



Nuclear and Renewables in Global Electricity

Reflections on Recent Developments & Future Outlook

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Legal Cautionary Note

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News surrounding the global nuclear industry is largely sobering unlike the “buzz” with renewables

News Headlines Around the World: Nuclear vs Renewables

Next-generation nuclear reactors stalled by costly delays

- Bloomberg, 2 February 2017

Toshiba is losing money on 2 nuclear plants it's building in Georgia and South Carolina

- The Guardian, 16 April 2017

Will India say no to risky nuclear deals with bankrupt nuclear majors Westinghouse, Areva?

- Outlook India, 31 March 2017

Real cost of Fukushima disaster will reach ¥70 trillion, or triple government's estimate: think tank

- The Japan Times, 1 April 2017

Unions warn Areva nuclear waste container fault shows safety flaws

- Reuters, 23 March 2017

China eyes trillion-yuan nuclear power market along One Belt and One Road

- China Daily, 18 April 2017

Renewables break records as wind and solar come online, International Renewable Energy Agency says

- CNBC, 30 March 2017

Cost of renewables fell in 2016, lowering global investment cost in clean energy

- UN News Centre, 6 April 2017

Rural electrification eyes \$15. billion renewable lending push

- Bloomberg, 19 April 2017

Offshore Wind Farms Offer Subsidy-Free Power for First Time – Dong Energy bid for German Power, Bloomberg 13 April 2017

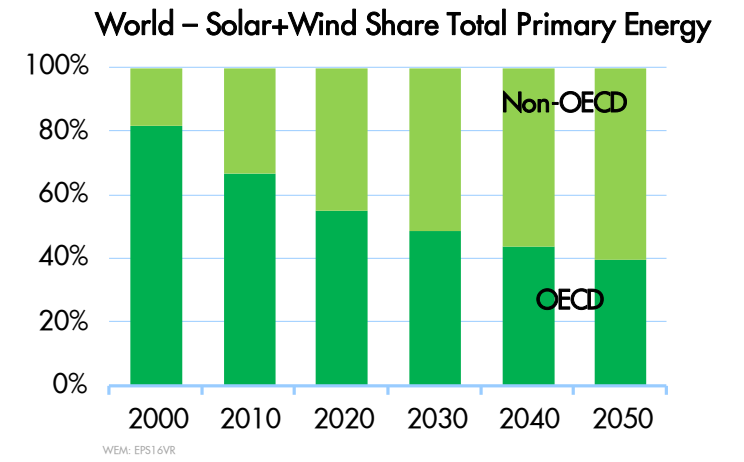
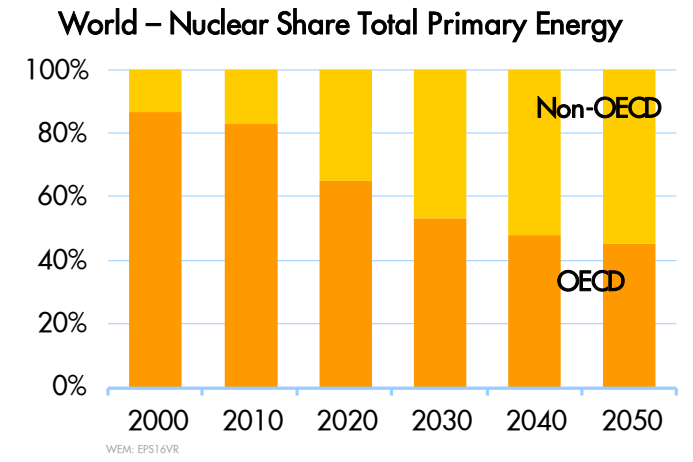
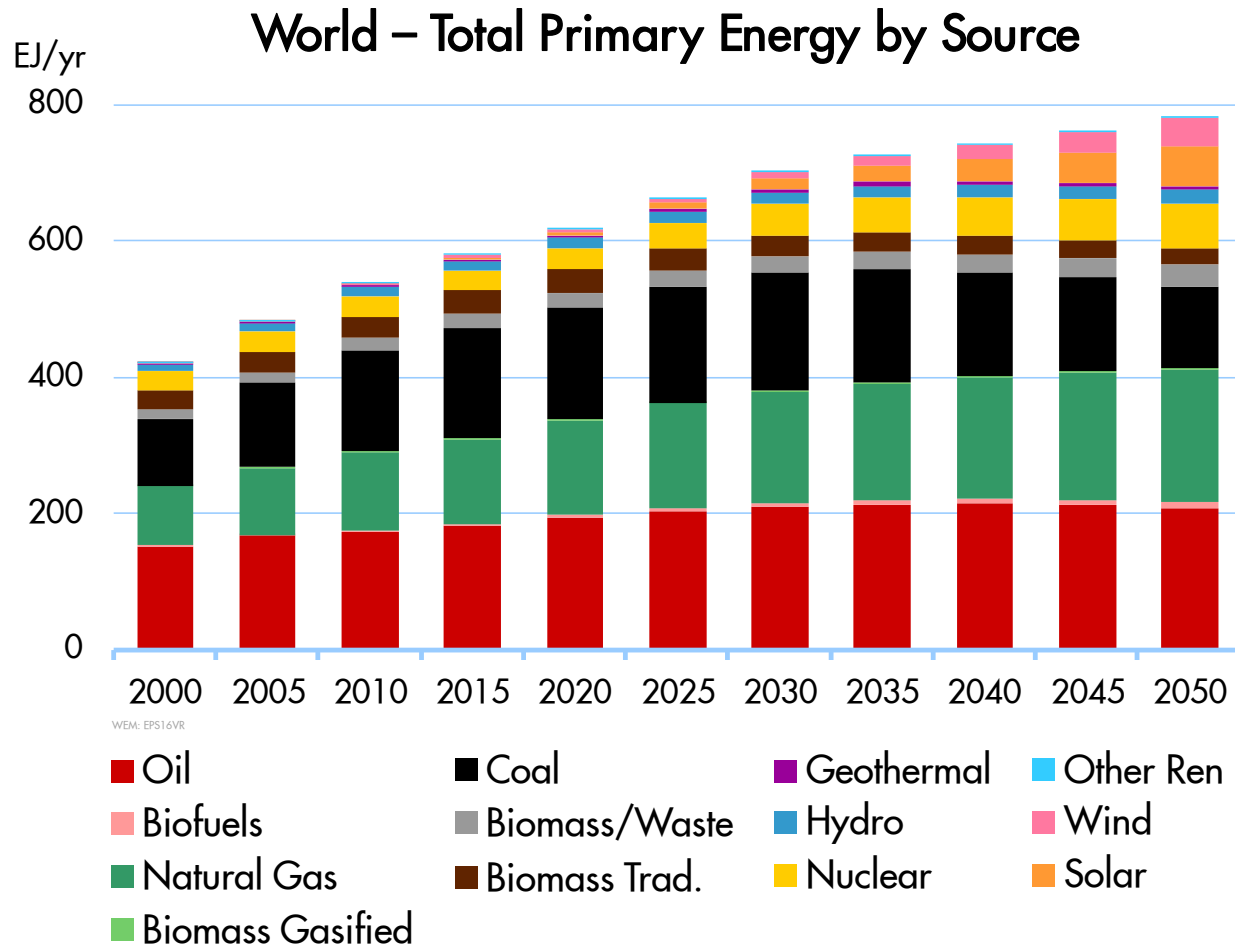
Saudi Arabia pushes ahead with renewable drive to diversify energy mix

