

Clean Energy Outlook

Federal Reserve Bank of Dallas

Logan Goldie-Scot
Head of Clean Power

November 20, 2020

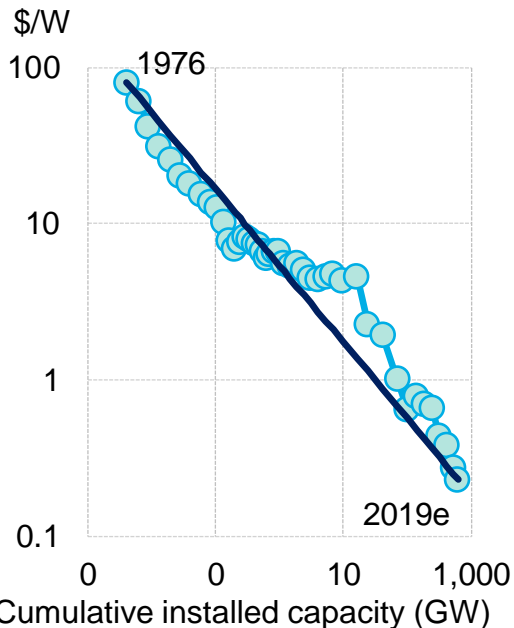


BloombergNEF

Falling technology costs are key to the decarbonization of power and transport

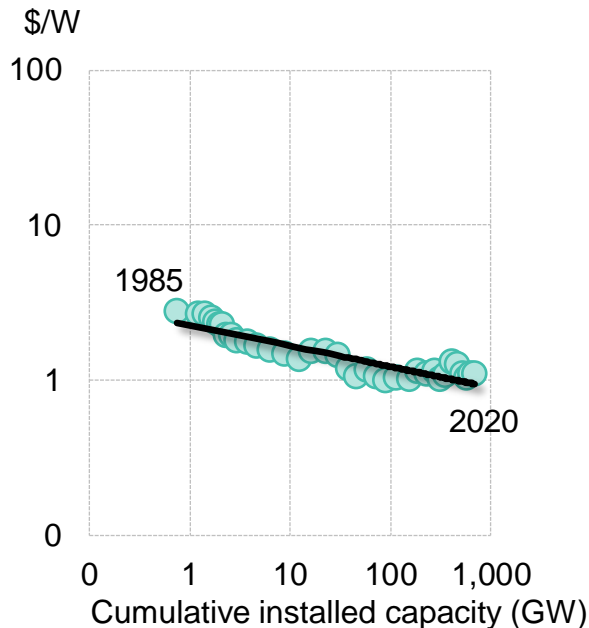
Solar module price (\$/W)

XP Curve = 28.8%



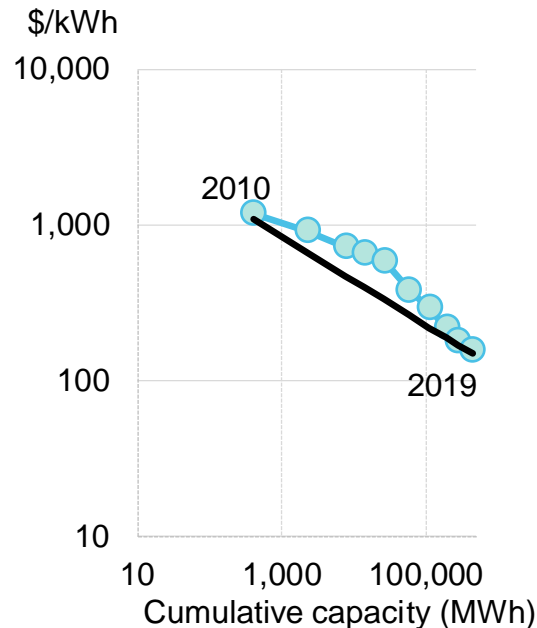
Wind turbine price (\$/W)

XP Curve = 7.1%



Batteries pack price (\$/kWh)

