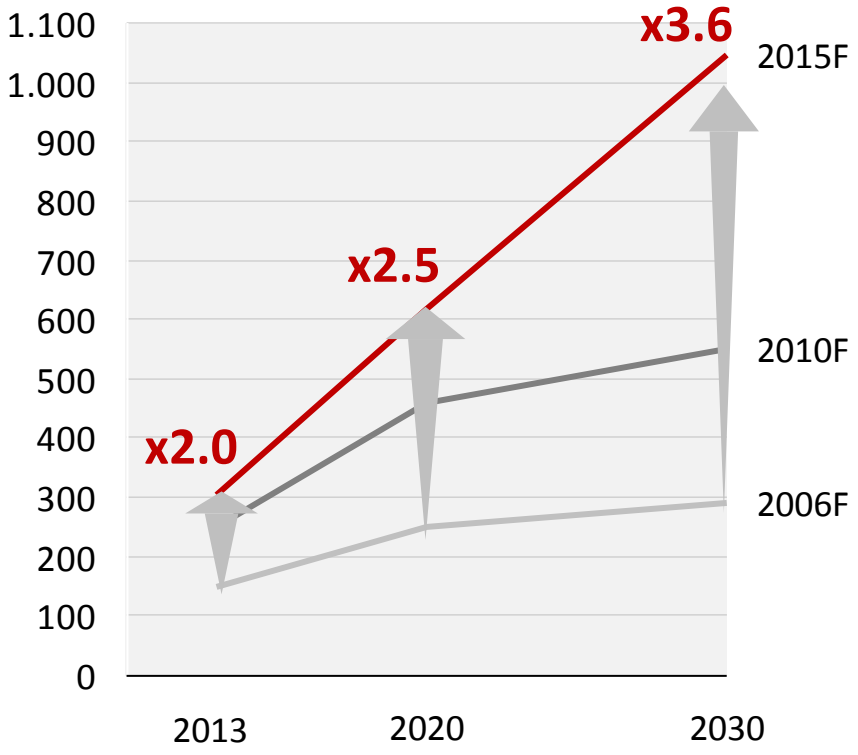
Solar energy installed capacity forecast

