

Achieving a low carbon economy: challenges, technological progress and responsibility

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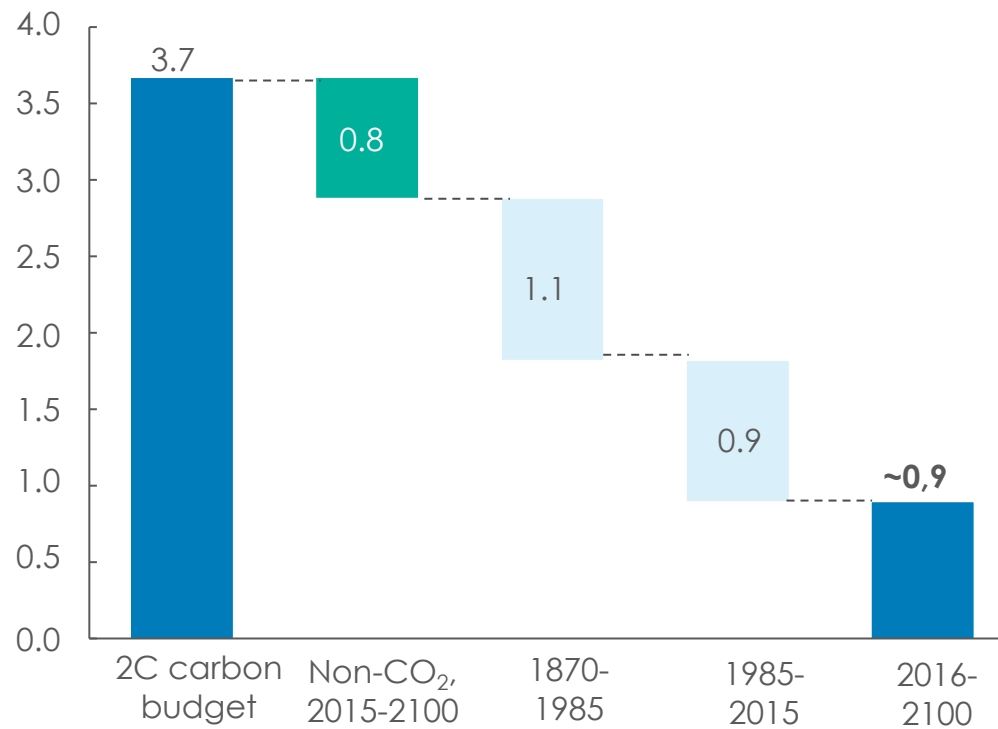
*Chairman, Institute for New Economic Thinking
Chairman, Energy Transitions Commission*

In the Long Run, Are We All Dead? Climate Change and Denial
Edinburgh, 23 October 2017

... within a 2°C carbon budget

Carbon budget emissions to 2100

1000 billion tonnes of CO₂-eq.