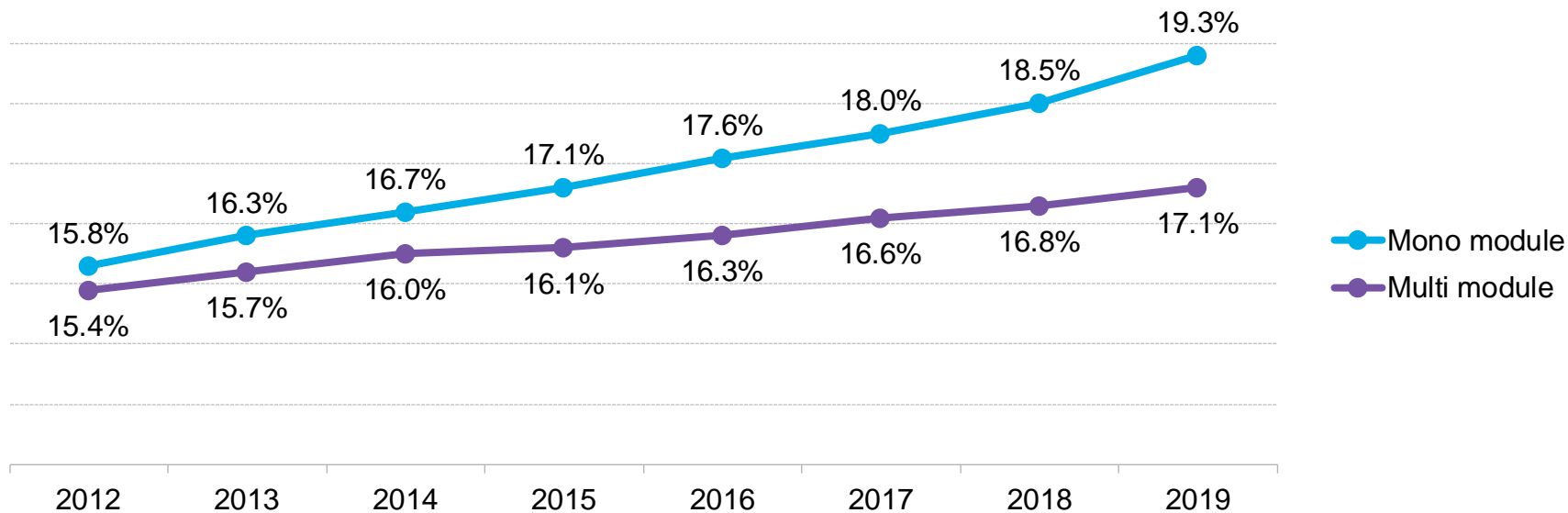
XP Curve = 18%



Source: BloombergNEF

PV is increasingly efficient

Average year-end PV module efficiency

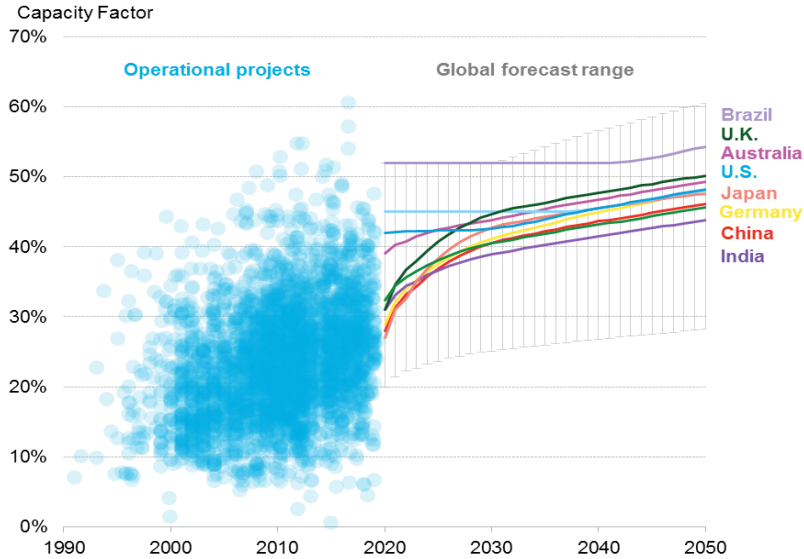


Source: BloombergNEF Note: 2017 multi module efficiency was adjusted downwards from the 2018 PV manufacturing overview to reflect the industry average instead of pure survey results.

Wind capacity factors are on the rise

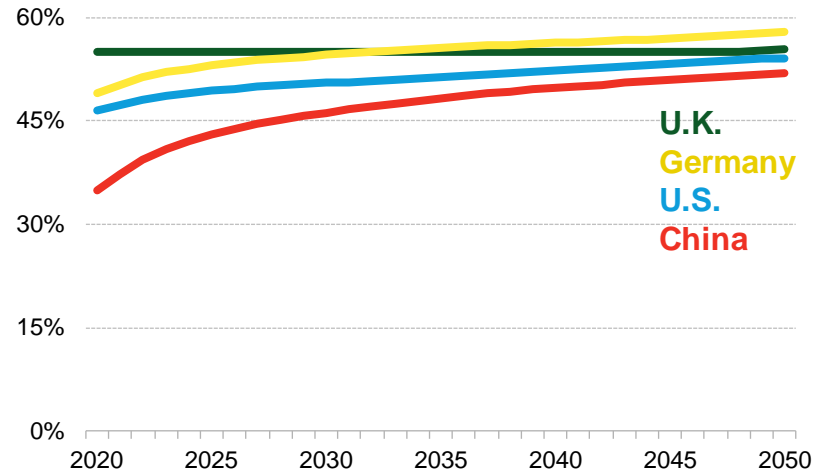
Wind capacity factors by technology

Onshore wind



Source: BloombergNEF

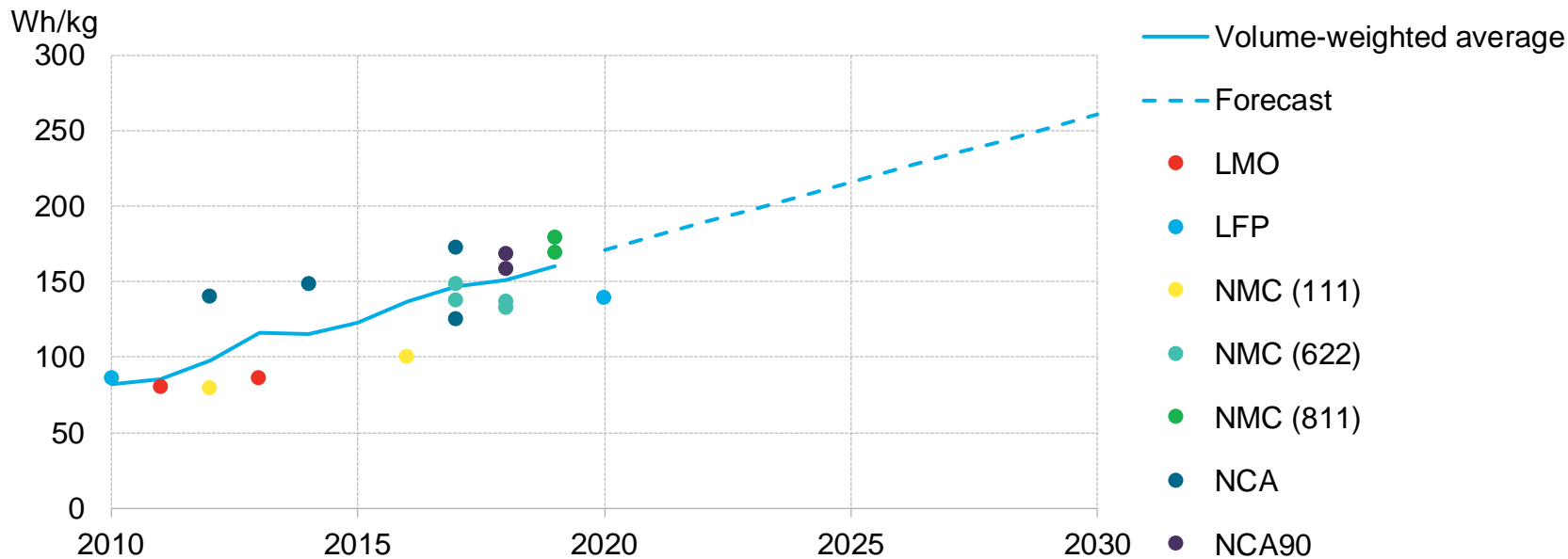
Offshore wind



Source: BloombergNEF

Lithium-ion battery pack energy density is improving (as is cycle life)