GW, 2013-2030



Wind energy installed capacity forecast

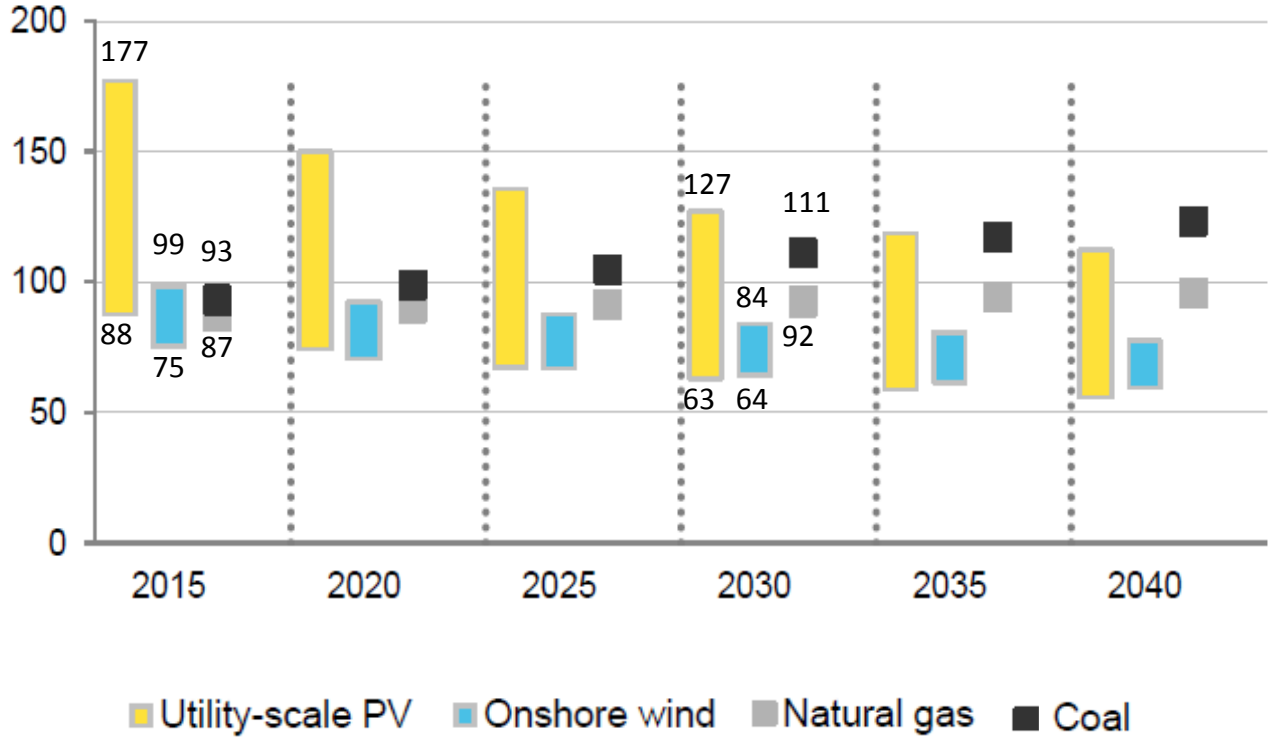
GW, 2013-2030



Source: IEA WEO 2015

…thanks to increased competitiveness as innovation and mass production drove sharp cost reductions which are expected to continue

Levelized costs of electricity for Europe
$/MWh, 2015-2040



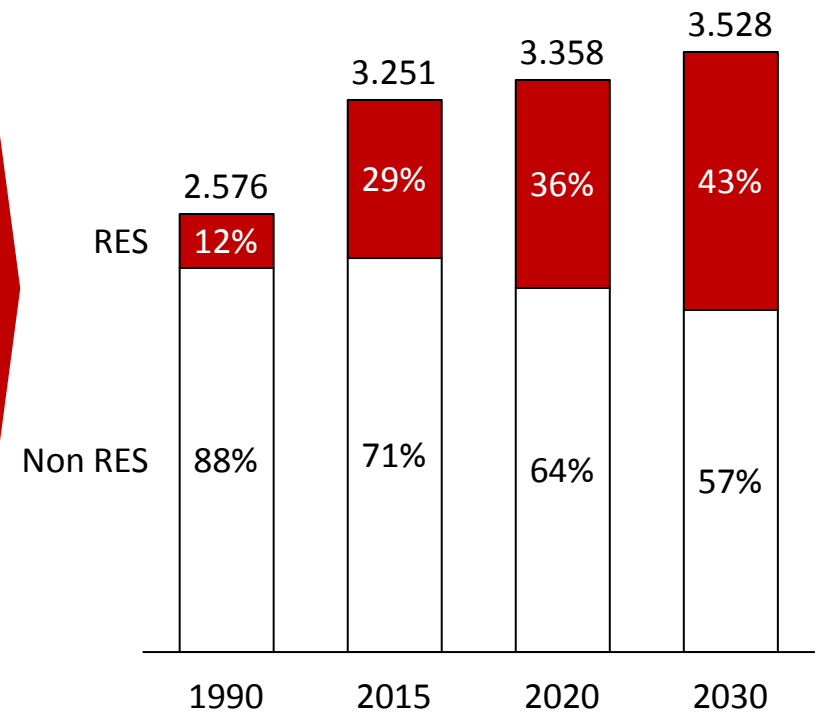
Source: BNEF NEO 2015

The EU Energy Policy has been a key driver in RES investment in Europe, with electricity as a major contributor – 43% share in generation in '30

Targets	2020	2030
ENERGY EFFICIENCY	> - 20% consumption vs BaU	> - 27% consumption vs BaU
RENEWABLE SHARE	> 20% in final consumption > 10% in transportation	> 27% share at EU level
EMISSION REDUCTION	> - 20% of GHG vs 1990	> - 40% of GHG vs 1990

