

# Flexibility and the Future of Power

Wärtsilä Capital Markets Day

Albert Cheung

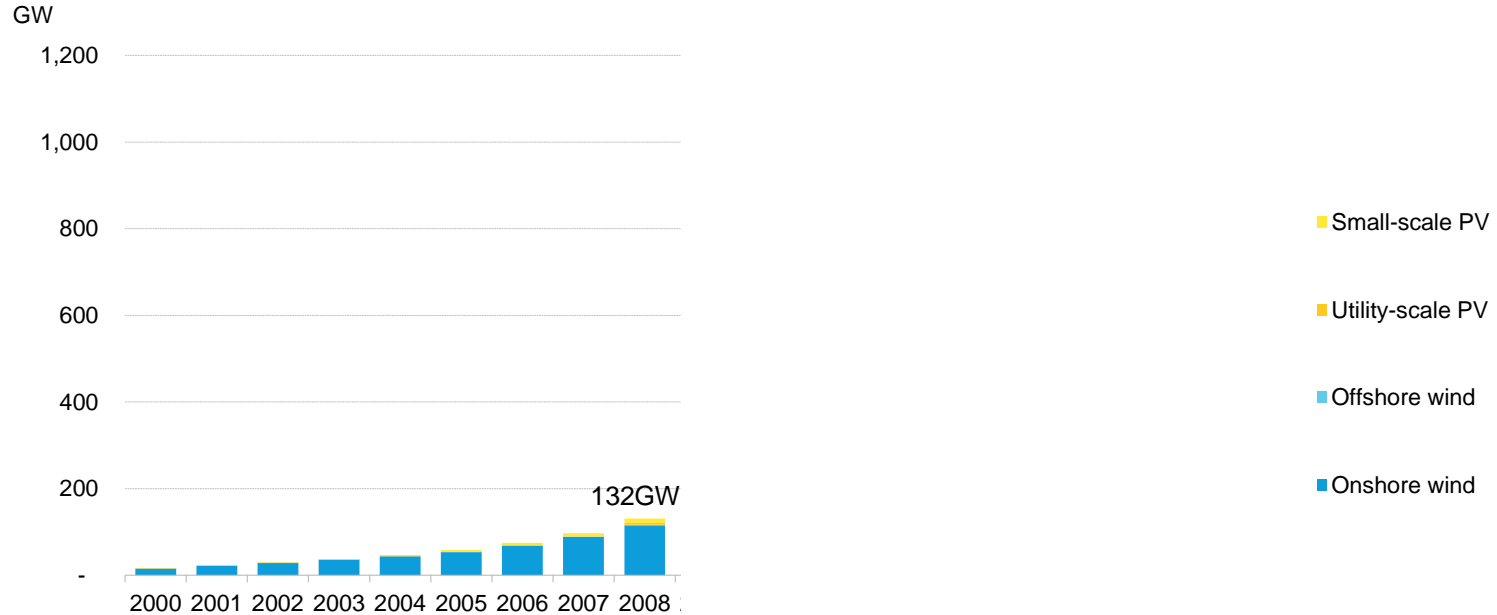
November 26, 2019



BloombergNEF

# A decade ago

## Global wind and solar installations, cumulative to 2008



Source: BloombergNEF.

# Energy transition challenges, 2008



## Costs

How to drive down costs of clean energy and reduce dependence on subsidies?

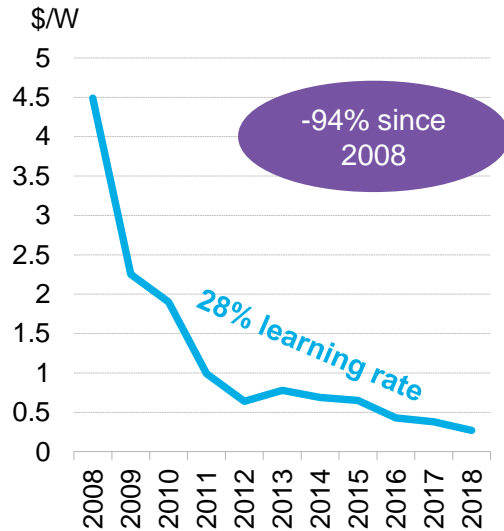


## Scale

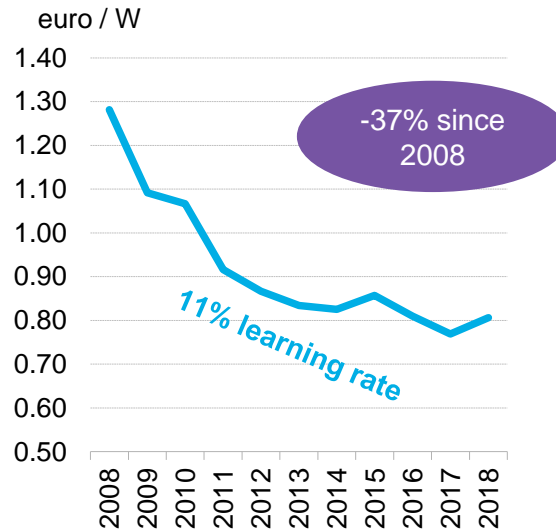
How to scale up deployments? How to raise and deploy the capital required for the energy transition?

# Technology costs plummeted

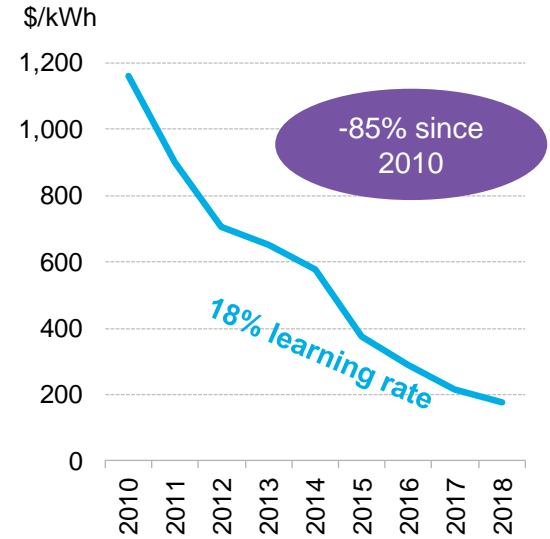
## Solar PV module prices



## Onshore wind turbine prices



## Lithium-ion battery prices

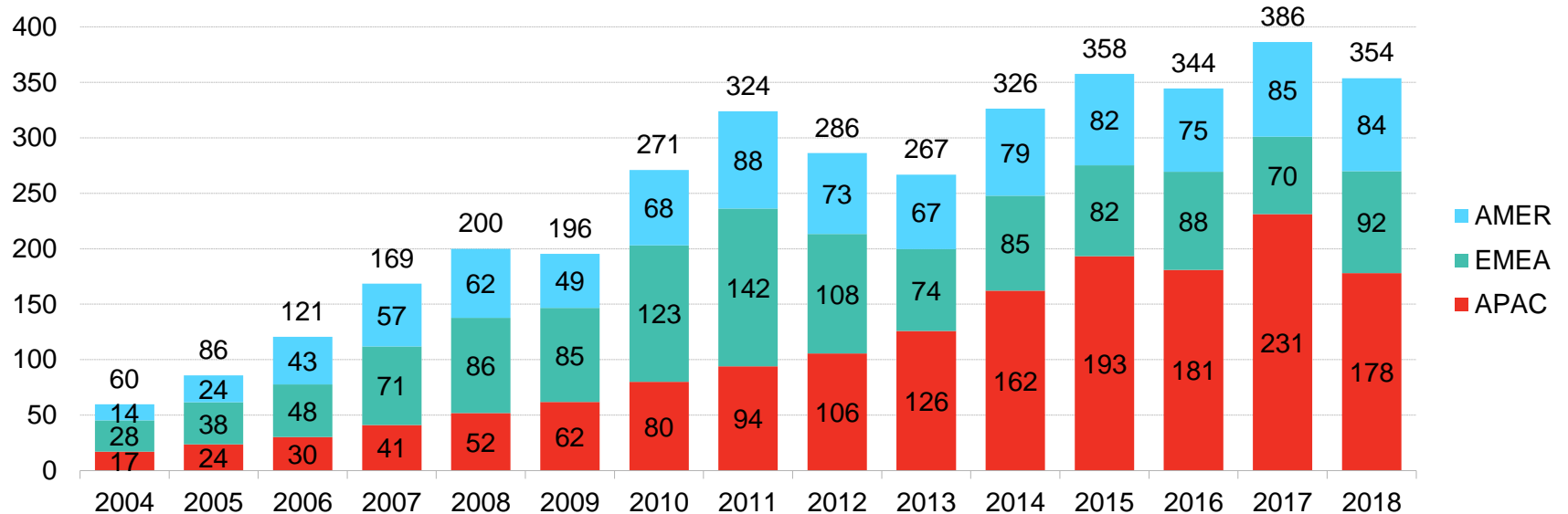


Source: BloombergNEF.