Lithium-ion battery pack energy density

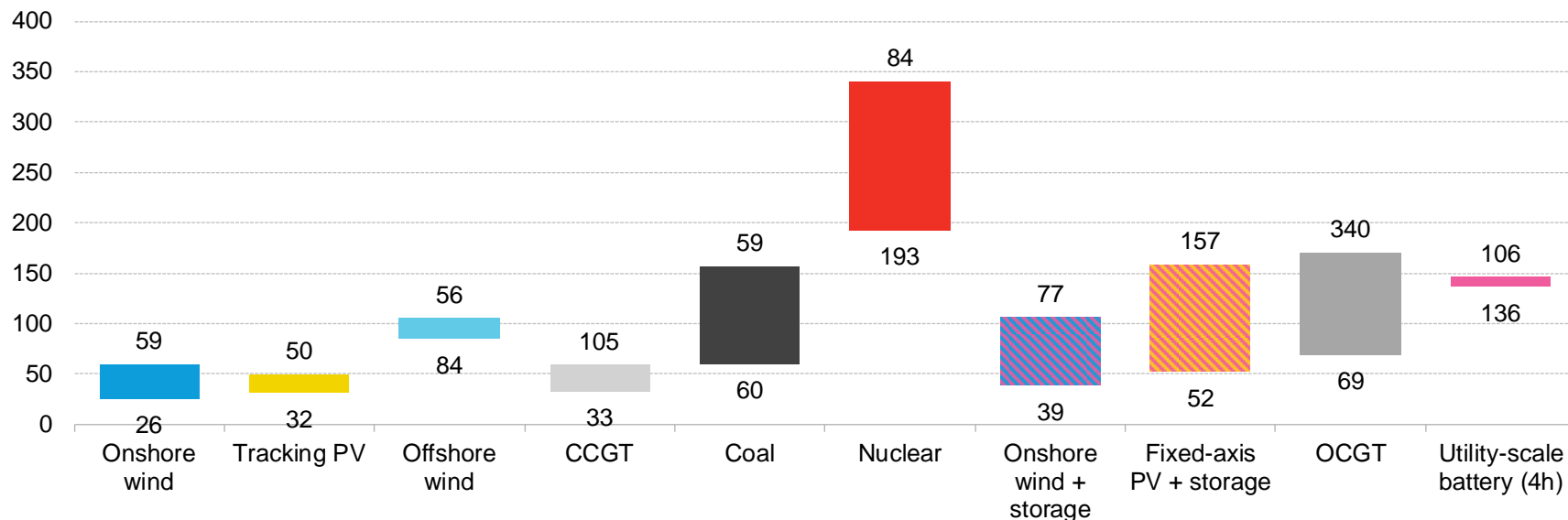


Source: BloombergNEF

Wind and PV are among the cheapest forms of generation in the U.S.

United States leveled cost of electricity

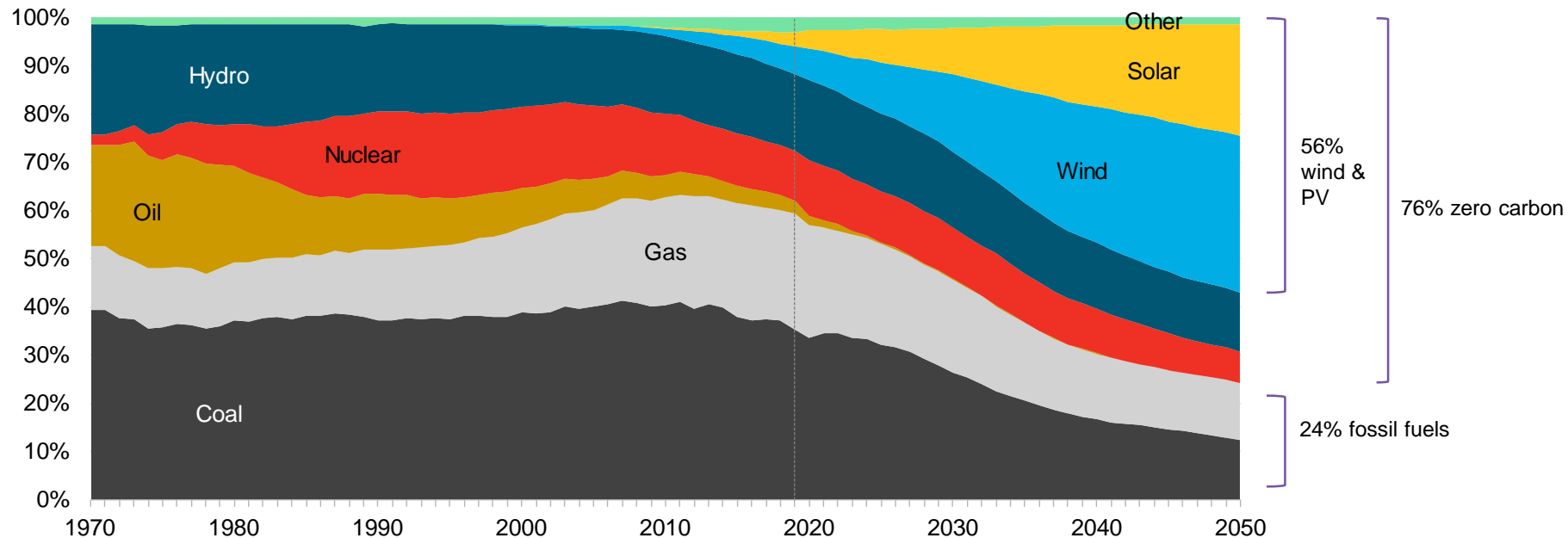
\$/MWh (nominal)



Source: BloombergNEF. Note: LCOEs exclude tax-credits (ITC & PTC) and curtailment. The LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar-and wind-plus-battery systems, the range is a combination of capacity factors and size of the battery relative to the power generating asset (25% to 100% of total installed capacity).