EU electricity generation mix

TWh, 1990-2030



Source: EC Reference Scenario 2016

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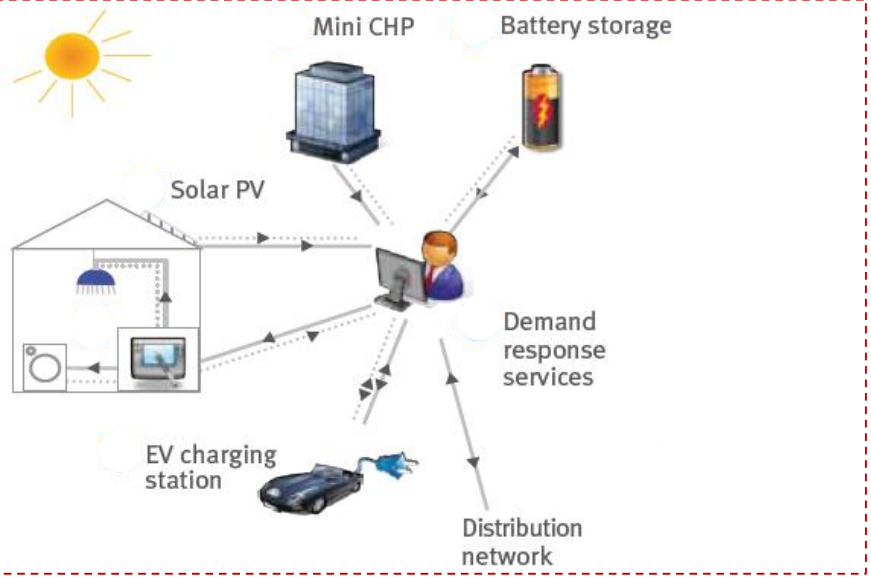
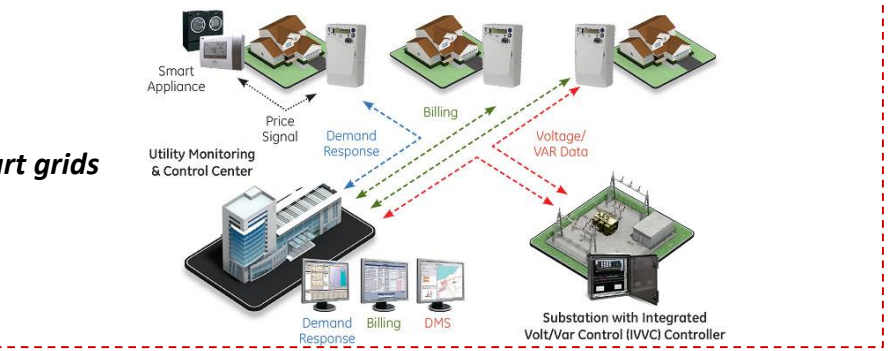
Source: EDP analysis

Changes should be structural for distribution and retail: smart grids, consumers also as producers, and new products and services

Distribution and downstream growth opportunities





Examples

Electric vehicles and services

- **Total costs of ownership** should achieve **parity in the 20's**
- **Remote control** and **Vehicle to Grid** expected soon

Smart grids

- Smart grids enable **bidirecional communication** and **energy flows**, enhancing **efficiency** and **quality of service**

Smart equipment

- **Equipment** controllable via **smartphone**
- Example: **Google's thermostat** learns the **consumer's habits**

Source: Eurelectric Innovation Action Plan Taskforce analysis, Google

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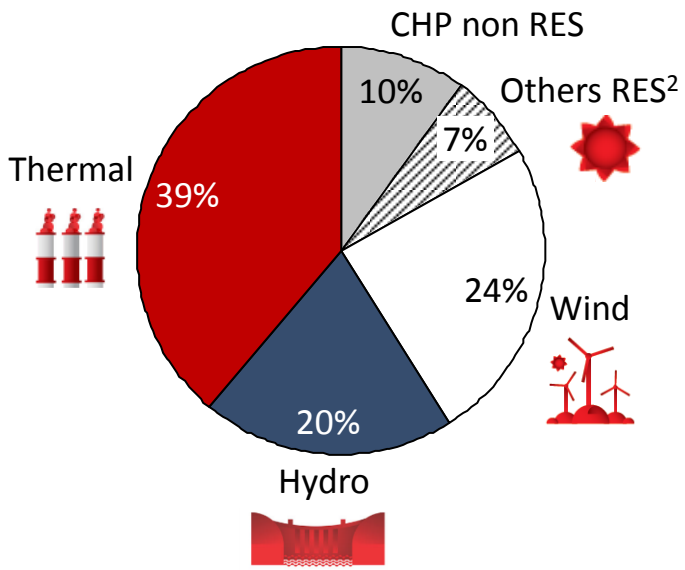
3 **Portugal's strategy for the electricity sector**

In 2015, RES accounted for 51% of total generation – over the last decade RES contributed to increase energy dependence and lower the energy bill

Electricity generation in Portugal[1]