# Clean energy investment scaled up

## Global clean energy investment

\$ billion

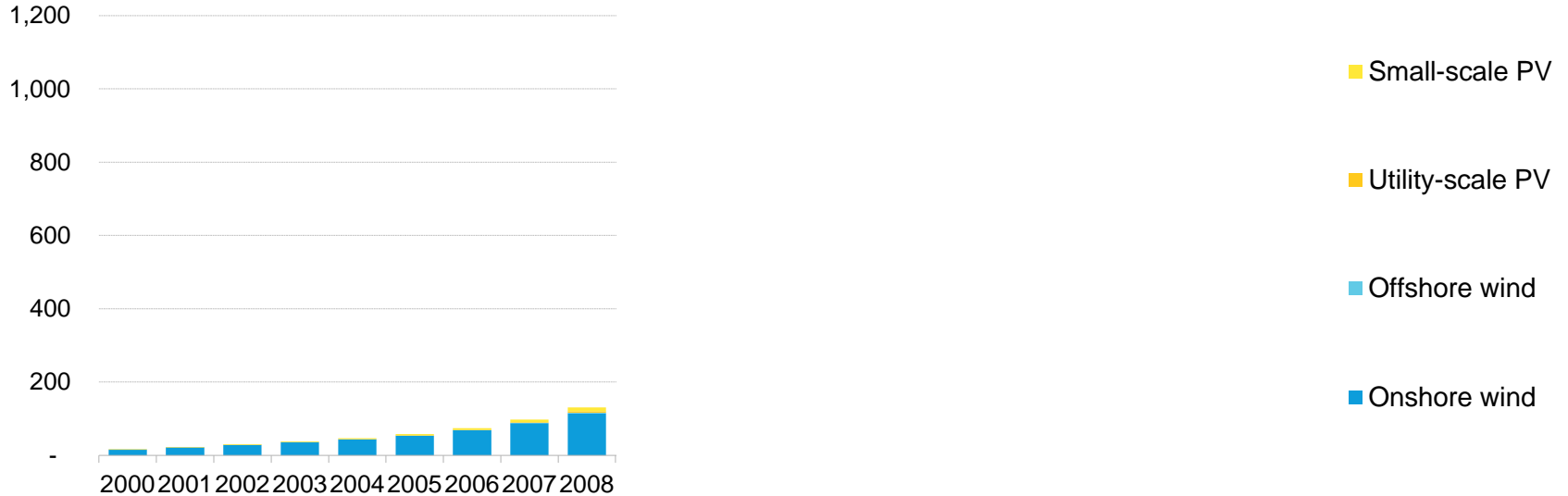


Source: BloombergNEF

# And the rest is history

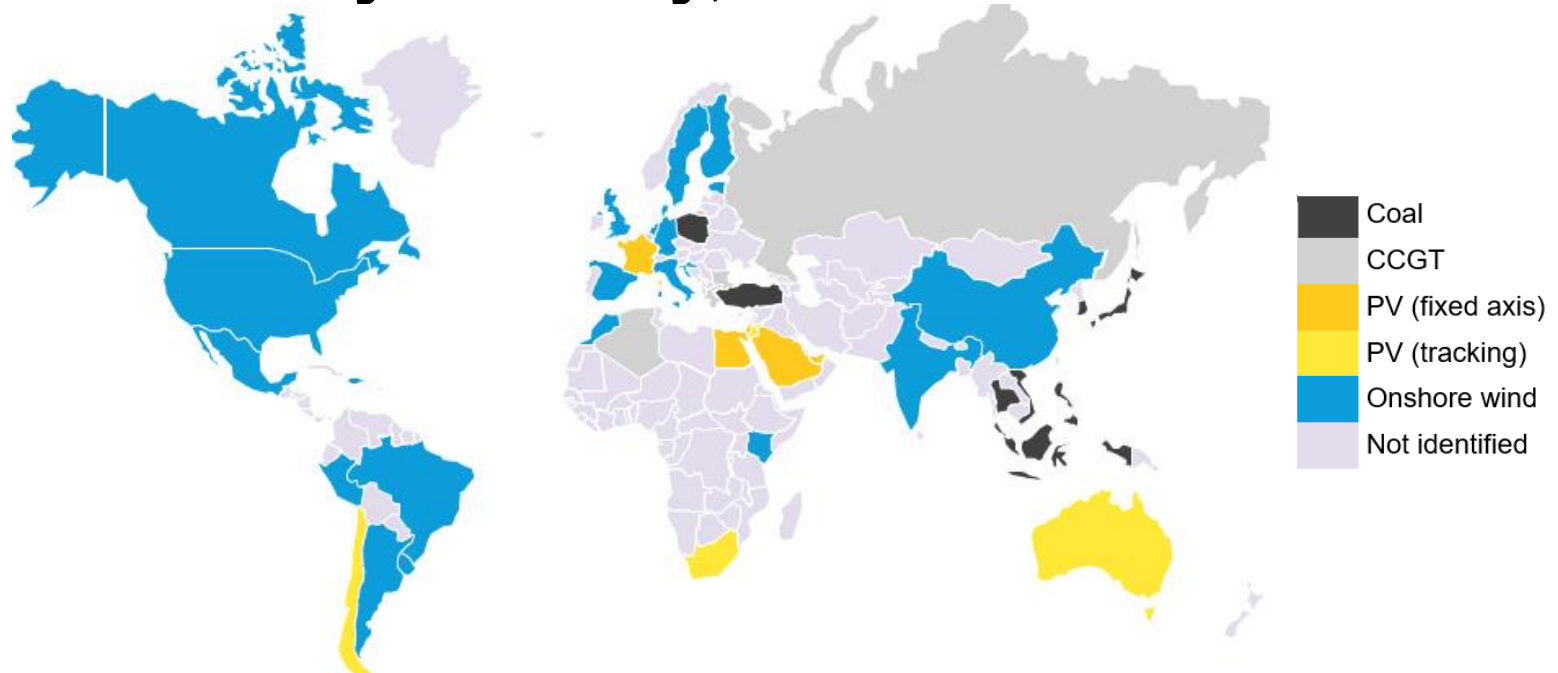
## Global wind and solar installations

Cumulative GW



Source: Bloomberg NEF.

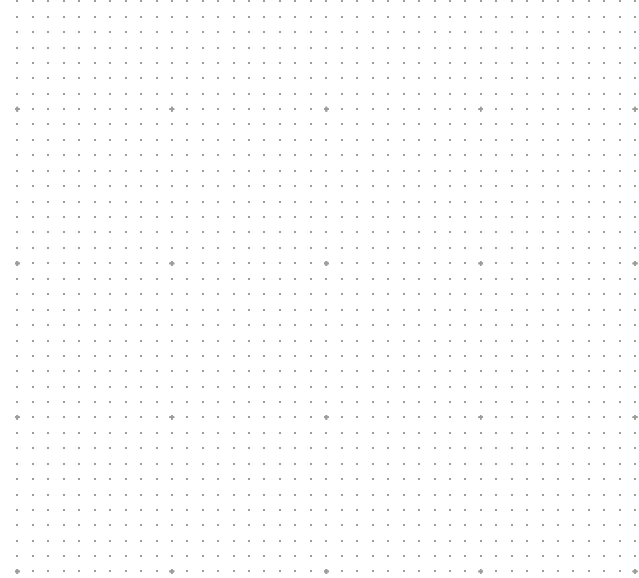
# Most competitive forms of power generation by country, 2019



Source: BloombergNEF. Note: Reflective of the cheapest benchmark project for each technology and market