Wind and PV grow to 56% of global electricity generation in 2050

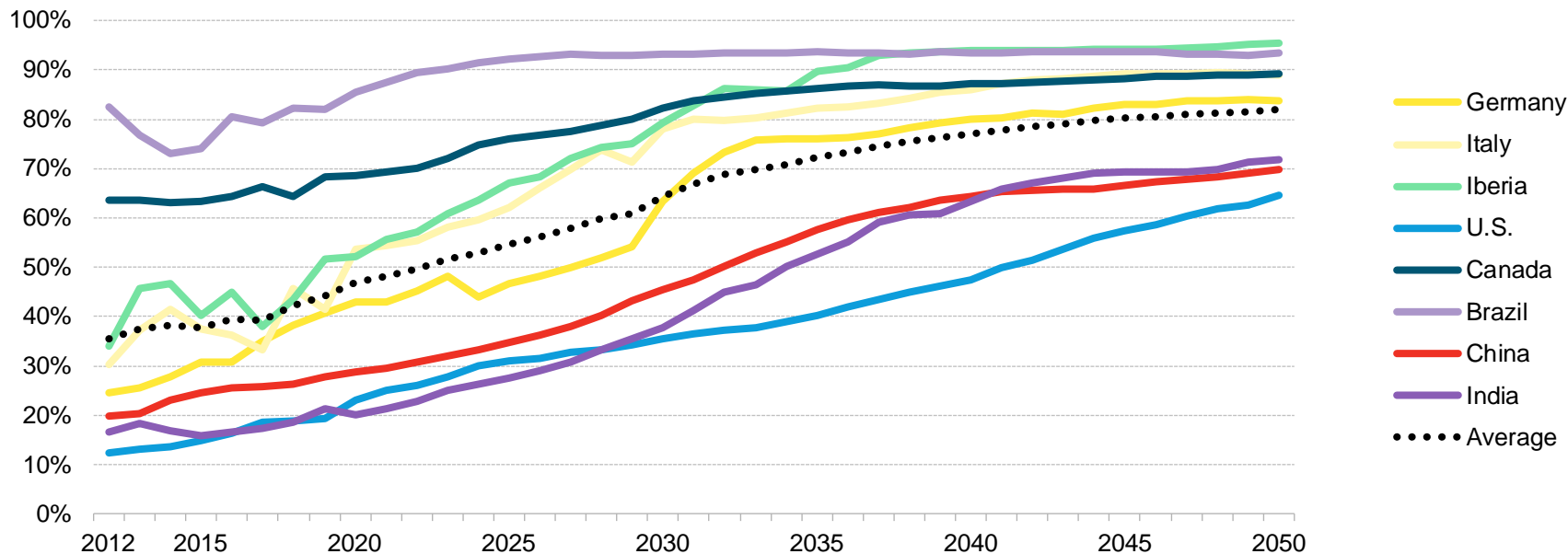
Global electricity generation



Source: BloombergNEF, IEA

PV, wind and energy storage is a least-cost combination to 70-80% renewables

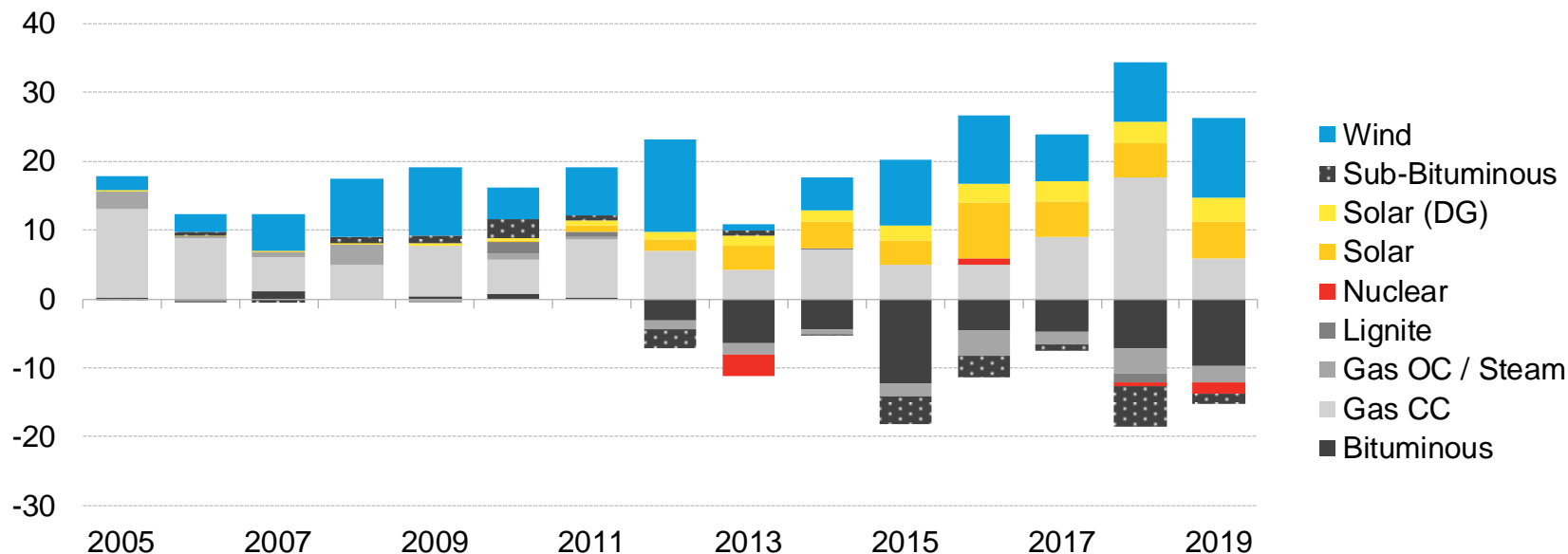
Share of wind and solar as % of total annual generation



Source: BloombergNEF

In the U.S., renewables and gas have thrived over the last decade at the expense of coal