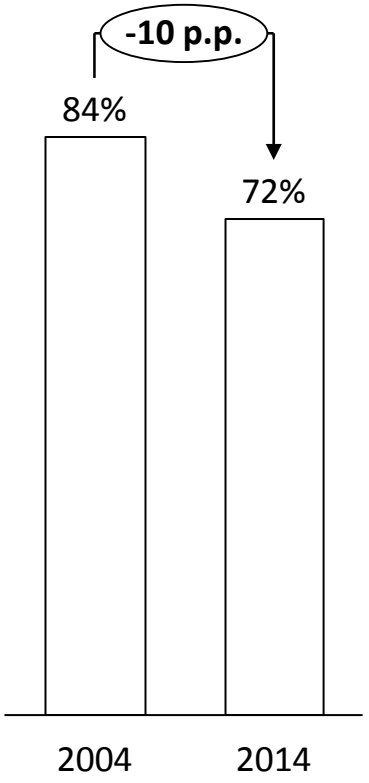
2015, % TWh



Σ Renewables in generation[1] = 51%

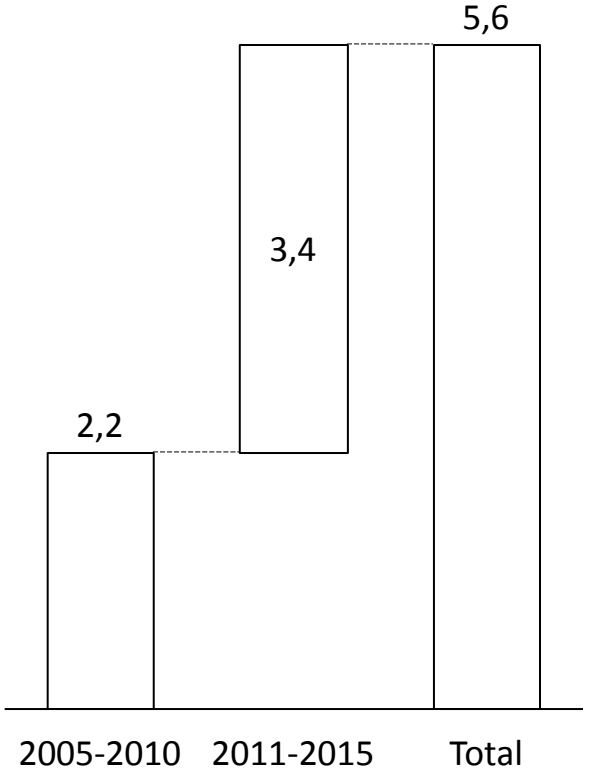
Energy dependence

%, 2004-2014



Cumulated energy bill savings from RES generation (excl. hydro)[3]