- Reuters, 17 April 2017

South Australia power crisis: Former ETSA chief says state needs nuclear power as renewable energy woes are being watched by the world

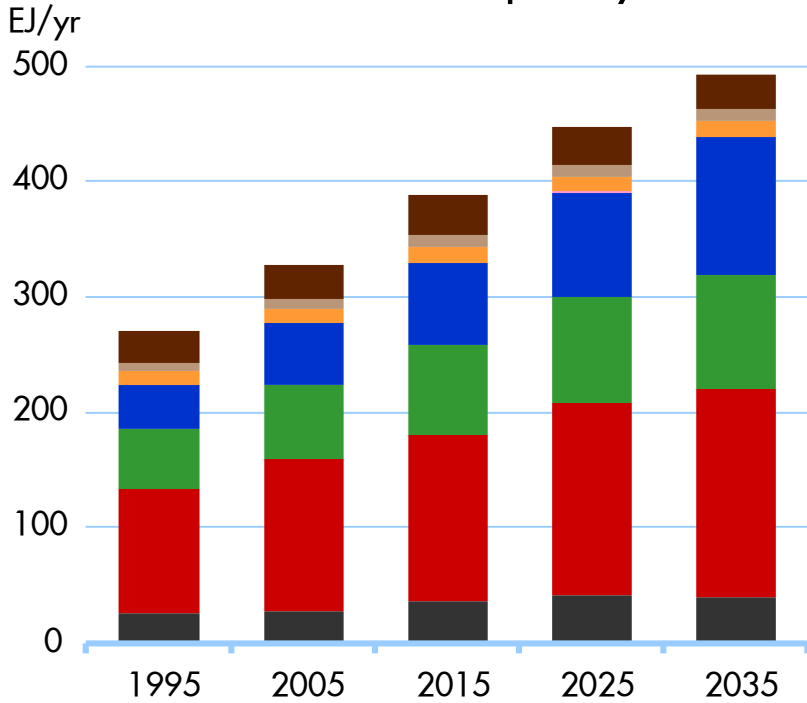
- The Advertiser, 24 March 2017

The role of Gas, Nuclear and Renewables a given in a cleaner world?