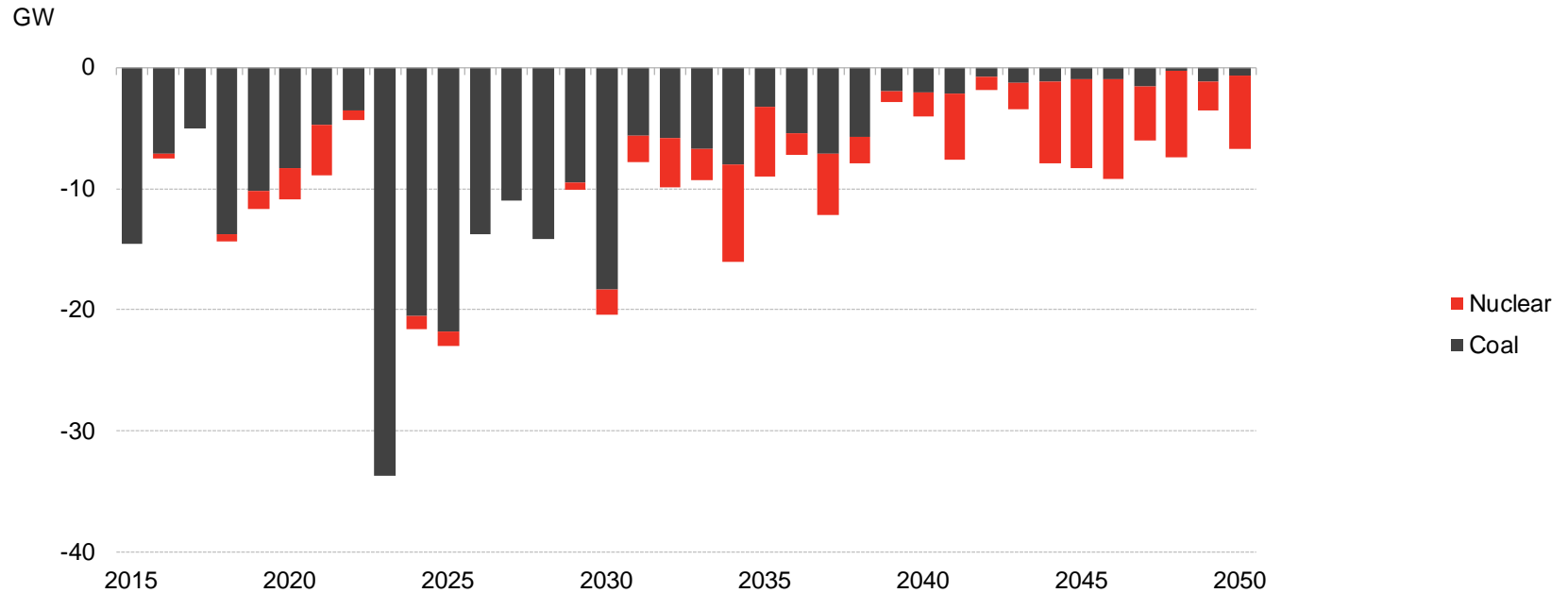
Net U.S. power generation additions (GW)



Source: BloombergNEF

Coal and nuclear continue to struggle based on economics alone

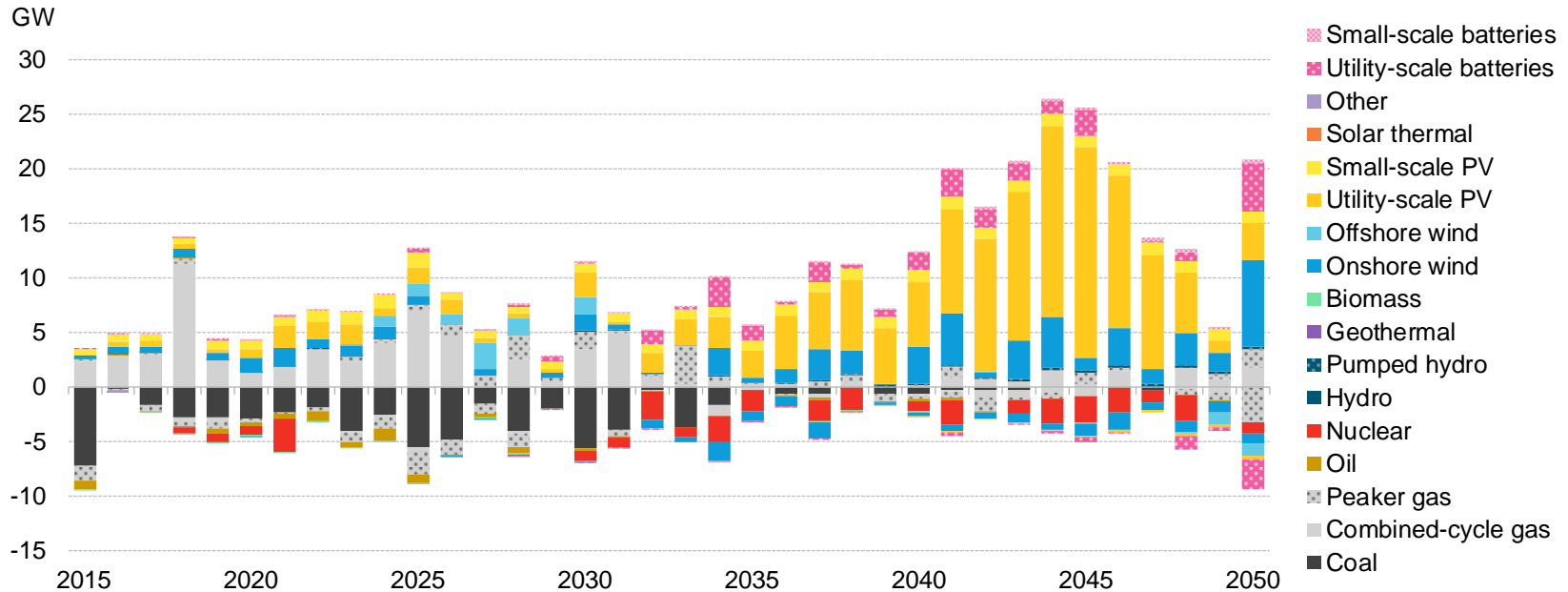
Coal and nuclear capacity retirements, United States