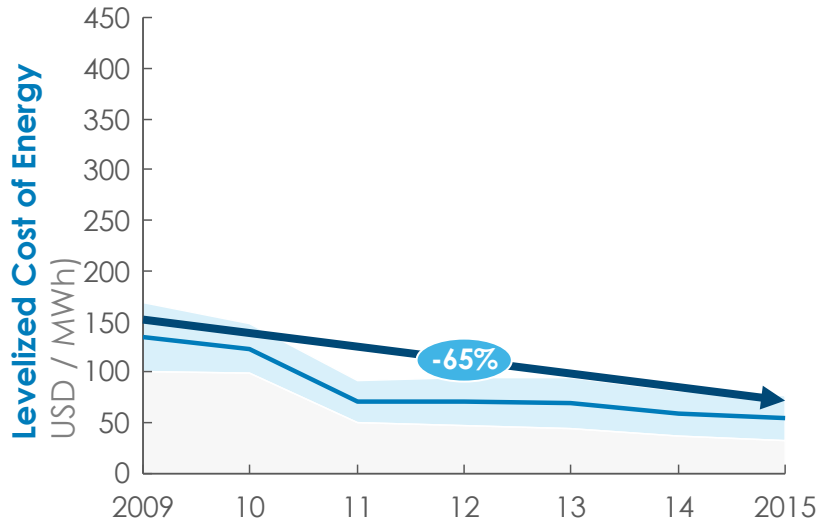


SOURCE: Copenhagen Economics analysis

Collapsing cost of renewables

Levelized Cost of Wind

USD/MWh, Unsubsidized

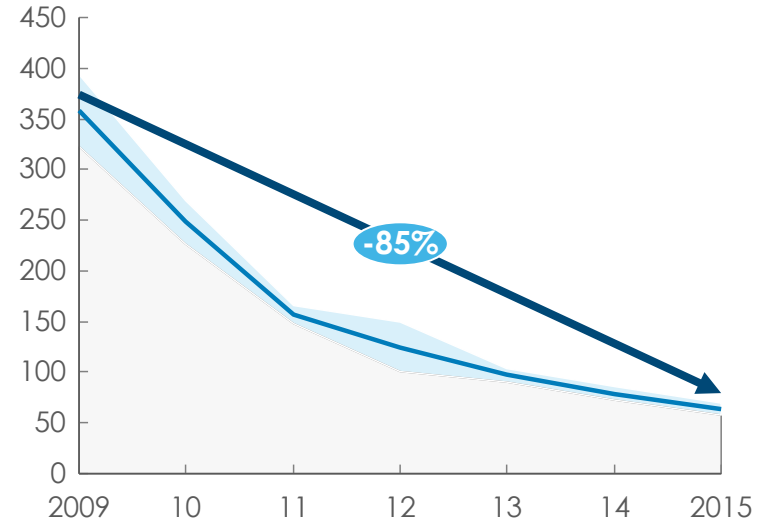


Recent Bid Prices

- 35 USD/MWh Onshore – USA, '15
- 72.5 EUR/MWh Offshore – Netherlands, July '16
- 54.5 EUR/MWh Offshore – Netherlands, Dec. '16

Levelized Cost of Utility-Scale PV

USD/MWh, Unsubsidized



Recent Bid Prices

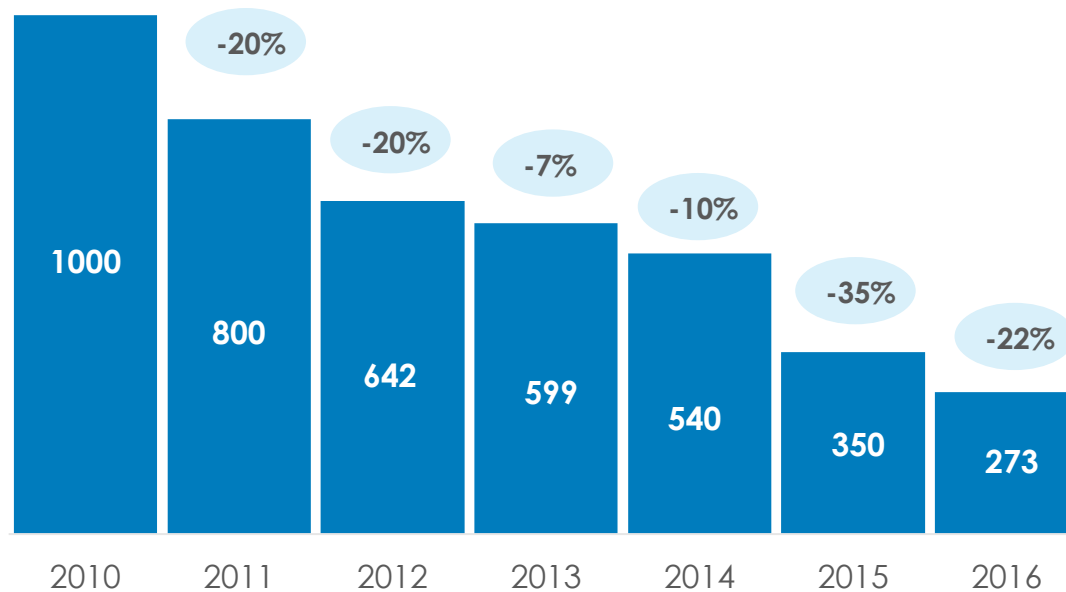
- 29.9 USD/MWh – Dubai, May '16
- 29.1 USD/MWh – Chile, August '16
- 24 USD/MWh – Abu Dhabi, September '16
- 18 USD/MWh – Saudi 2017