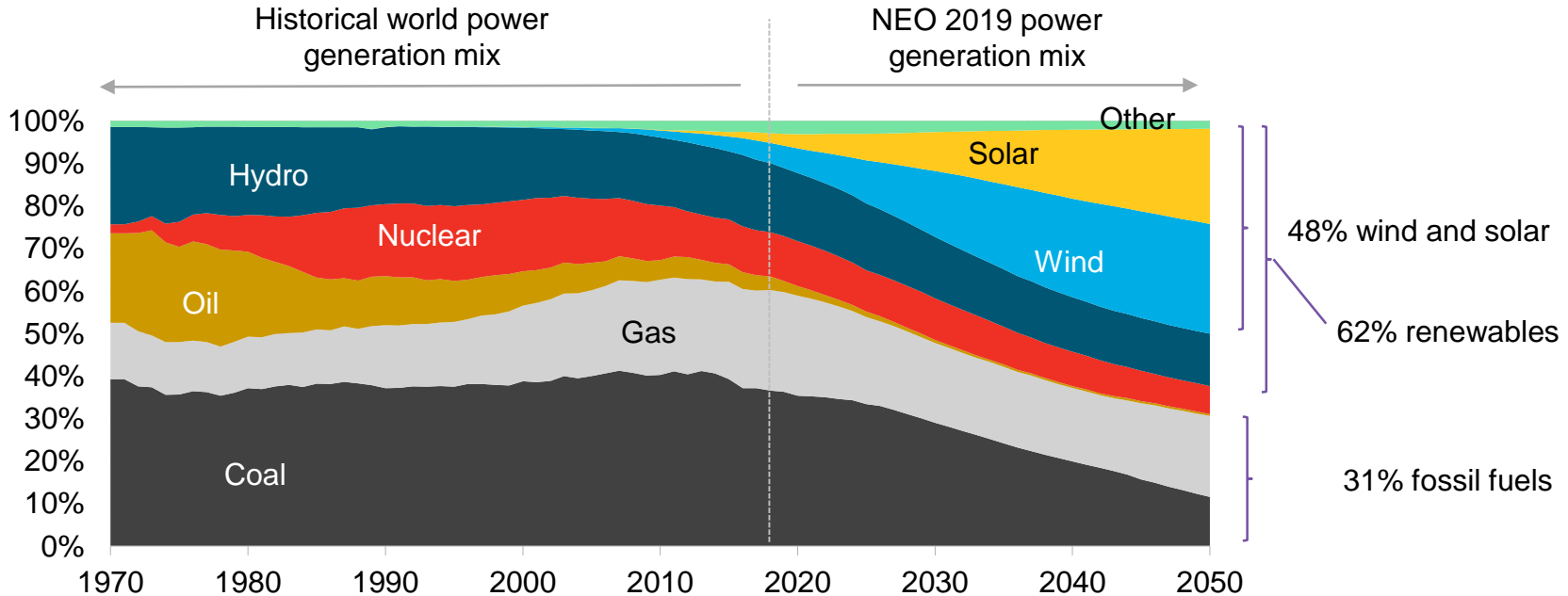
# Looking forward

## BNEF New Energy Outlook





# New Energy Outlook: ~50% wind + solar power globally by 2050

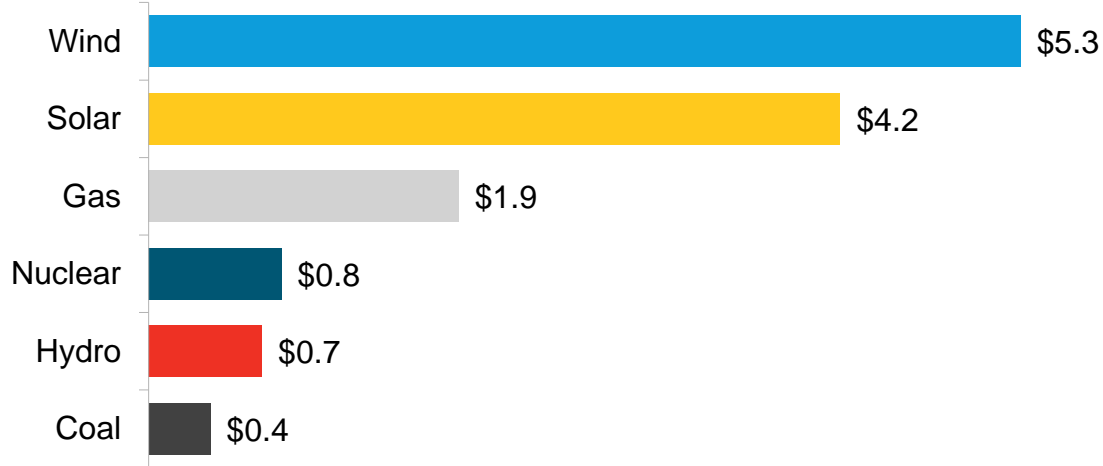


Source: BloombergNEF, IEA

# \$13.3 trillion new investment to 2050

## Investment by technology, 2019-2050

\$ trillion, real 2018

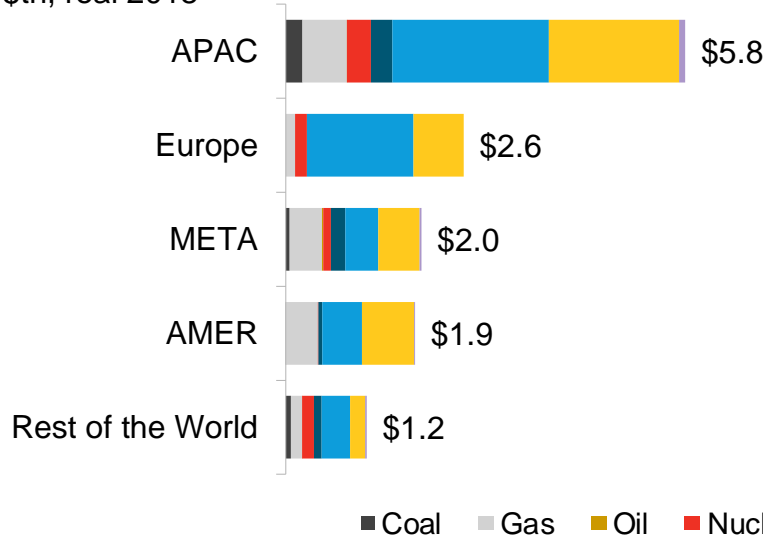


Source: BloombergNEF

# Asia Pacific is the driving force behind global investment

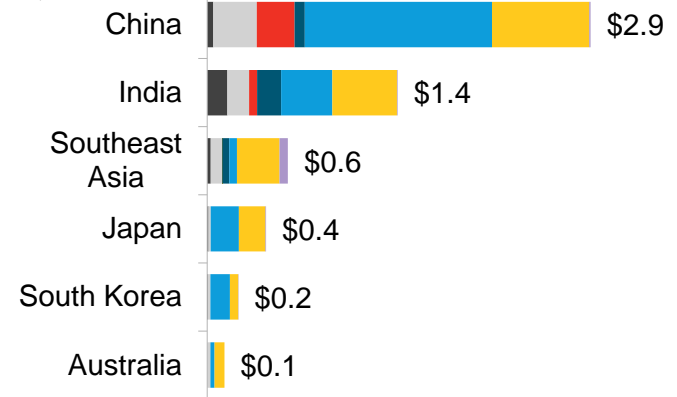
Global investment in power generation by region, 2018-2050