Source: BloombergNEF

Wind, solar and gas (in the 2020s) continue to thrive

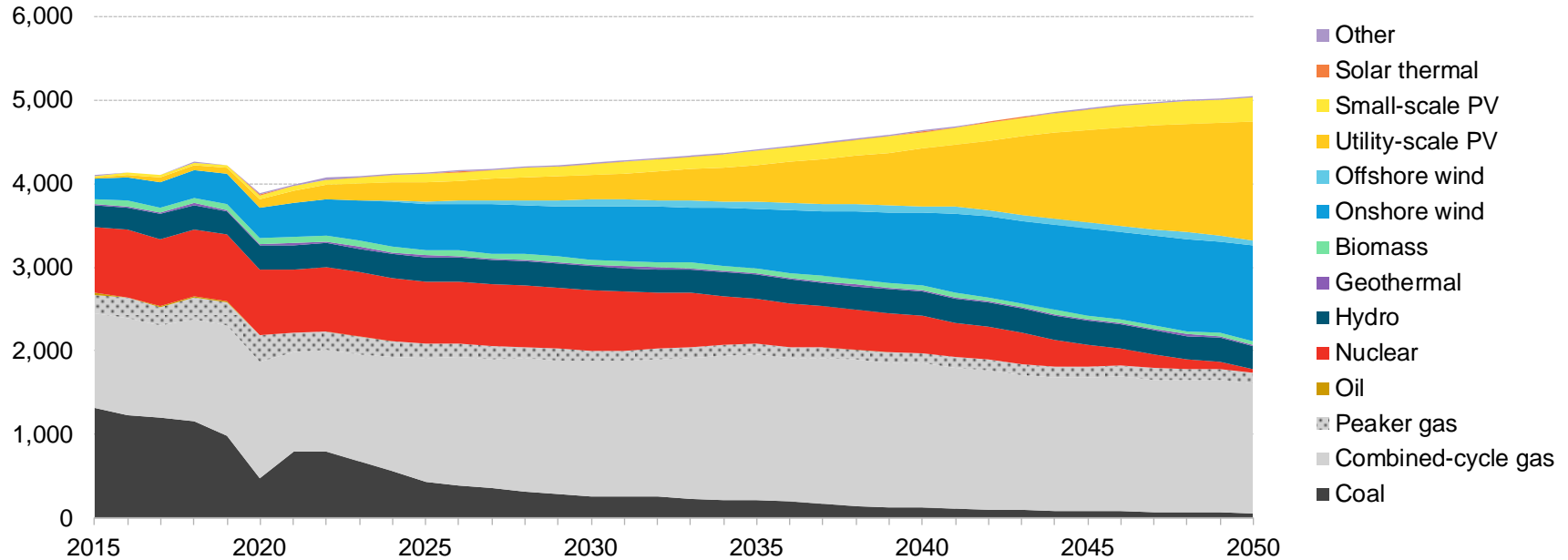
U.S. power generation capacity additions (GW)



Source: BloombergNEF

Renewables overtake gas as the leading source of generation in 2041

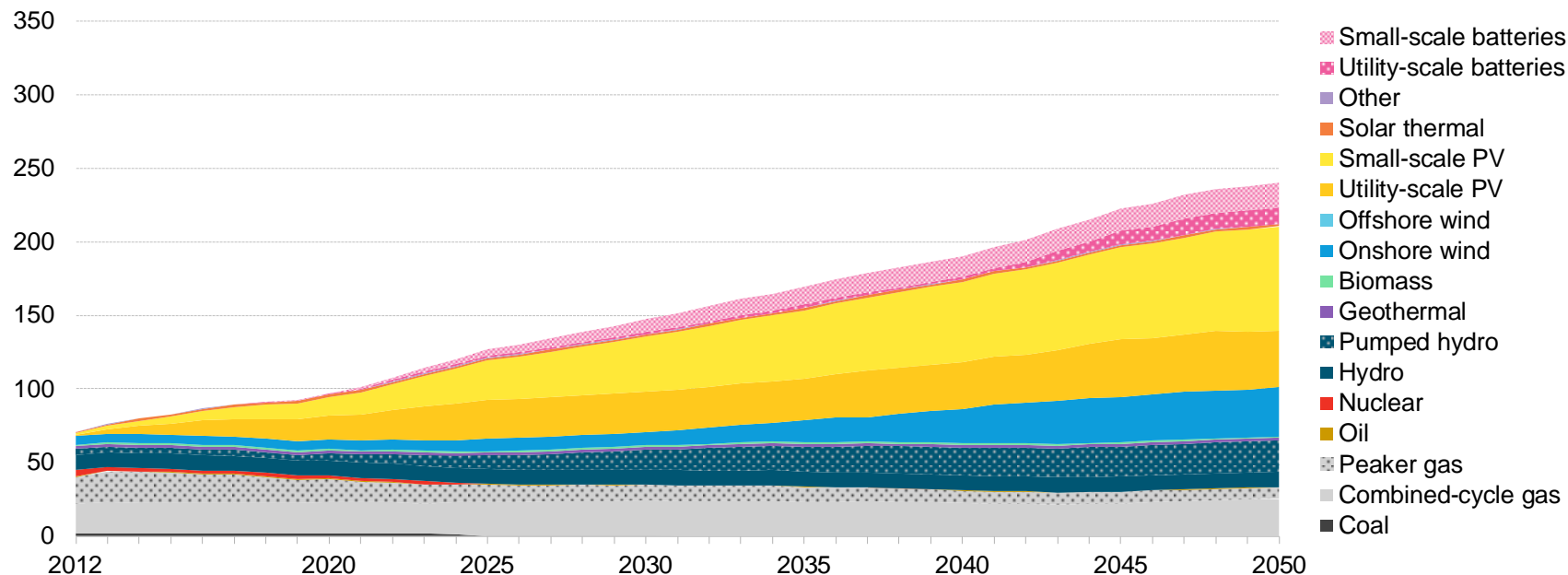
U.S. gross generation (TWh)



Source: BloombergNEF

Wind and solar make up some 60% of total installed capacity in California in the ETS