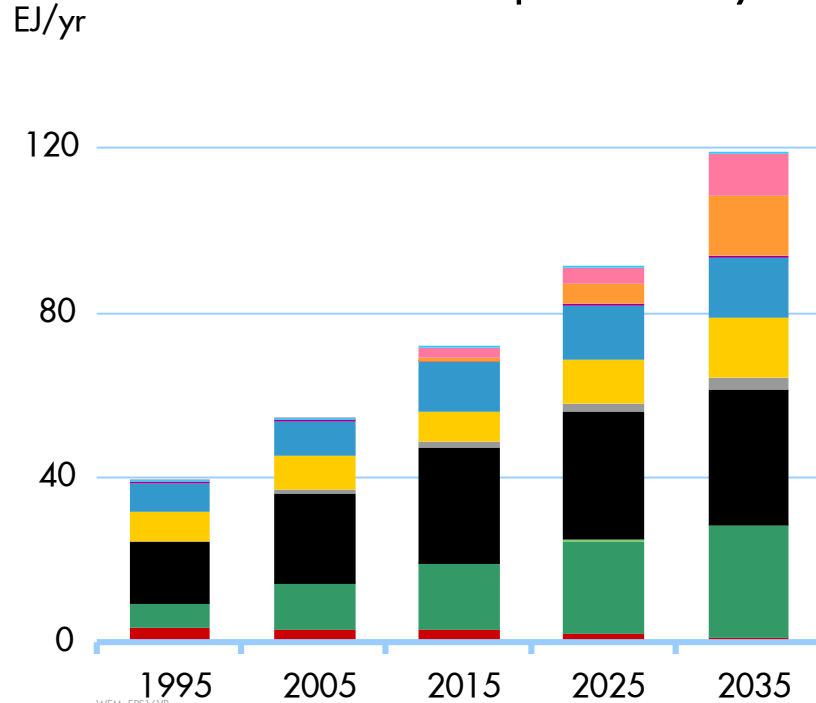


Fast electrification via non-emitting energy resources is critical in a transition towards a higher efficient and lower carbon world

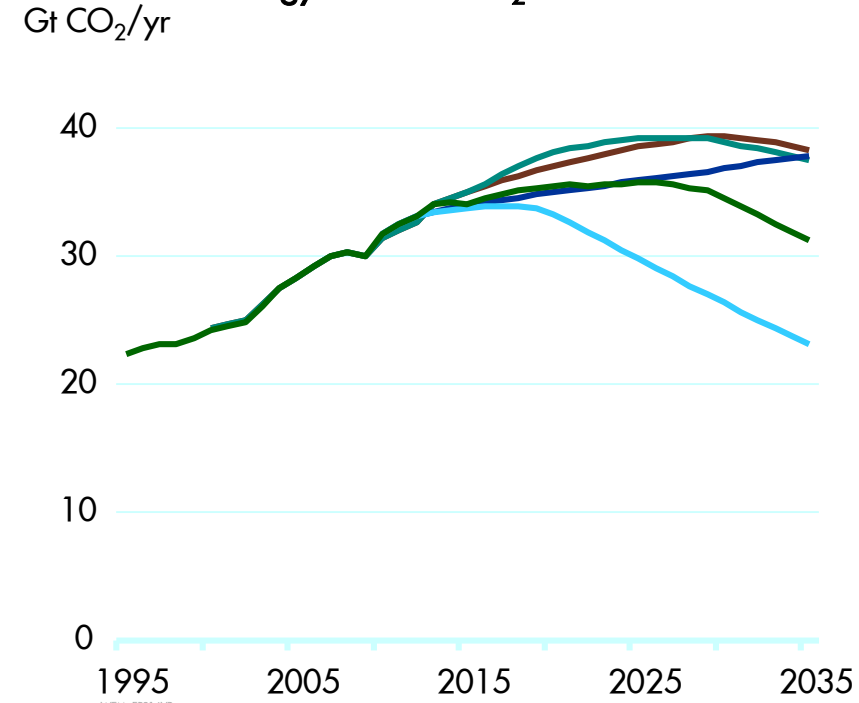
World- Total Final Consumption by Carrier



World - Total Final Consumption Electricity



Energy Related CO₂ Emissions



- Solid HC Fuels
- Liquid HC Fuels
- Gaseous HC Fuels
- Electricity
- Hydrogen
- Heat
- Biomass – Commerc.
- Biomass – Trad.