\$tn, real 2018



APAC investment in power generation by region, 2018-2050

\$tn, real 2018

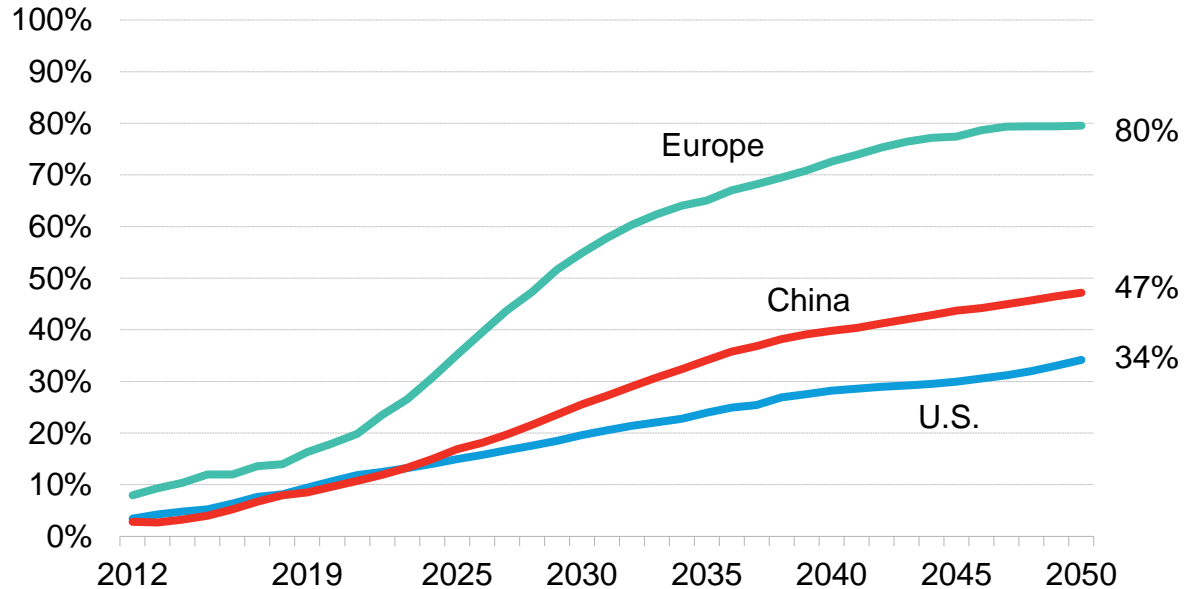


Source: BloombergNEF

Source: BloombergNEF

# Europe transitions furthest, fastest

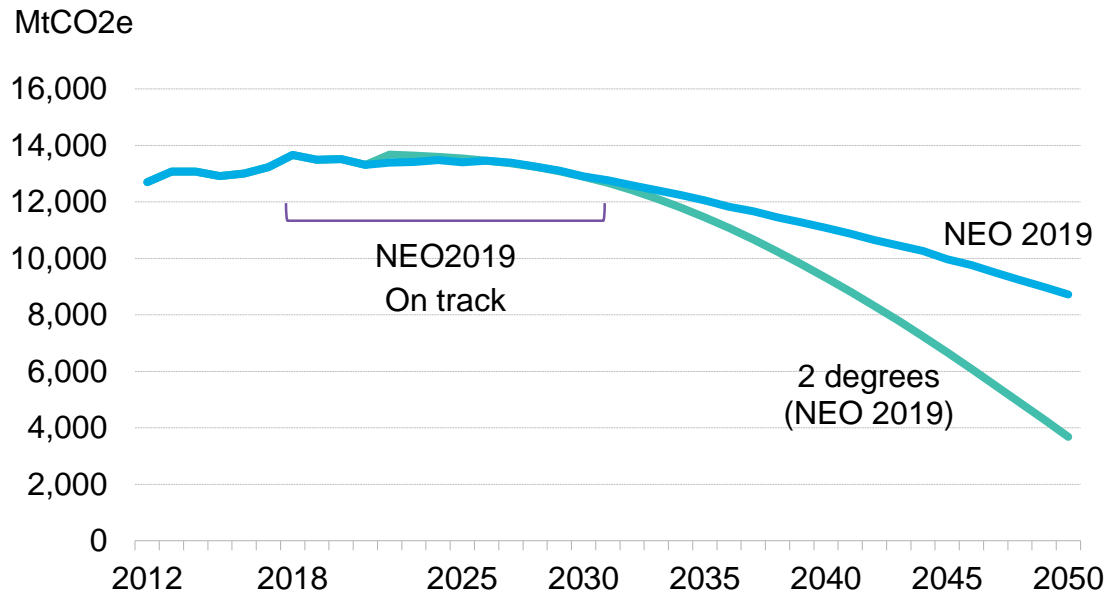
## Wind and solar penetration



Source: BloombergNEF

# Keeping power sector on track for 2 degrees to 2030

## Global power sector emissions

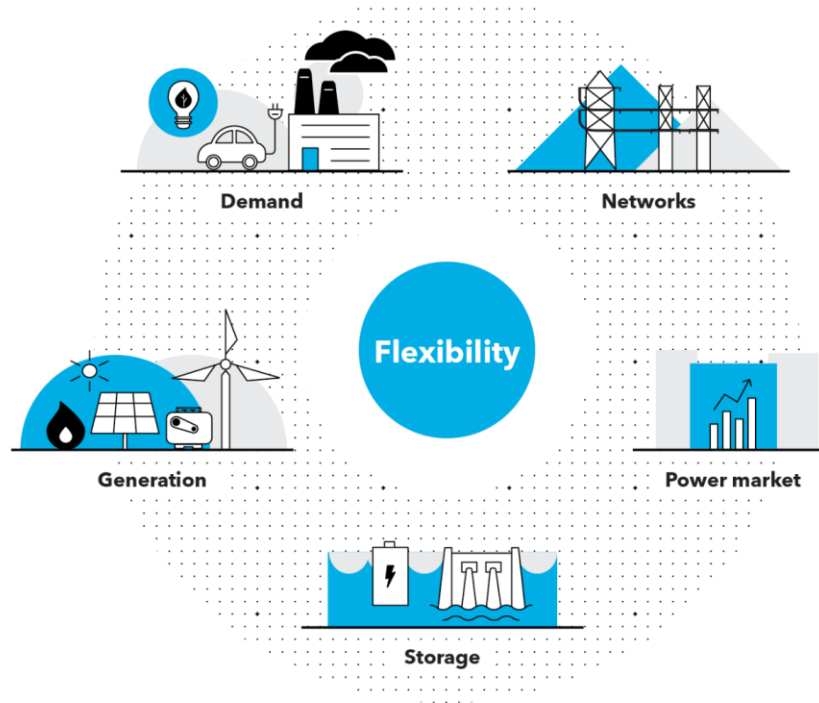


Source: BloombergNEF

# How will the future power system operate?

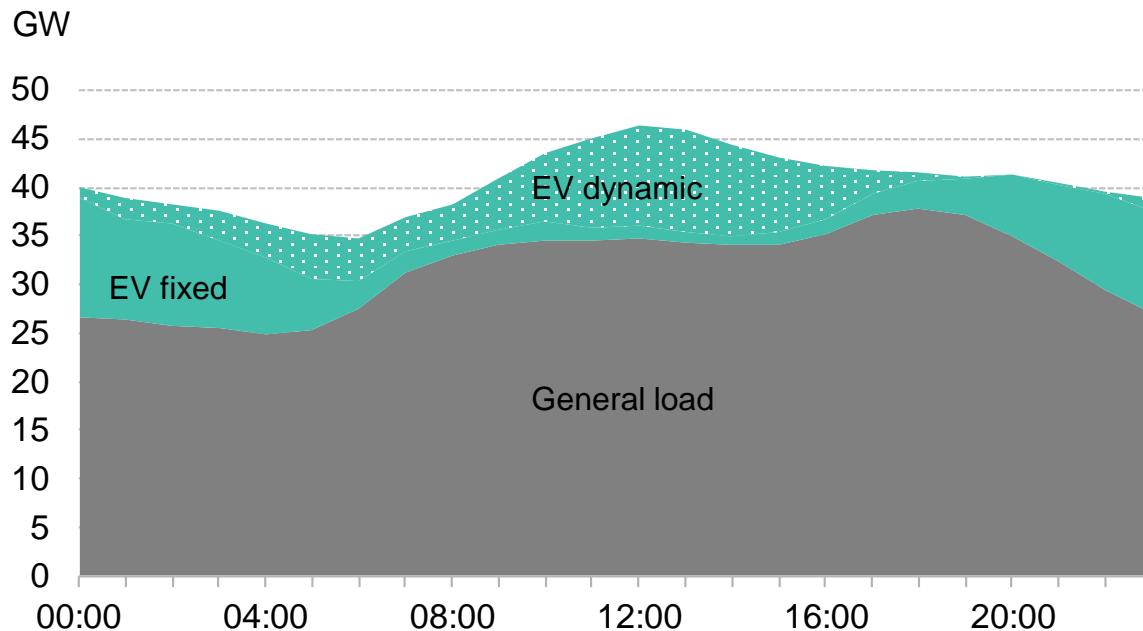
The race for flexibility

# Flexibility



# Demand-side flexibility: dynamic EV charging

U.K. typical daily load profile, Q1, 2050

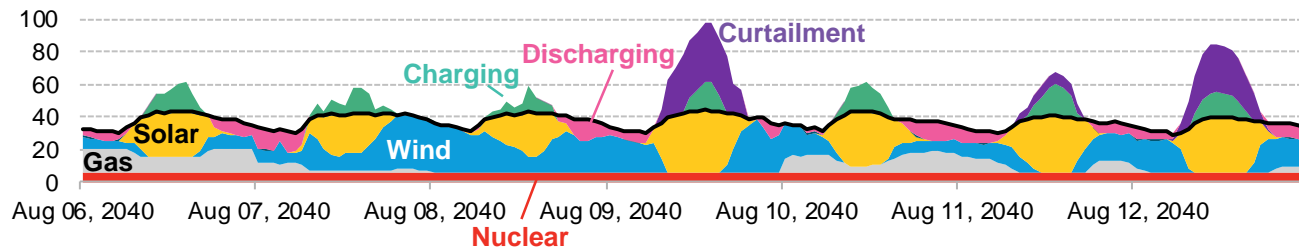


Source: BloombergNEF



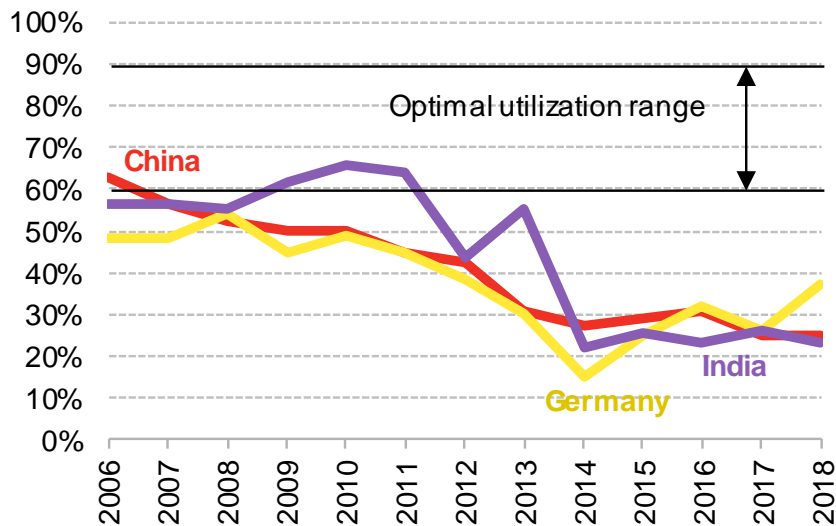
# The U.K. power system in 2040

Week with median renewable output



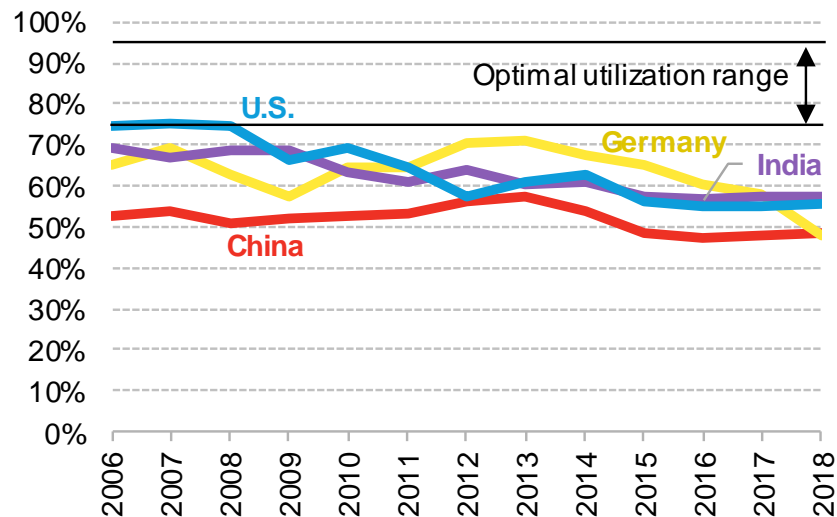
# The dispatchable fleet will operate very differently

## CCGT average fleet utilization



Source: BloombergNEF

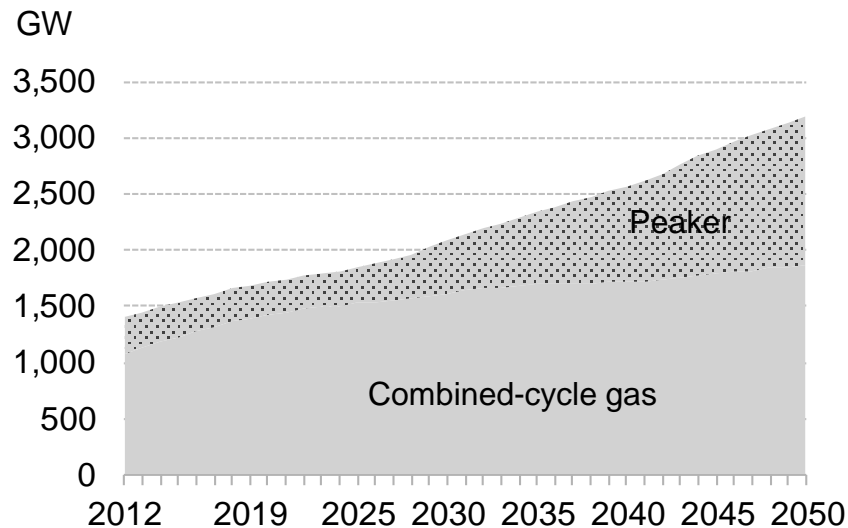
## Coal average fleet utilization



Source: BloombergNEF

# Gas capacity almost doubles to 2050

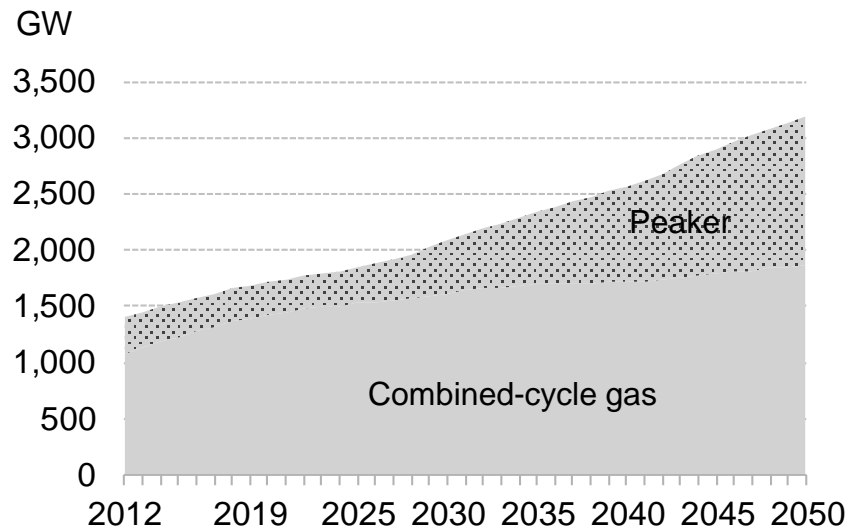
## Cumulative installed gas capacity



Source: BloombergNEF

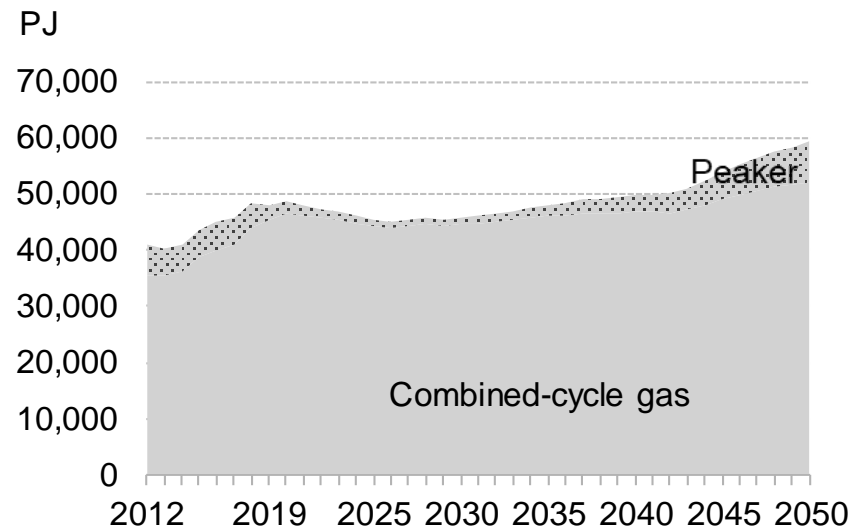
# Gas capacity almost doubles to 2050, but gas burn only up ~22%