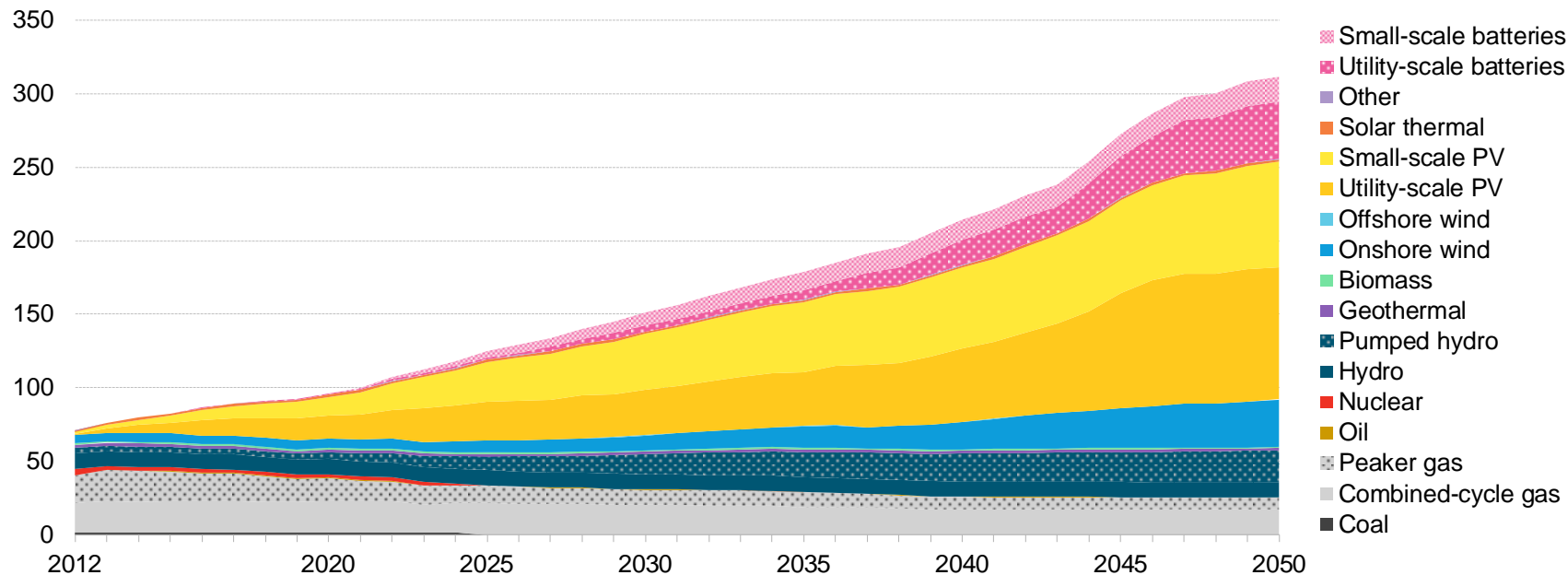
Installed power generation capacity (GW) in California, Economic Transition Scenario



Source: BloombergNEF Note: ETS stands for Energy Transition Scenario

Meeting California state goals requires much more capacity (solar+storage)

Installed power generation capacity (GW) in California, Renewable Portfolio Standard Scenario



Source: BloombergNEF

U.S. federal policy changes could be similarly impactful

Net-zero pledges of top global economies

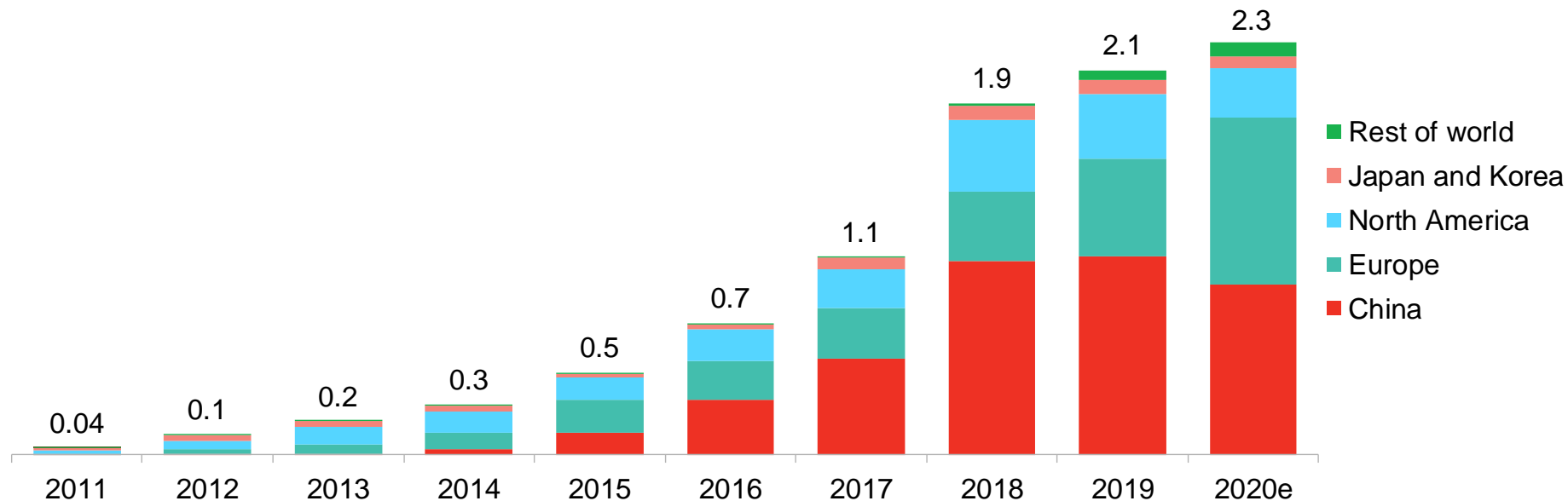
1. United States ❌
2. China ✅
3. Japan ✅
4. India ❌
5. Germany ✅
6. United Kingdom ✅
7. France ✅
8. Italy ✅
9. Brazil ❌
10. Canada ✅
11. Russia ❌
12. South Korea ✅



Source: Bloomberg

The U.S. currently lags behind Europe and China in terms of EV sales

Passenger electric vehicle sales (millions)