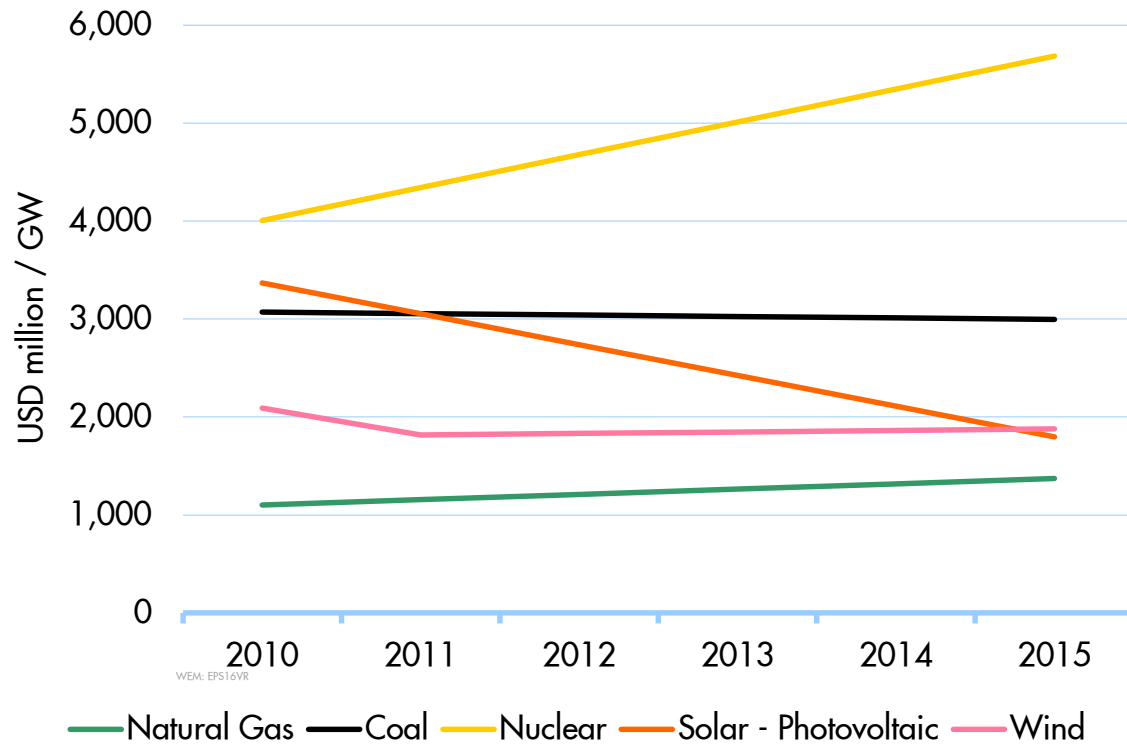
- Oil
- Natural Gas
- Coal
- Biomass/Waste
- Nuclear
- Geothermal
- Wind
- Hydro
- Solar
- Other Ren.

- Mountains
- IEA NPS (2015)
- NZE70
- Oceans
- IEA 450 (2015)

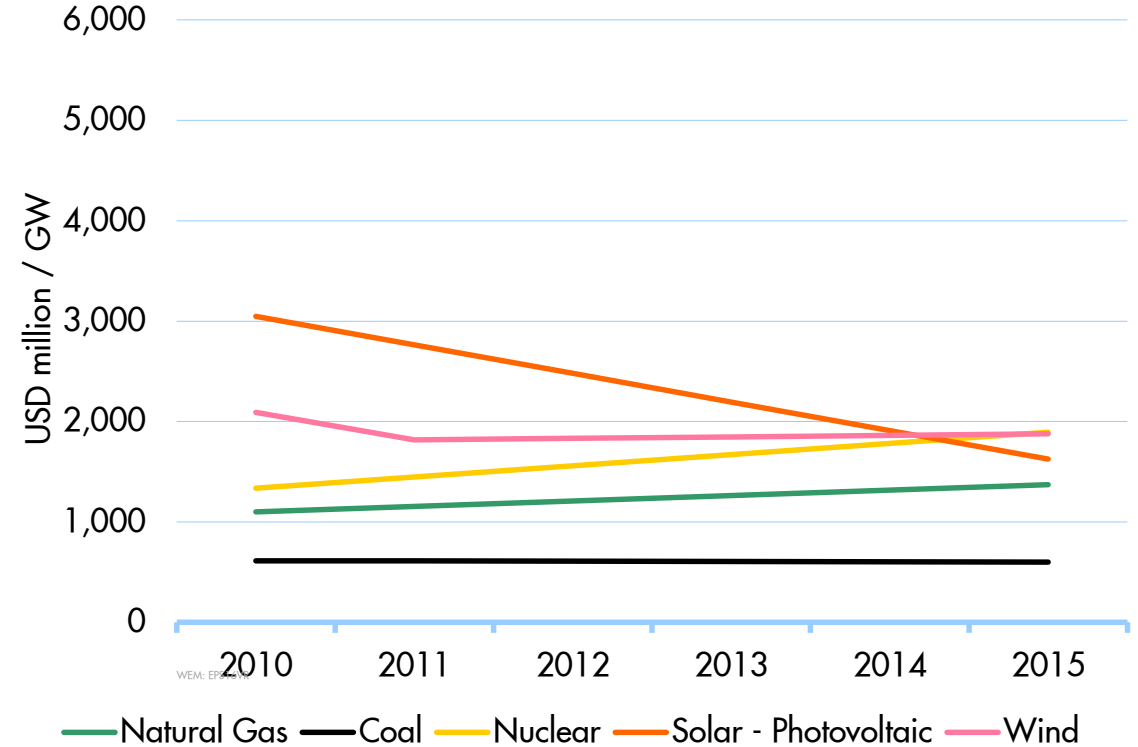
Source: Shell Scenarios, IEA
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Nuclear remains an expensive capital-intensive technology when compared against rapidly falling renewable costs