## Cumulative installed gas capacity



Source: BloombergNEF

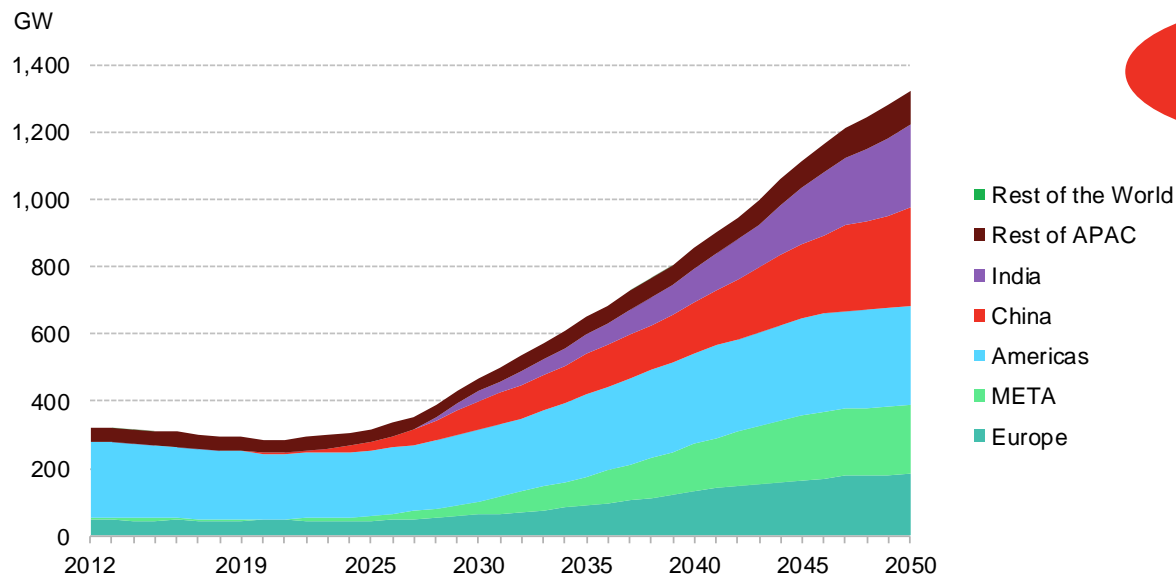
## Fuel burn



Source: BloombergNEF

# Spotlight on gas peakers to 2050

Peaker gas: cumulative installed capacity by country/region (GW)

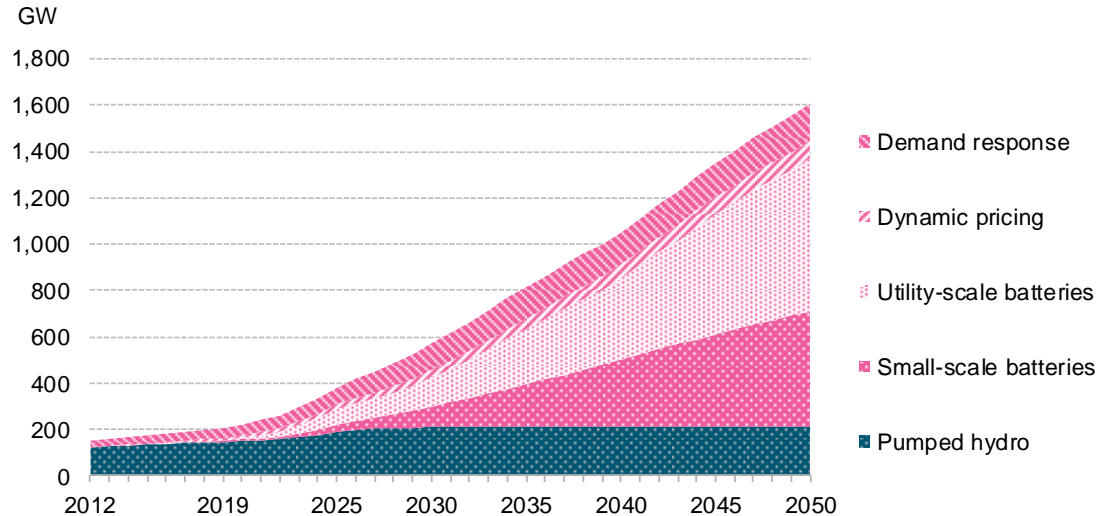


4.5x more peakers in 2050

Source: BloombergNEF

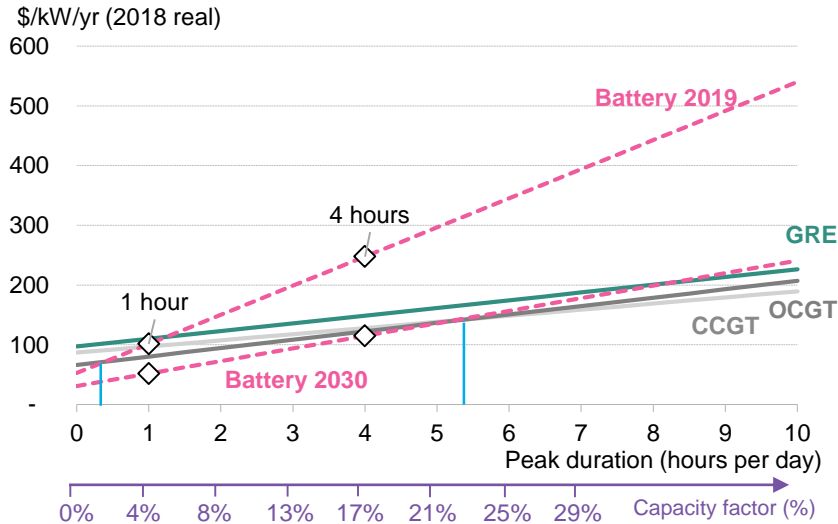
# What about other flexibility technologies?

Non-gas flexibility: cumulative installed capacity by technology (GW)

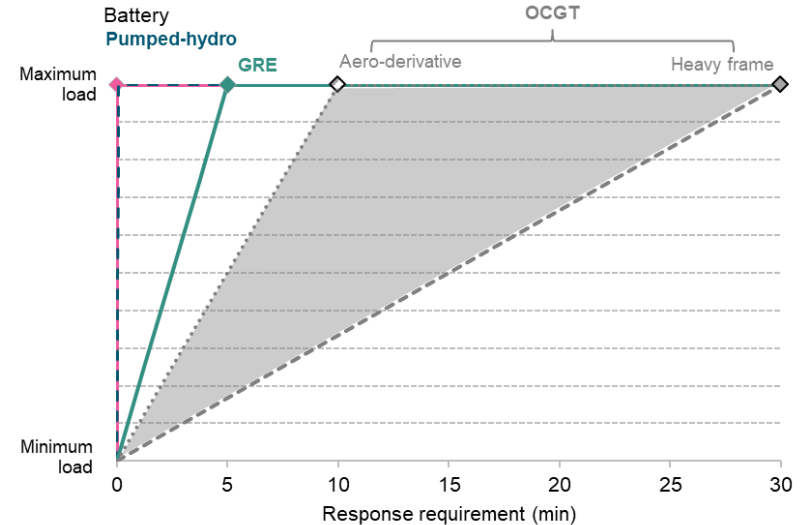


# Duration and speed

## Levelized cost of capacity for batteries and gas



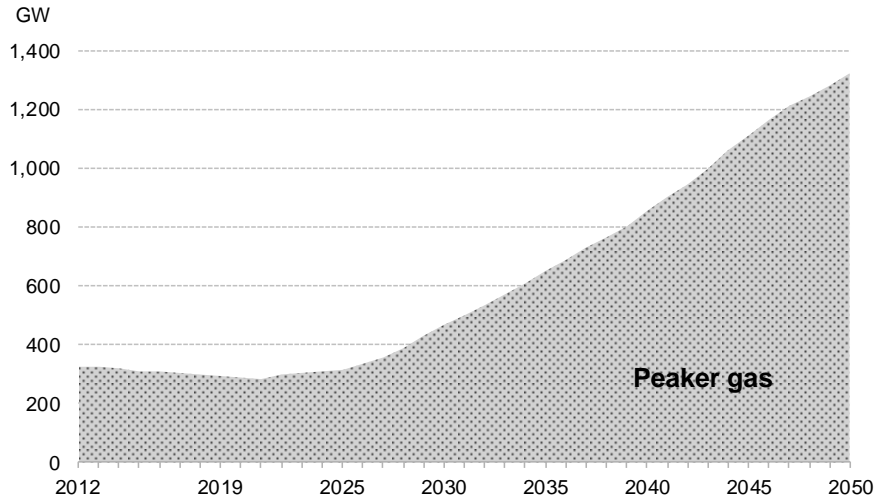
## Ramp-up times for batteries and gas



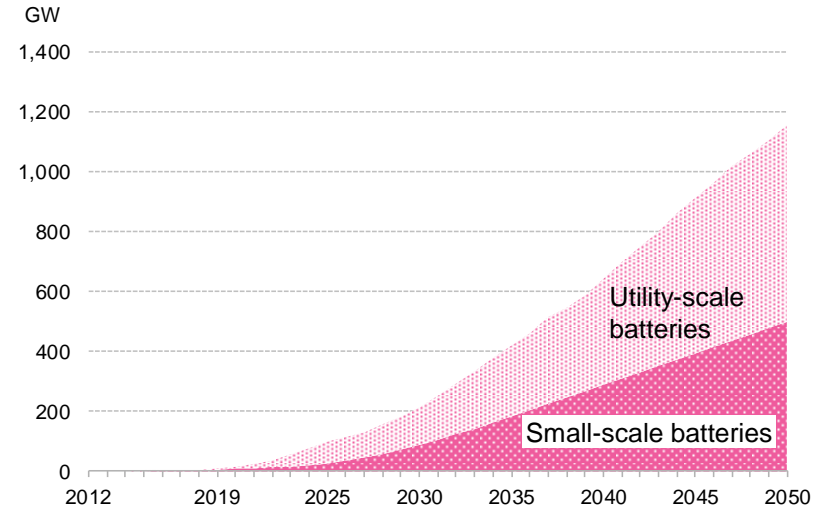
Source: BloombergNEF. Note: GRE = gas reciprocating engine, OCGT and CCGT are open- and combined-cycle gas turbine respectively.