Source: BloombergNEF. Includes BEVs and PHEVs

Transitions are slow, right up until they're not

Policy



Source: Jean Chung/Bloomberg

Performance



Source: Tomohiro Ohsumi/Bloomberg

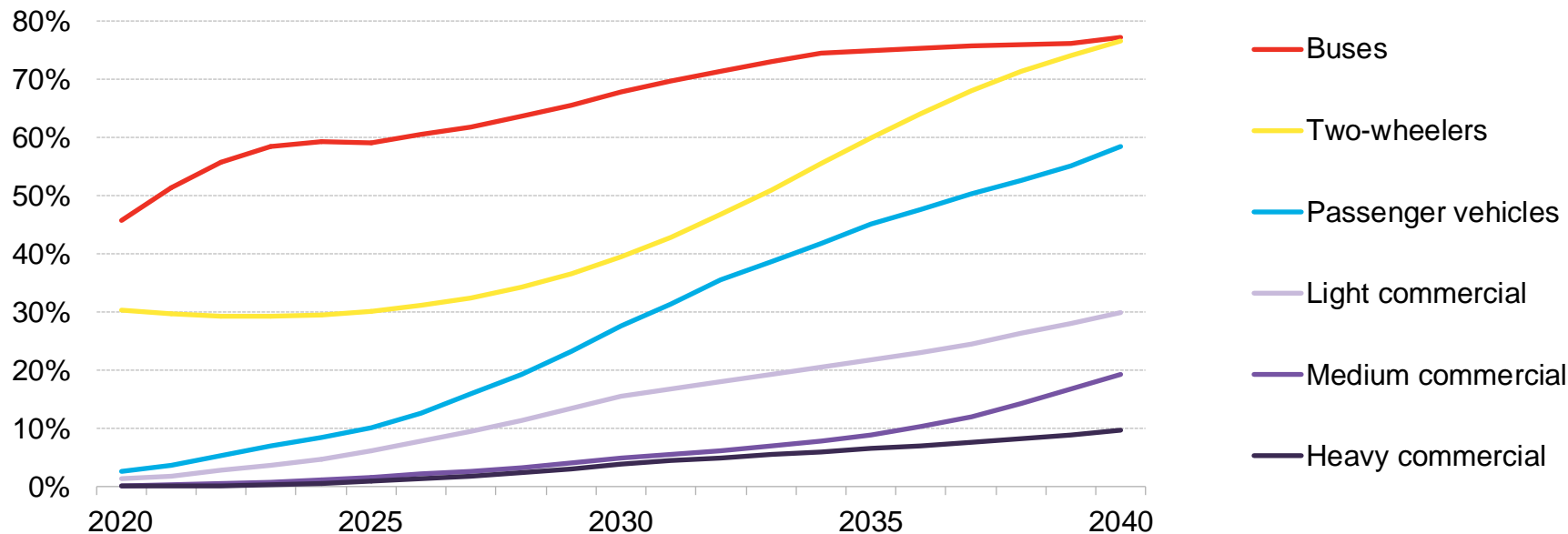
Corporate actions



Source: Volkswagen

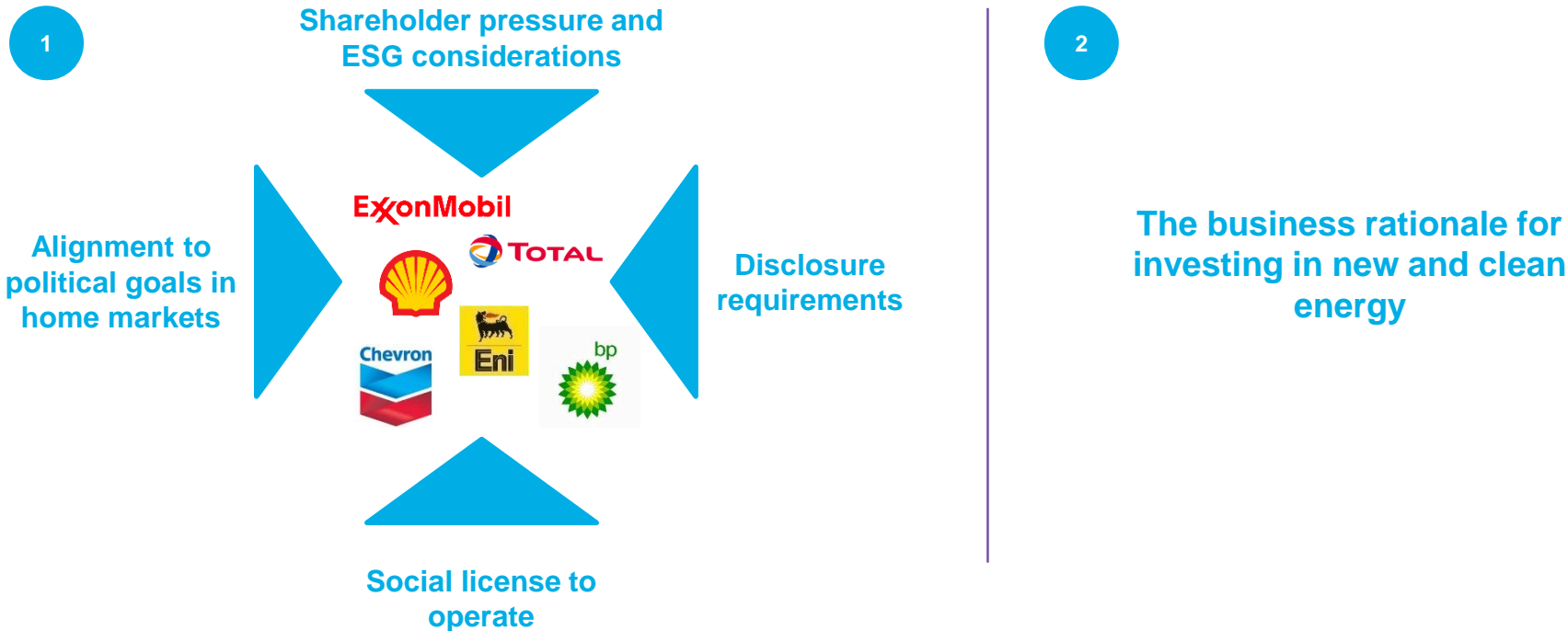
Passenger vehicles electrify quickly from the mid-2020s based on economics

Electric vehicle share of global new vehicle sales



Source: BloombergNEF

Two ways to think about O&G transition strategies



Shell at BNEF New York Summit, 2019



We believe we can be the largest electricity power company in the world in the early 2030s.

Maarten Wetselaar, Integrated Gas & New Energies Director, Shell



Interested in learning more about BNEF?

Contact: Brent Smelter, Commercial Director (BNEF)

Email: bsmelter@bloomberg.net

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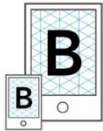
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