NOTE: USA 2015 wind bid price adjusted for Production Tax Credit. According to LBNL's 2015 Wind Technologies Market Report, 2015 USA PPA prices are as low as ~20 USD/MWh after PTC, plus an adjustment of 15 USD/MWh levelized value of the PTC.

SOURCE: Lazard Levelized Cost of Energy 9.0 (2015), Greentech Media, Lawrence Berkeley National Lab

Cost of lithium ion battery parks

\$ per Kwh

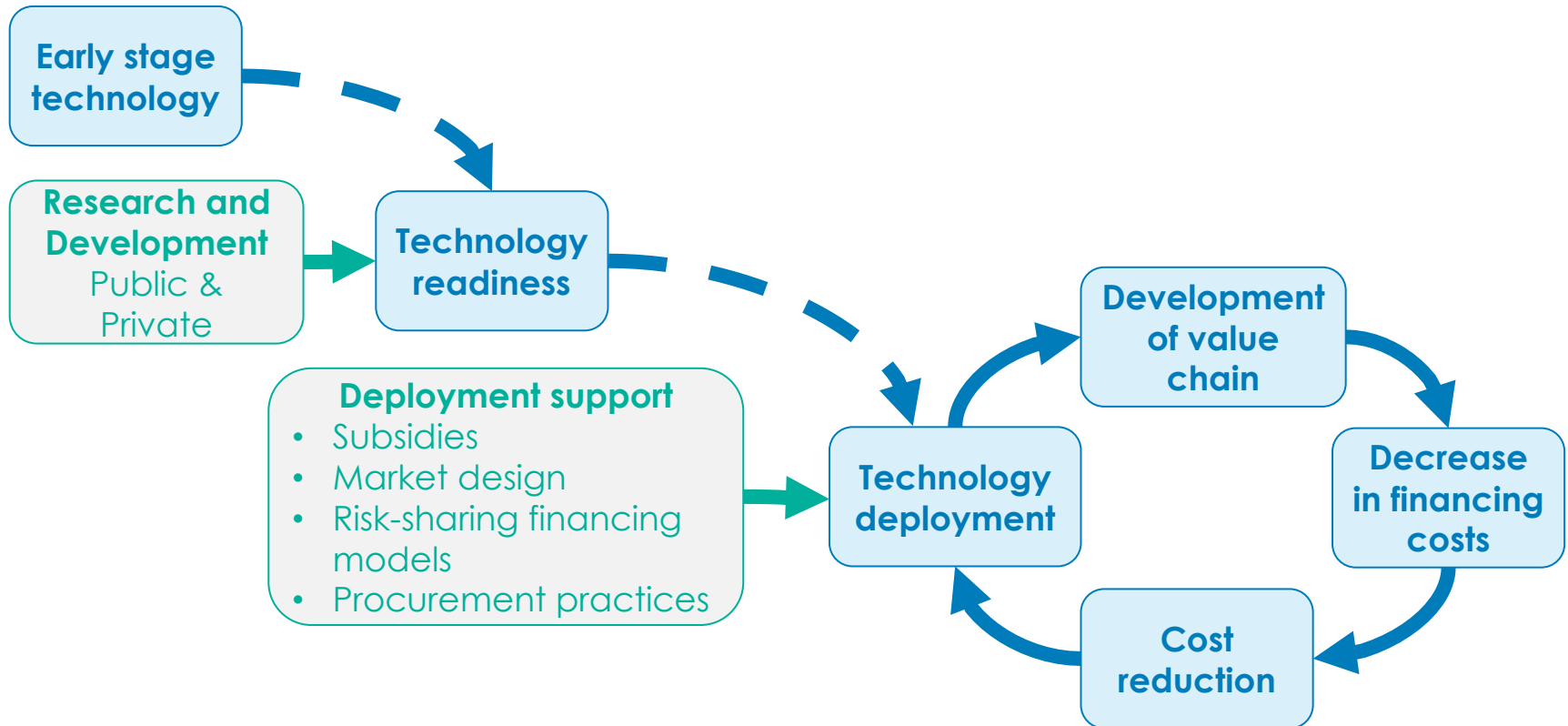


Outlook:

- Certainty < \$150 by 2020
- Possibly of < \$100

SOURCE: Bloomberg New Energy Finance, Battery Price Survey

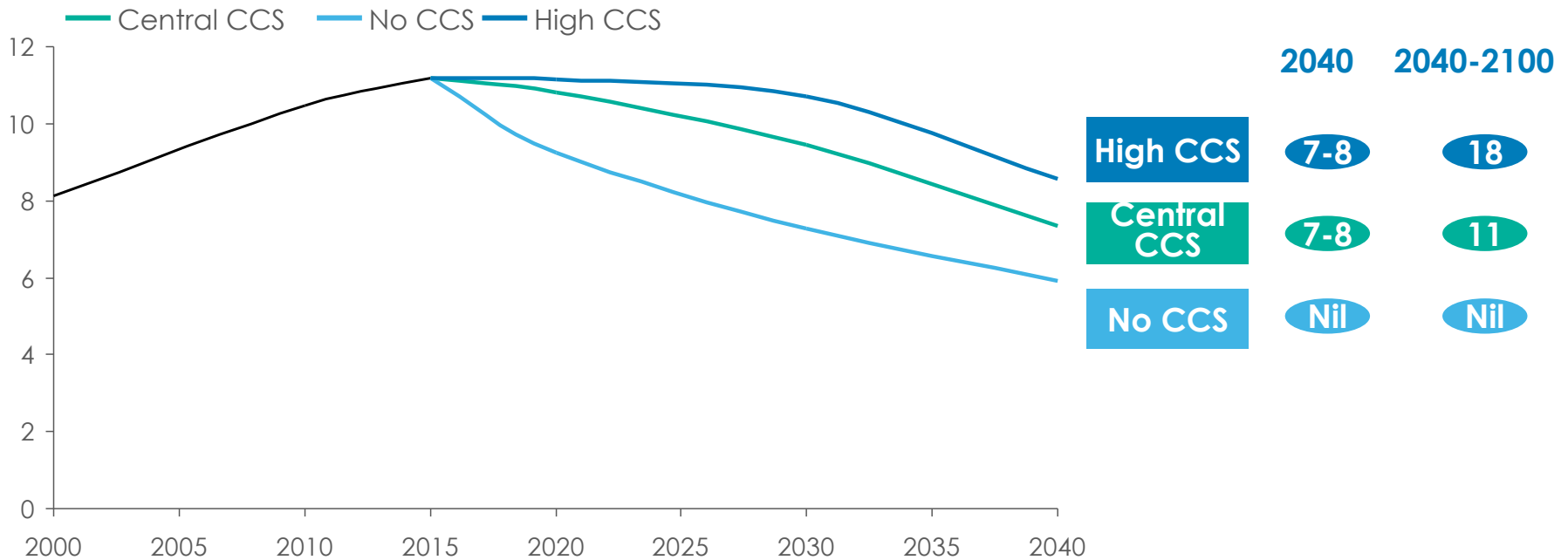
Public policies required: repeating the renewables success story