# Batteries and peaker gas will co-exist

## Peaker gas: cumulative installed capacity



## Batteries: cumulative installed capacity

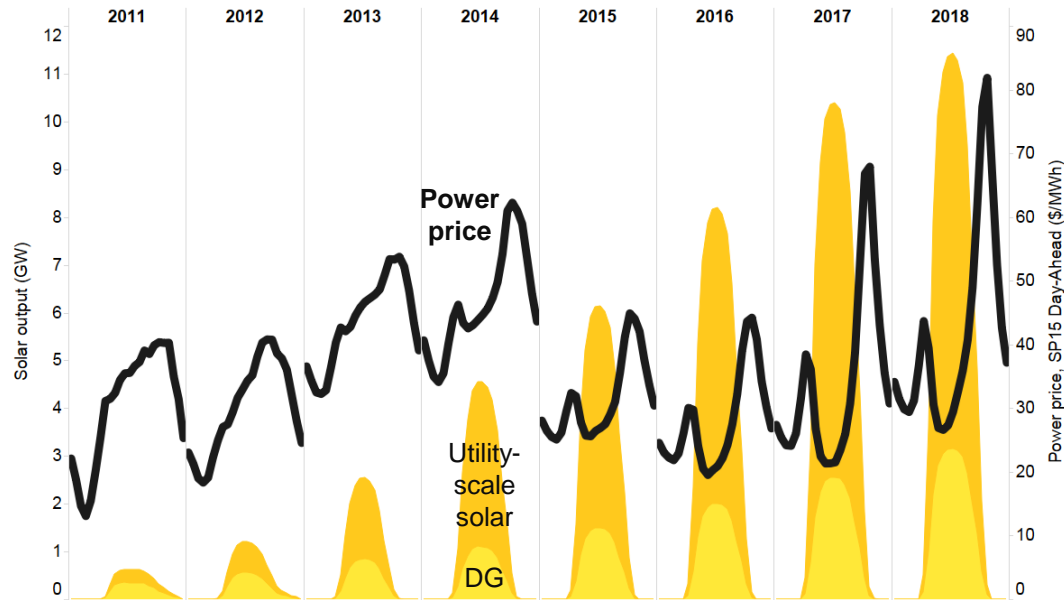


Source: BloombergNEF



# Early signs from California

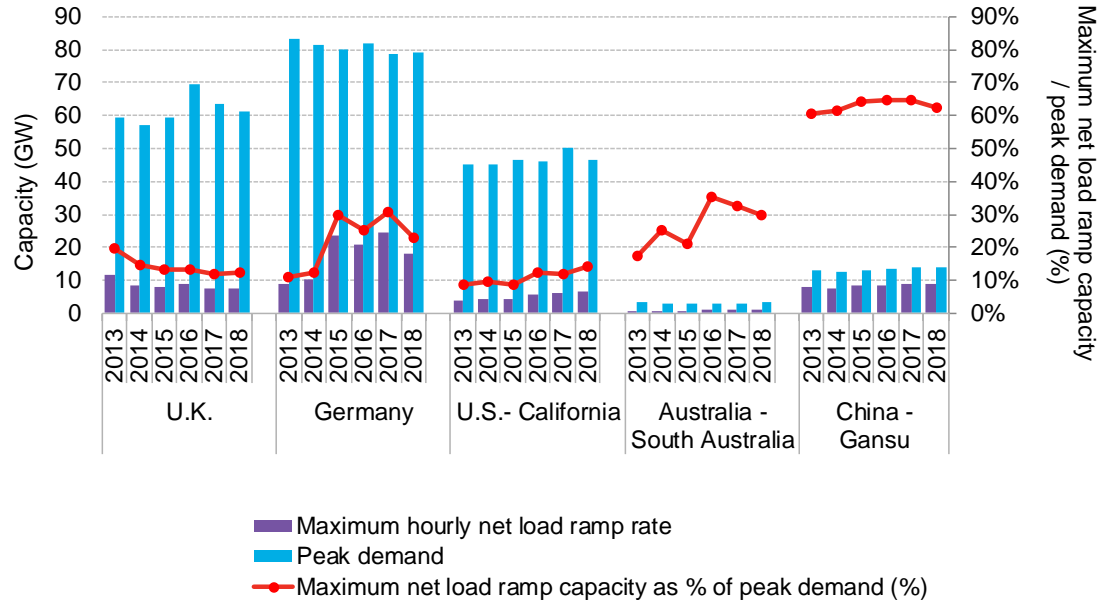
## CAISO solar generation versus wholesale power price, average day 2011-18



Source: BloombergNEF

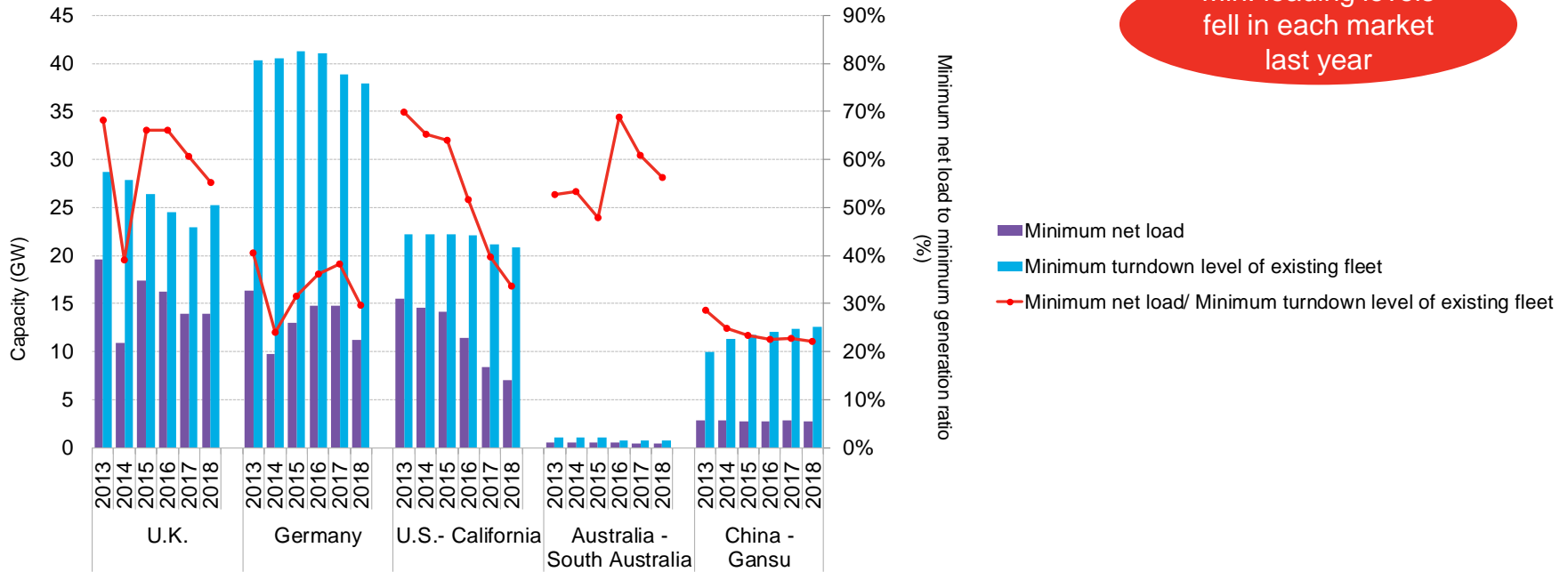
# Max. required net load ramp as proportion of peak demand

Max ramp rates are rising in several markets



Source: BloombergNEF

# Minimum net load versus minimum turndown level of existing fleet

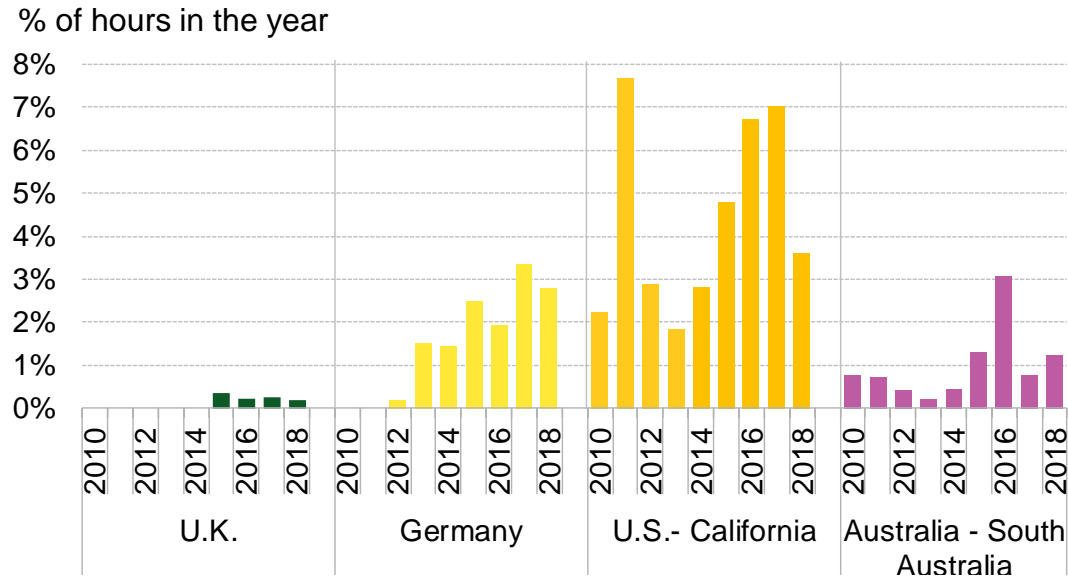


Min. loading levels fell in each market last year

Source: BloombergNEF. Note: For detailed metric explanation, please see Research Note Global Power System Flexibility Review ([web](#) | [terminal](#)).