USA Capital Cost of Electricity Generation Capacity



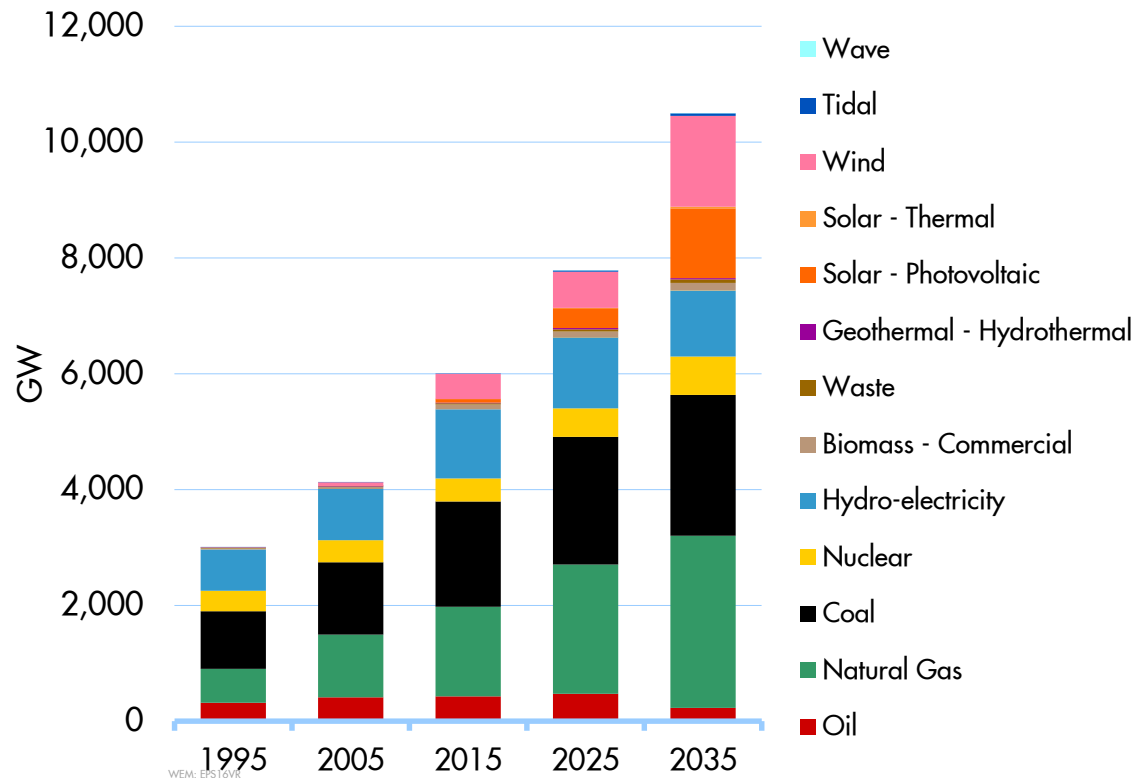
China Capital Cost of Electricity Generation Capacity



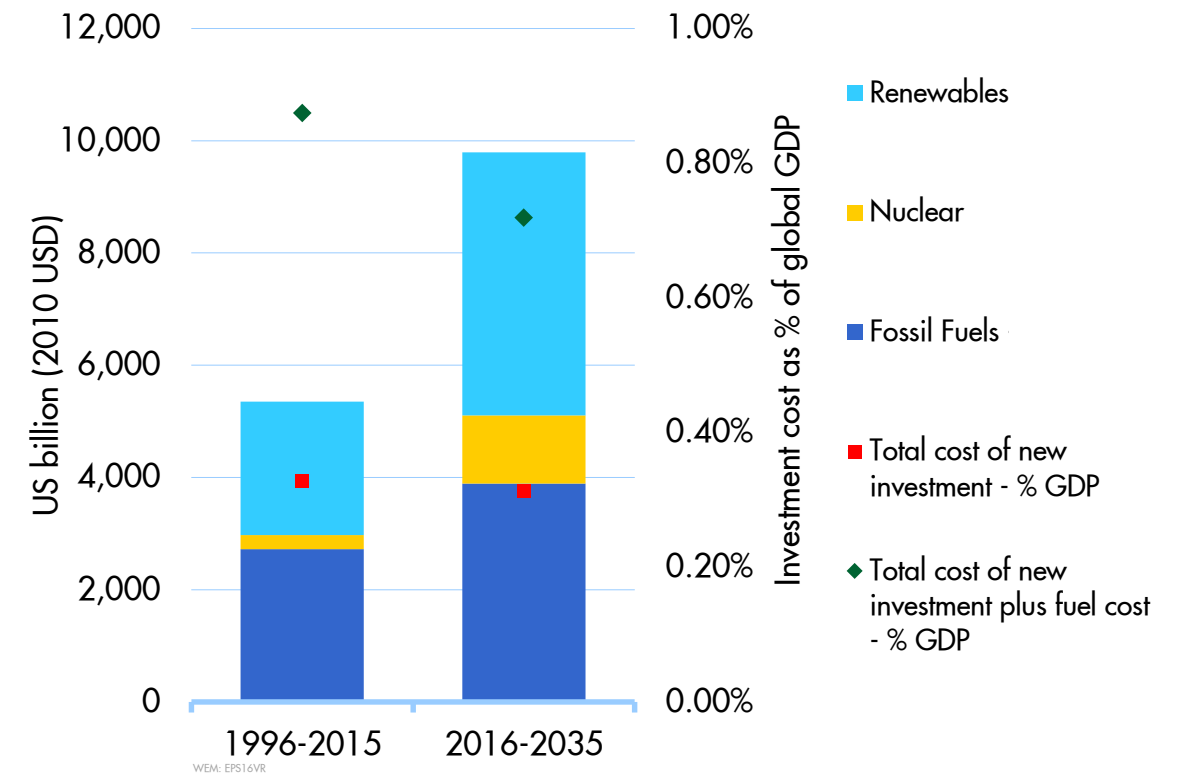
■ Nuclear capital costs have been escalating at a time when renewable costs (particularly solar) have fallen significantly