Fossil fuel consumption compatible with WB2C

1000 Million tonnes of oil equivalent per year

Average annual total CO₂ removals
Billion tonnes CO₂ per year

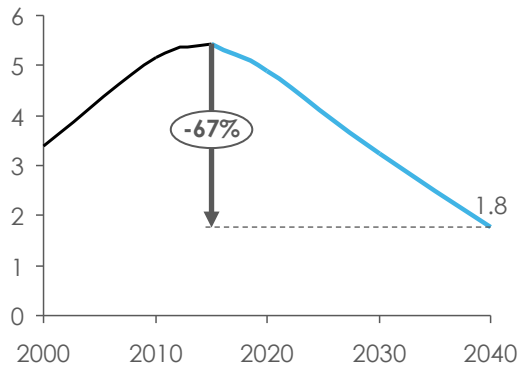


NOTE: Central scenario is based on scenarios limiting the risk of a global temperature rise of more than 2 degrees to less than one third, with 2020 emissions of at least 30 GtCO₂ and with no more than 15 GtCO₂ removal from CCS in any given year. No CCS scenario fulfils the same criteria as the Central scenario and in addition requires 0 GtCO₂ removal from CCS in any given year. High CCS allows for CCS capture rates of between 15 and 40 Gt in any given year.

... with big variations by specific fuel

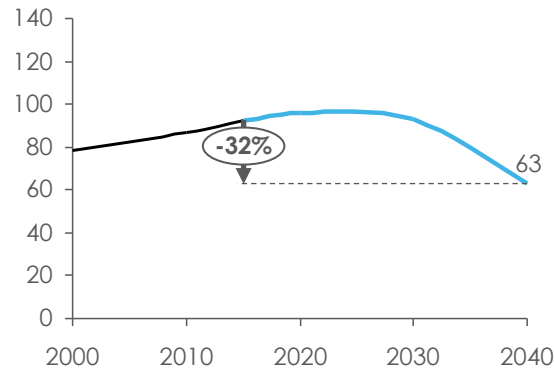
Coal consumption

Billion tonnes per year



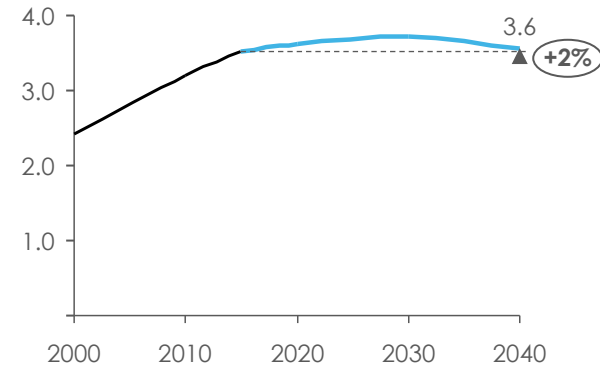
Oil consumption

Million barrels per day



Natural gas consumption

Bcm per year



- **Use:** Thermal coal falls far more rapidly than metallurgical.
- **Key challenge:** Phasing out coal in power in emerging economies.

- **Use:** increasingly concentrated in long-distance transport, plus feedstock for chemicals.
- **Key challenge:** Pace of electrification and development of biofuels/hydrogen.

- **Use:** across the energy system, with an increased role in industry.
- **Key challenge:** Methane leakages and new gas infrastructure in emerging economies.

Notes: All fossil fuel trajectories are based on scenarios reaching a 2°C objective with at least two-thirds probability. The charts show median fossil fuel use in 21 scenarios with less than 15 GT CO₂ removal in any given year. Average removals 2050-2100 are 3 GT/year through CCS on fossil fuels and 8 GT/year through BECCS or other negative emissions.