# Negative power prices indicate a lack of flexibility

## Negative price occurrences, 2010-18



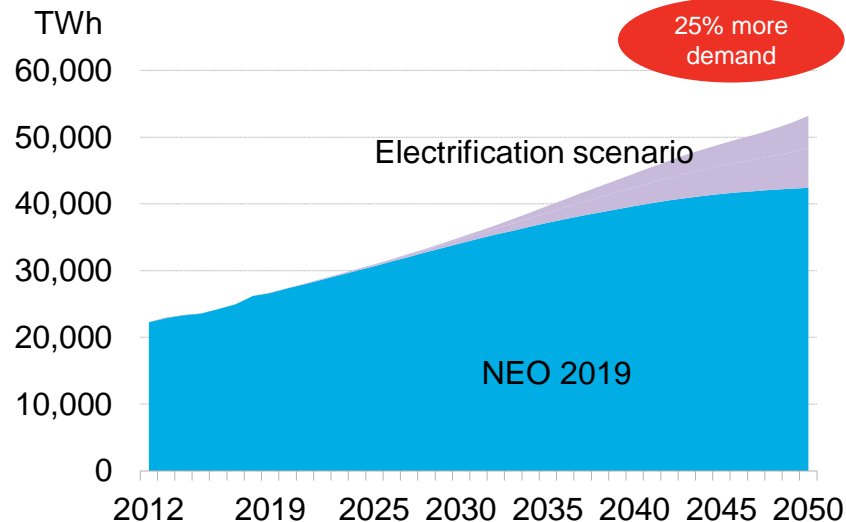
Source: BloombergNEF. Note: power prices represent real-time or intraday power prices.

# Getting to two degrees

Electrification and decarbonization

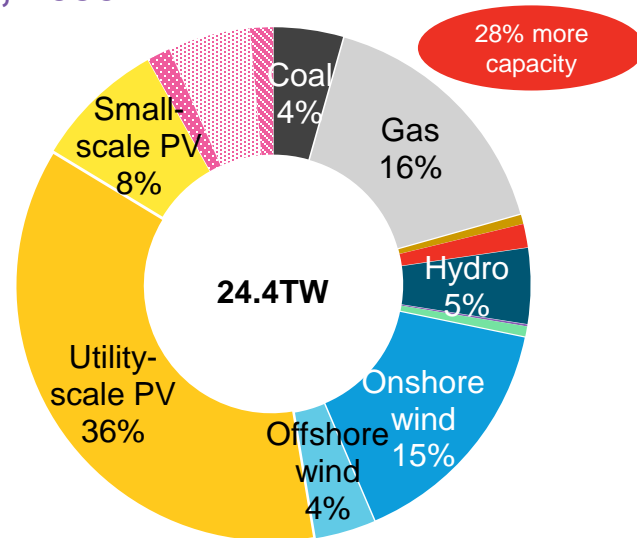
# Scenario: full electrification of residential heat and road transport

## Total electricity demand, electrification scenario



Source: BloombergNEF

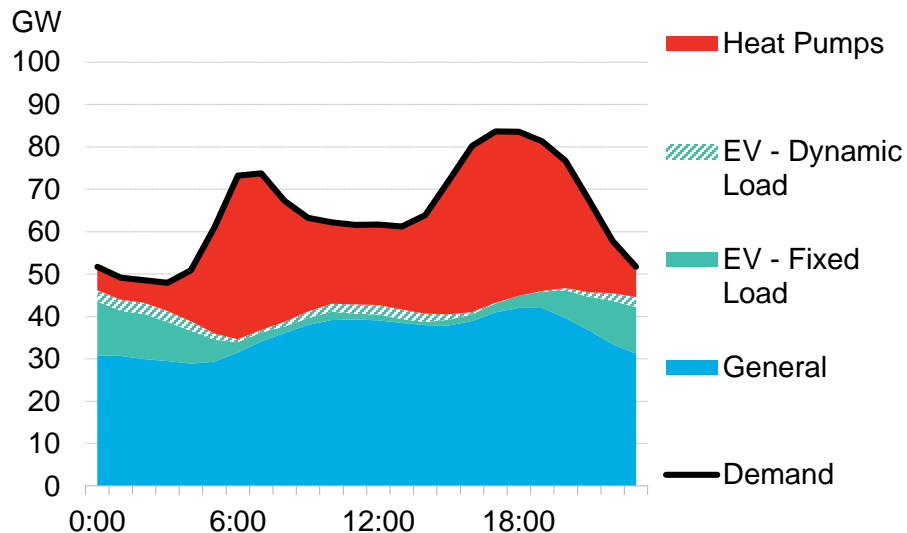
## Total installed capacity, electrification scenario, 2050



Source: BloombergNEF

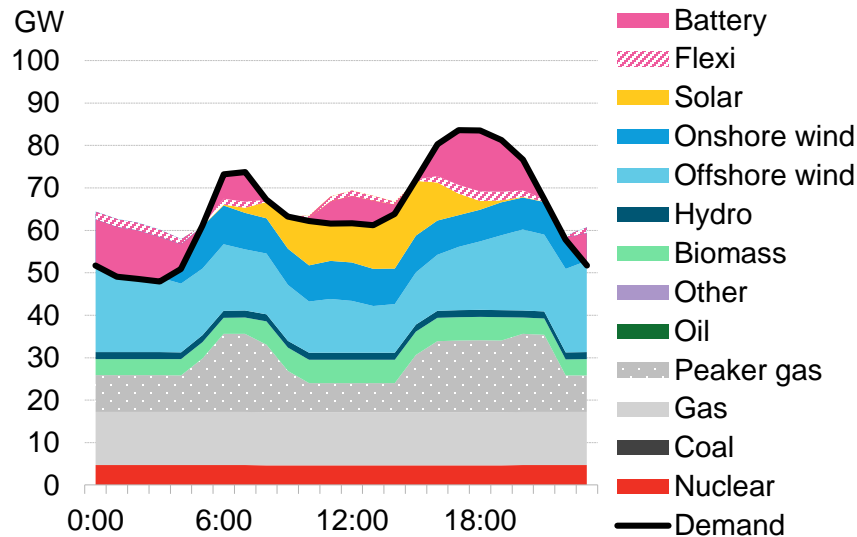
# Winter heat doubles peak demand in 2040

Power demand, cold winter's day, UK, 2040



Source: BloombergNEF

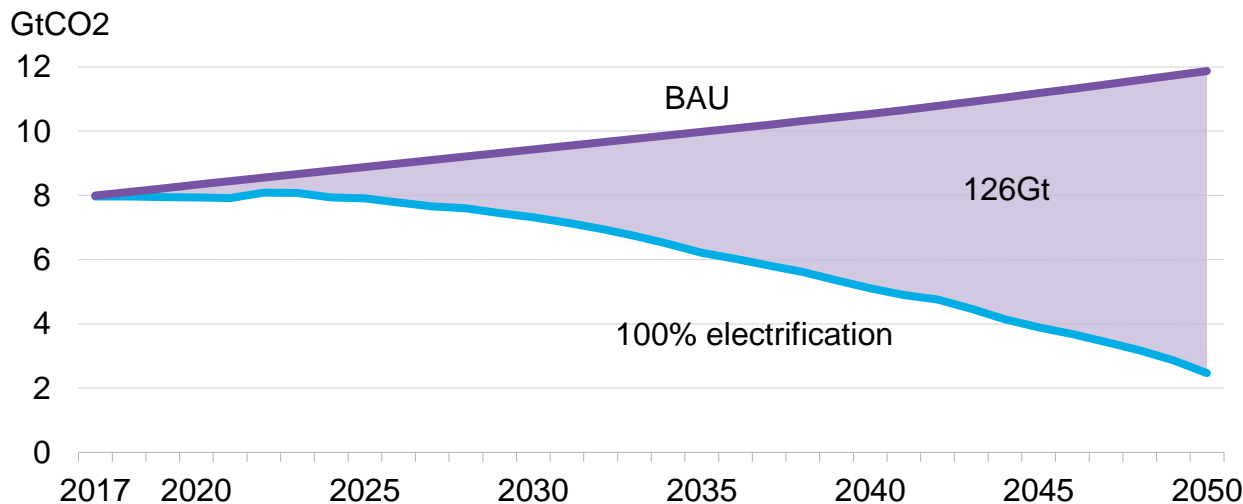
Hourly generation, cold winter's day, UK, 2040