Global electricity capacity is likely to double over the next 20 years but total cost of new investment remains affordable

World Electricity Grid Capacity by Source (Base Case)

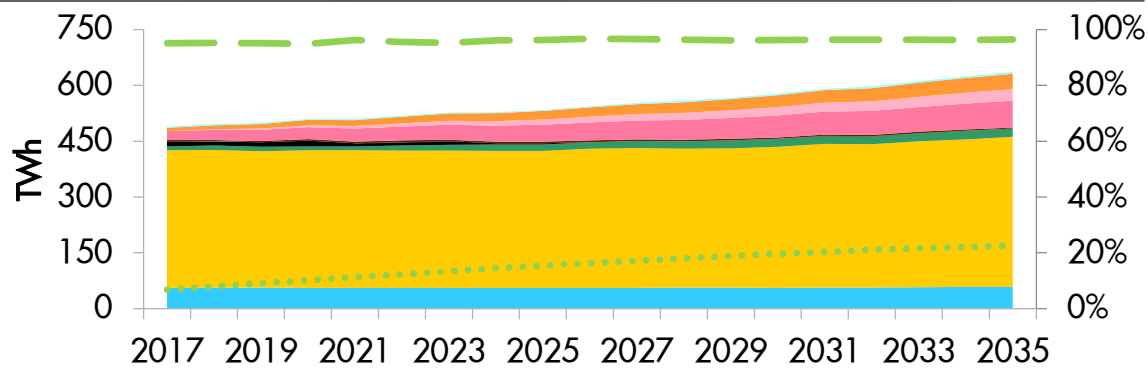


Cumulative Investment Cost for Global New Electricity

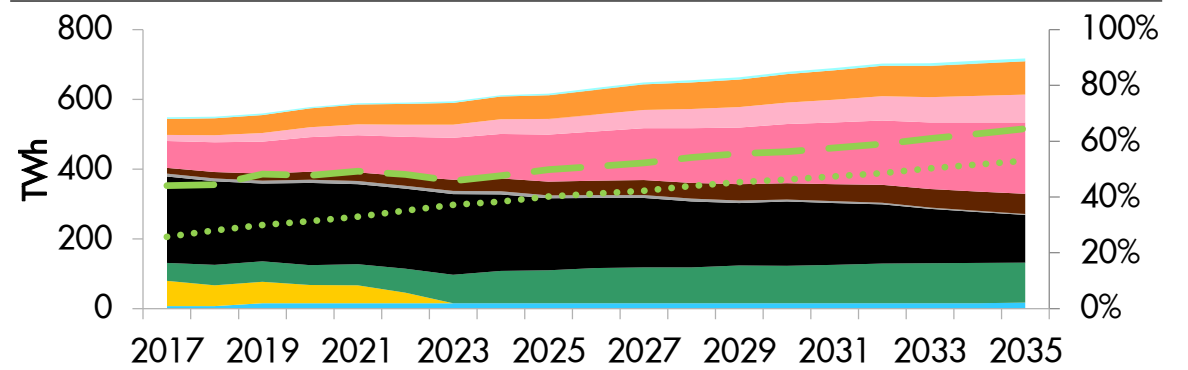


In Europe, countries without nuclear have heavier reliance on intermittent renewable generation for decarbonisation