Bn€, 2005-2015



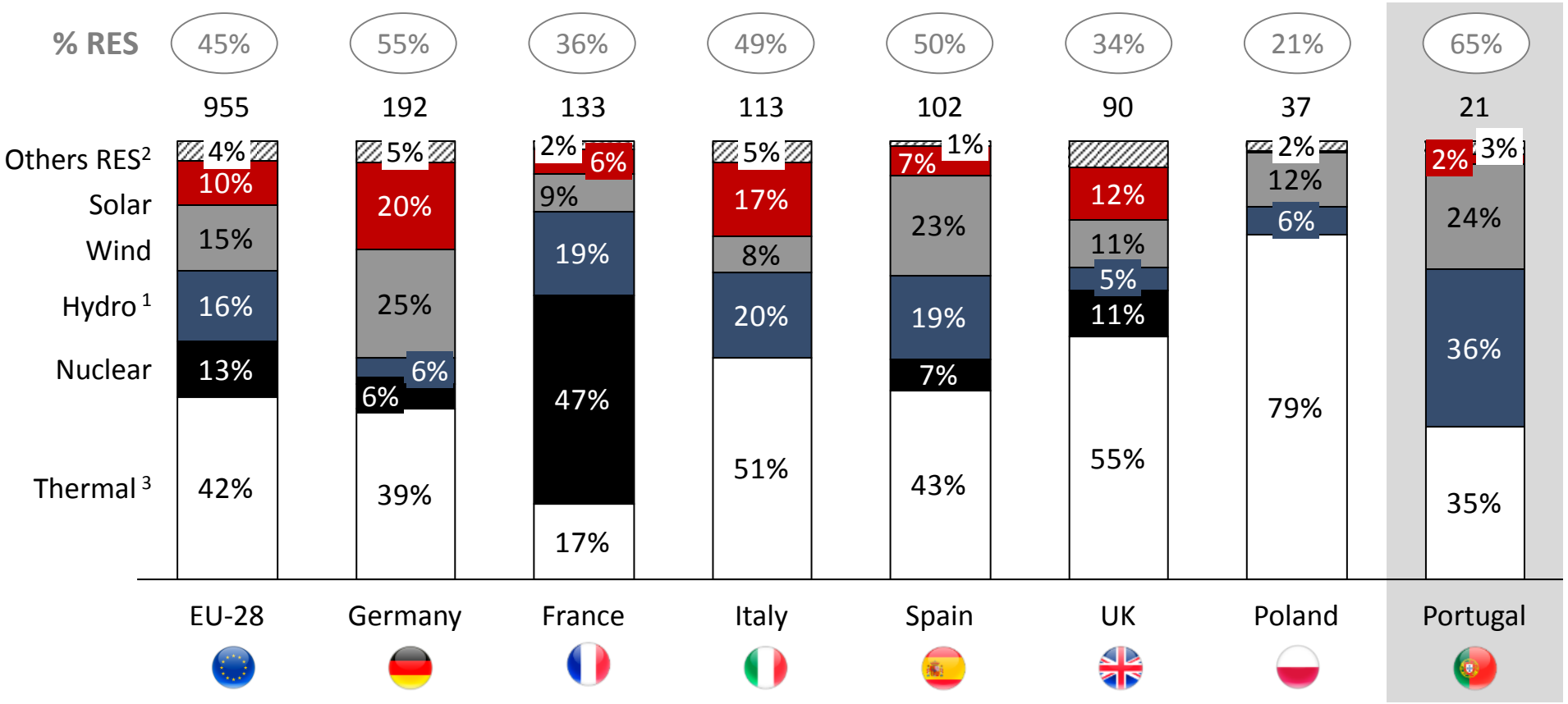
1. Includes pumping and small hydro; not adjusted for hydro index
2. Includes solar PV, solar CSP, biomass, biogas, MSW, geothermal and waves/ocean/tides
3. Excludes hydro; considers the replacement of RES for CCGT (60%), coal (30%) and interconnection (10%), and includes CO_2 savings

Source: EDP, REN, DGEG, ERSE, IMF, Eurostat

By leveraging on its natural resources, Portugal has achieved one of the highest shares of renewable capacity in the European Union