Source: BloombergNEF

# Electrification lowers heat and transport emissions...

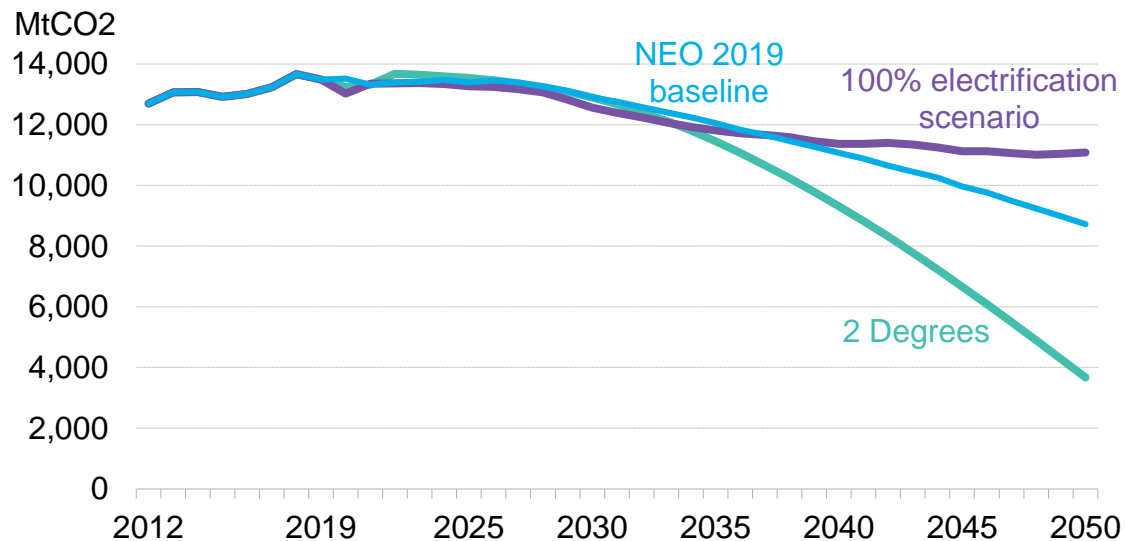
## Heat and transport sector emissions





# ...but shifts them into the power sector

## Power sector emissions



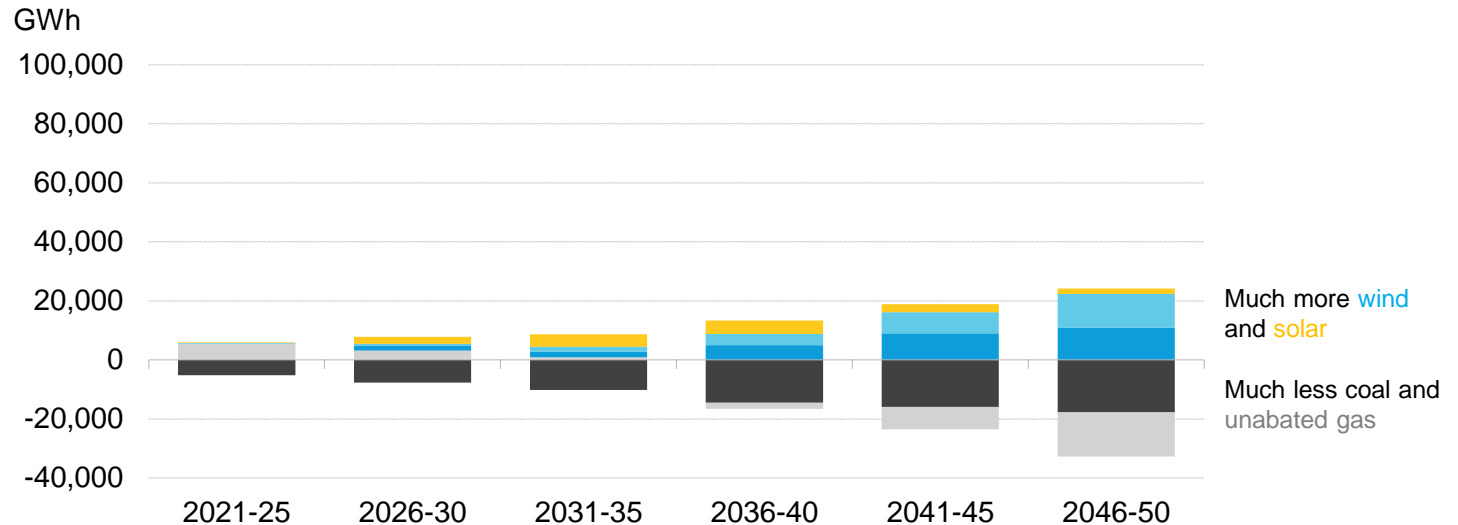
How to decarbonize this fully electrified system?

How to stay on track for 2° beyond 2030?

Source: BloombergNEF

# Scenario: a 2<sup>0</sup>-compatible power system that includes heating and transport

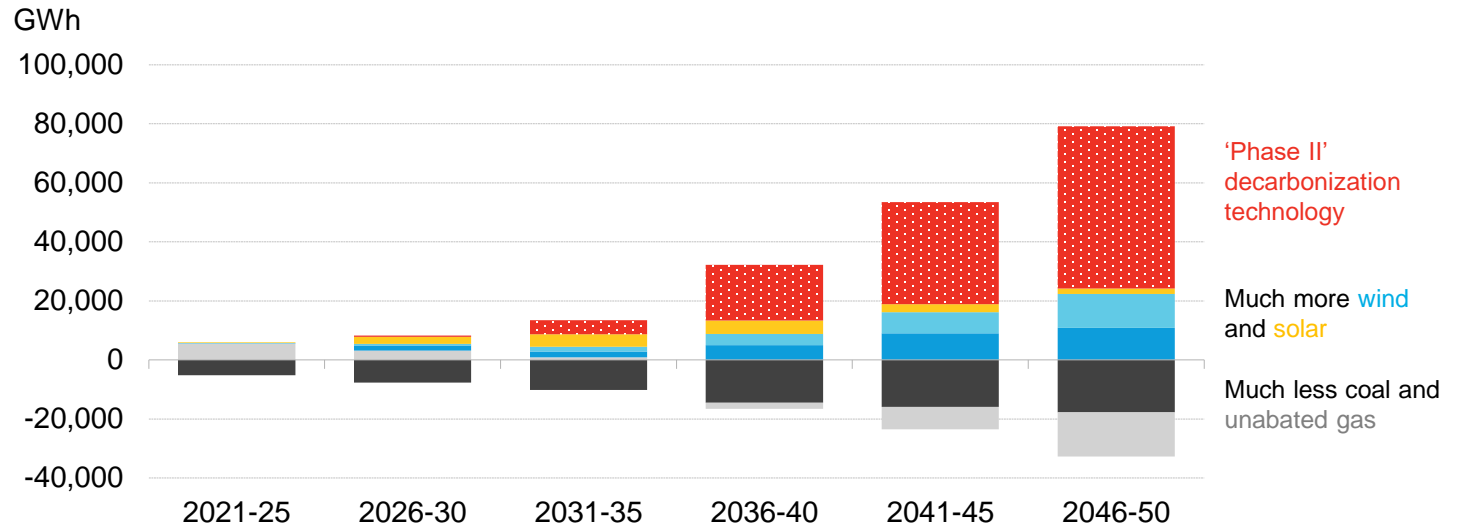
## Change in generation from NEO base case



Source: BloombergNEF

# Scenario: a 2<sup>0</sup>-compatible power system that includes heating and transport

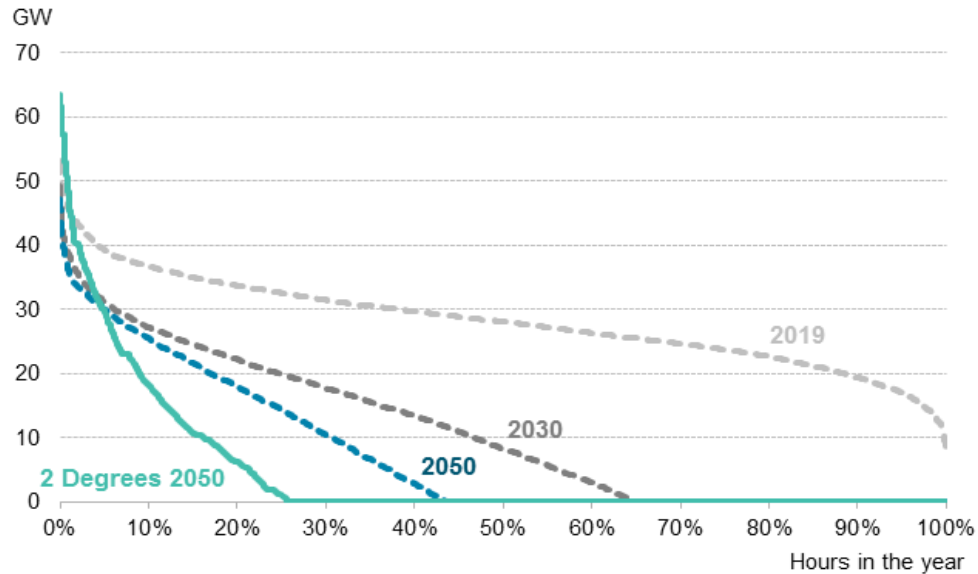
## Change in generation from NEO base case



Source: BloombergNEF

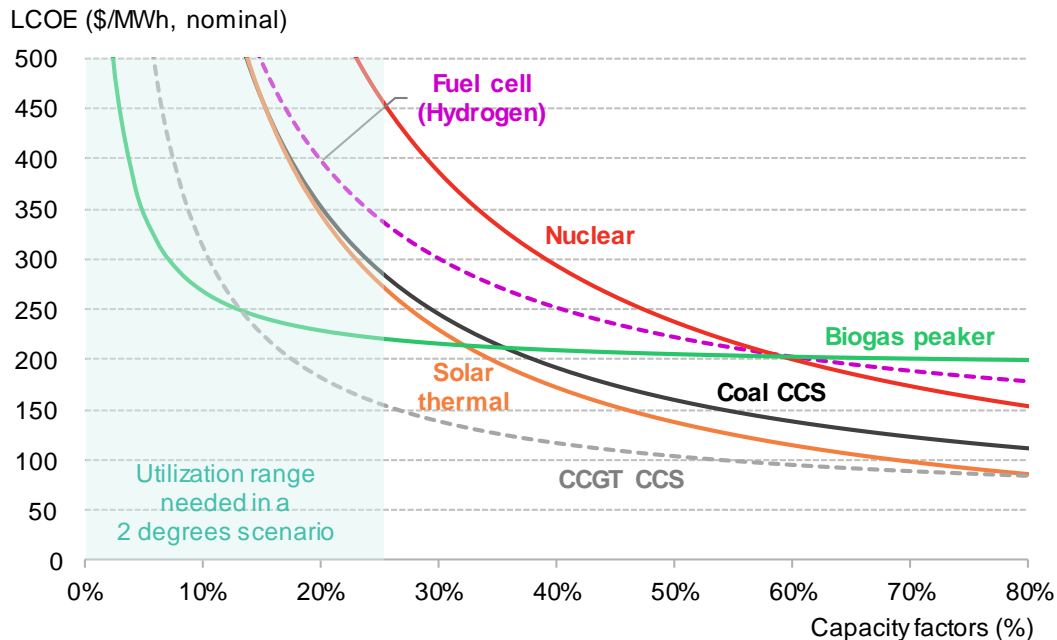
# 'Phase II' technology runs at low load factor

Load net of renewables, NEO 2019 and 2 degree scenario



Source: BloombergNEF

# LCOEs of example 'Phase II' decarbonization technologies



Source: BloombergNEF

Solutions for 'Phase II' will need to be:

- Low/zero-carbon
- Rampable / flexible
- Economic at low load factors
- Able to run reliably for days during challenging periods

# Energy transition challenges, 2020+

## Deployment

Driving – and accelerating – deployment of renewables and flexible resources

## Development

Developing the next generation of flexible technologies for a 2<sup>o</sup> trajectory beyond 2030

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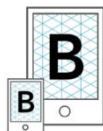
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# Thank you!

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