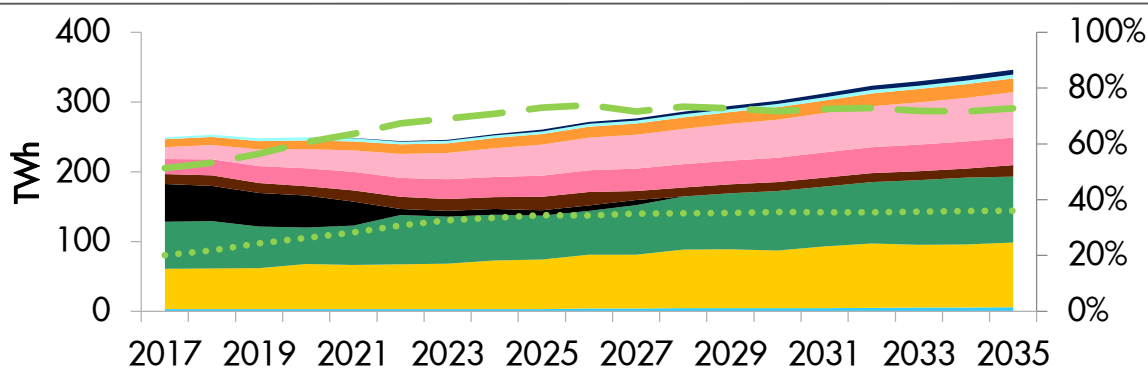
Electricity Generation Outlook: France



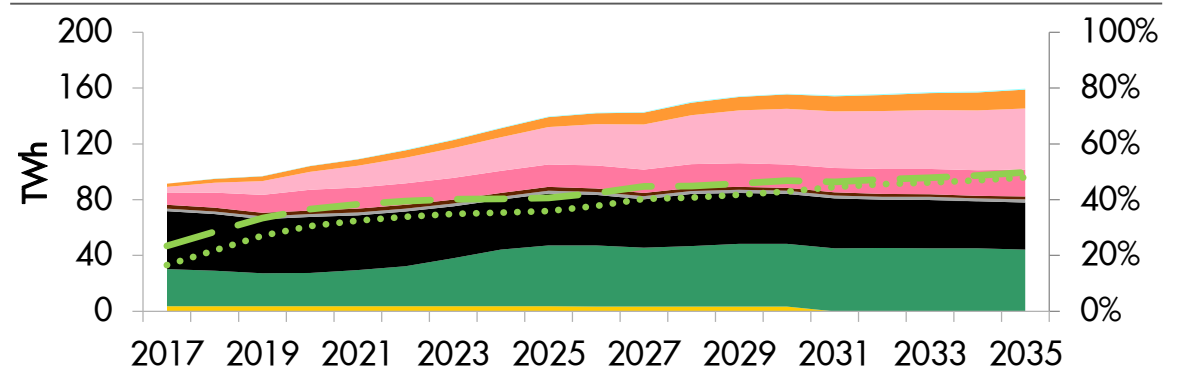
Electricity Generation Outlook: Germany



Electricity Generation Outlook: United Kingdom



Electricity Generation Outlook: Netherlands



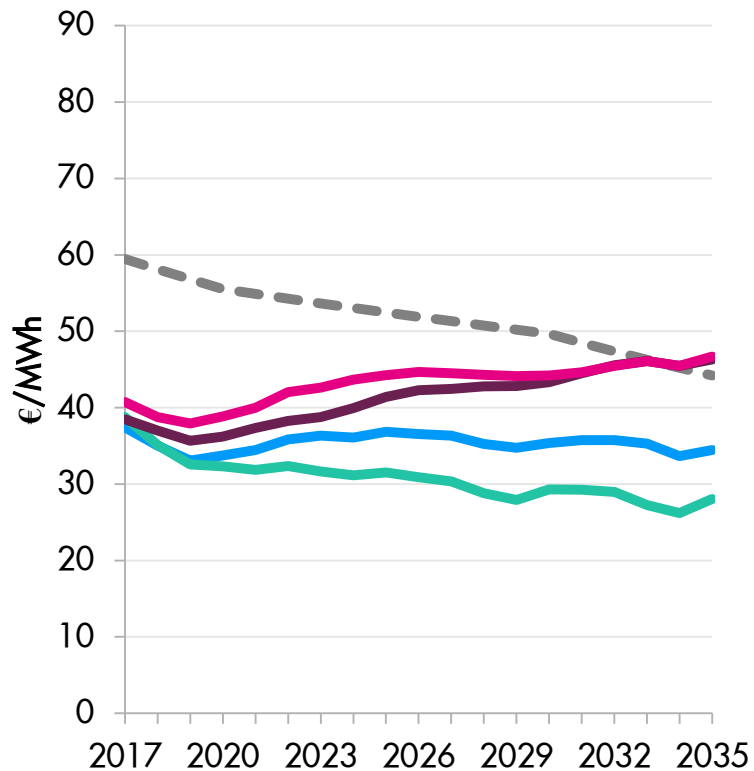
- - - % Low Carbon
- Coal
- Gas
- Hydro
- Offshore wind
- Nuclear
- Biomass
- Solar
- Onshore wind
- % Intermittent