Installed capacity mix

GW, February 2016



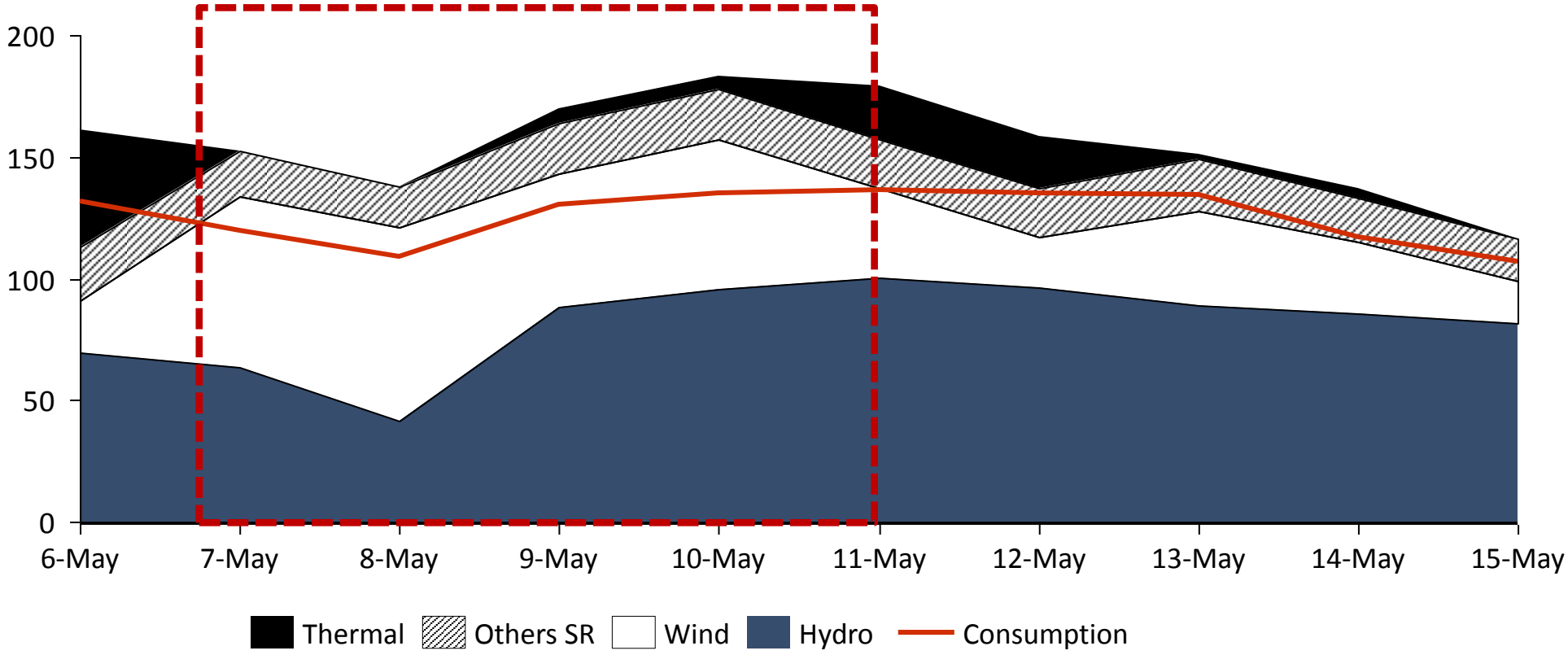
1. Includes small hydro and pumping
2. Includes geothermal, Tidal, Ocean, Wave and biomass
3. Includes Special Regime Production with fossil fuels

Source: IHS February 2016 Planning Scenario

Portugal's generation has already relied entirely on renewables during particular periods – for 4 days in May, demand was fully covered by RES

Generation mix in Portugal

GWh, 6th-15th May 2016



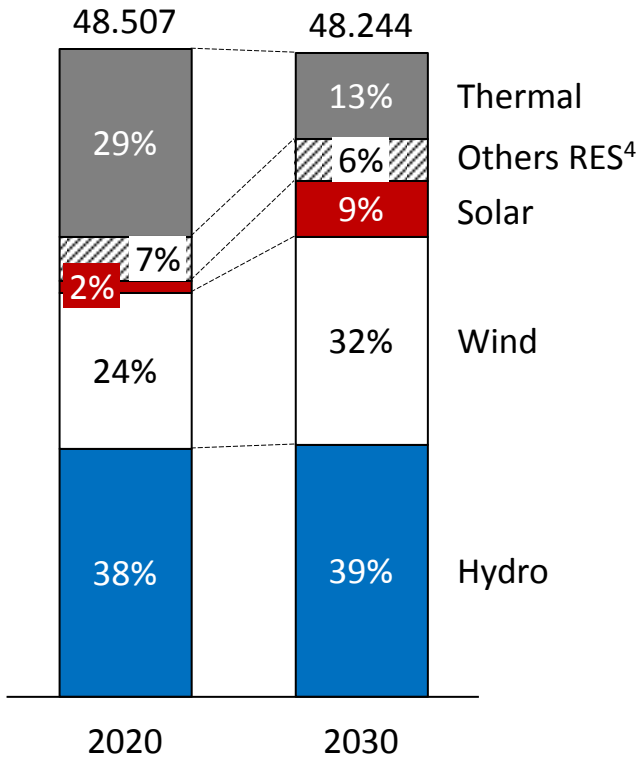
Source: REN

The investment in RES is also key to fulfill the energy policy commitments – the share of wind, hydro and solar should grow further until 2030

Renewable share in final demand target	2020	2030
European Union target	20%	27%
Portugal target	31%[1]	40%[2]
Impact on the power sector	50%-60%	60%-70%[3]

Gross generation forecast – European Commission Reference scenario

GWh



1. Scenarios PNAER 2013, RCM 20/2013
2. Target defined by the Government at the *Compromisso para o Crescimento Verde*, RCM 28/2015
3. EDP estimate
4. Mainly biomass-waste

Source: EC, PNAER, Compromisso para o Crescimento Verde, European Commission

Questions?