Source: Shell, Baringa Partners LLP

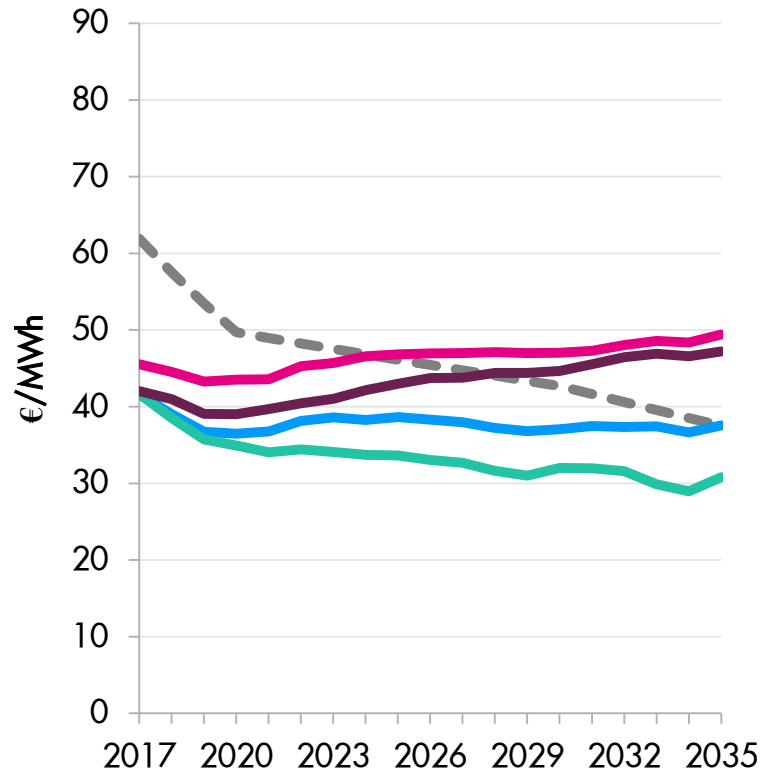
“Missing money”: Capture prices vs. LCOE Onshore & Offshore wind and Solar

Offshore wind is the only type of renewables to capture prices above its LCOE in some scenarios

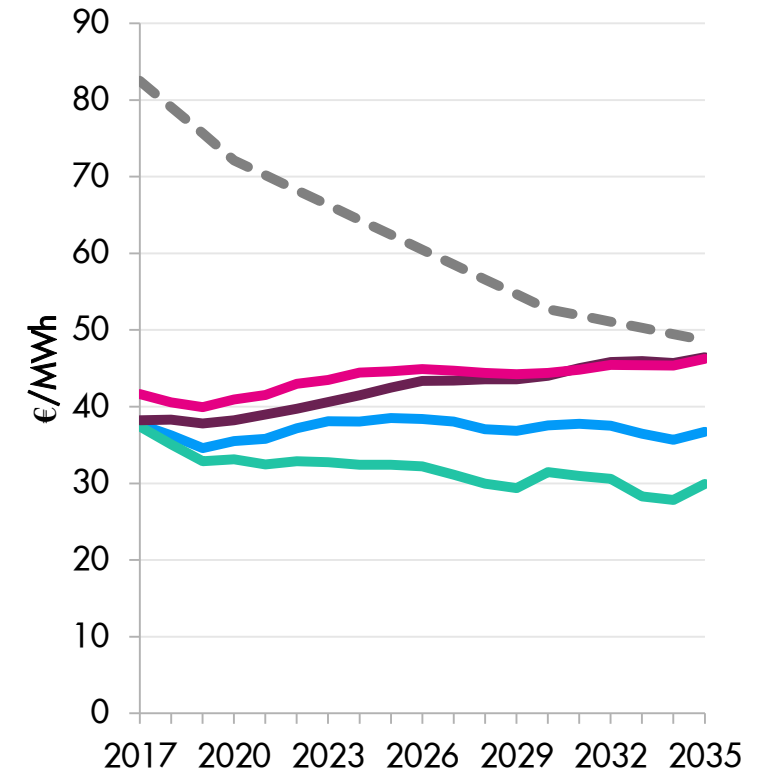
Onshore Wind



Offshore Wind



Solar



LCOE
 Reference Case
 Accelerated Case
 Shell Mountains
 Shell Oceans

Note: Missing money calculated on new build generation only

Source: Baringa Partners LLP 2017

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Concluding remarks

- ❑ Society's drive for higher end-use efficiency and cleaner fuels with less CO₂ emissions means higher rates of electrification of energy use
- ❑ Post 2020, renewables are expected to deliver the cheapest MWh across most parts of the world
- ❑ Nuclear remains a relative expensive option, but some countries will continue developing new capacity for security of supply reasons
- ❑ Electricity market reforms will be required to allow capital cost recovery of all technologies needed

