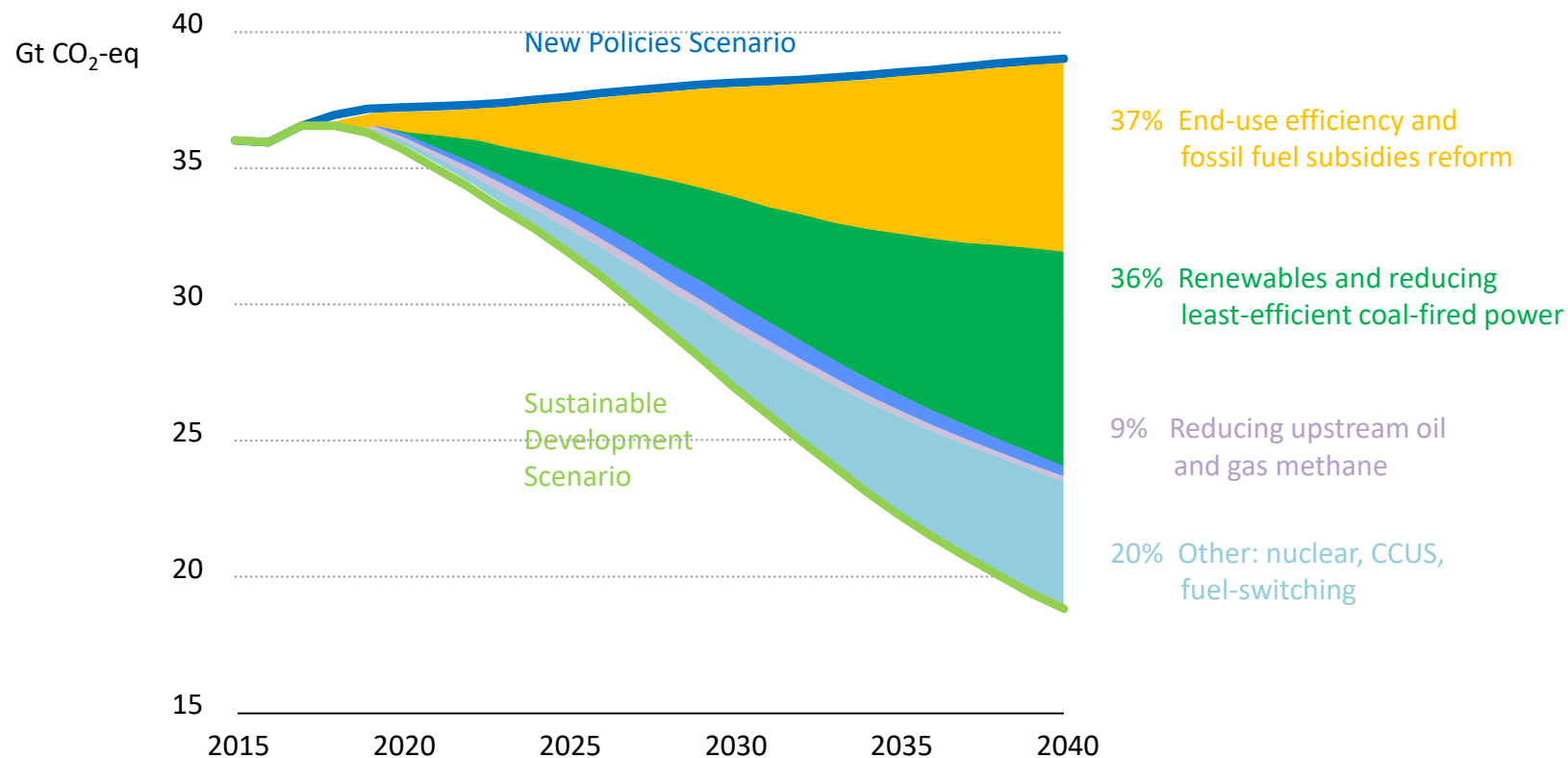




# **Investment, technology and policy for a sustainable energy system**

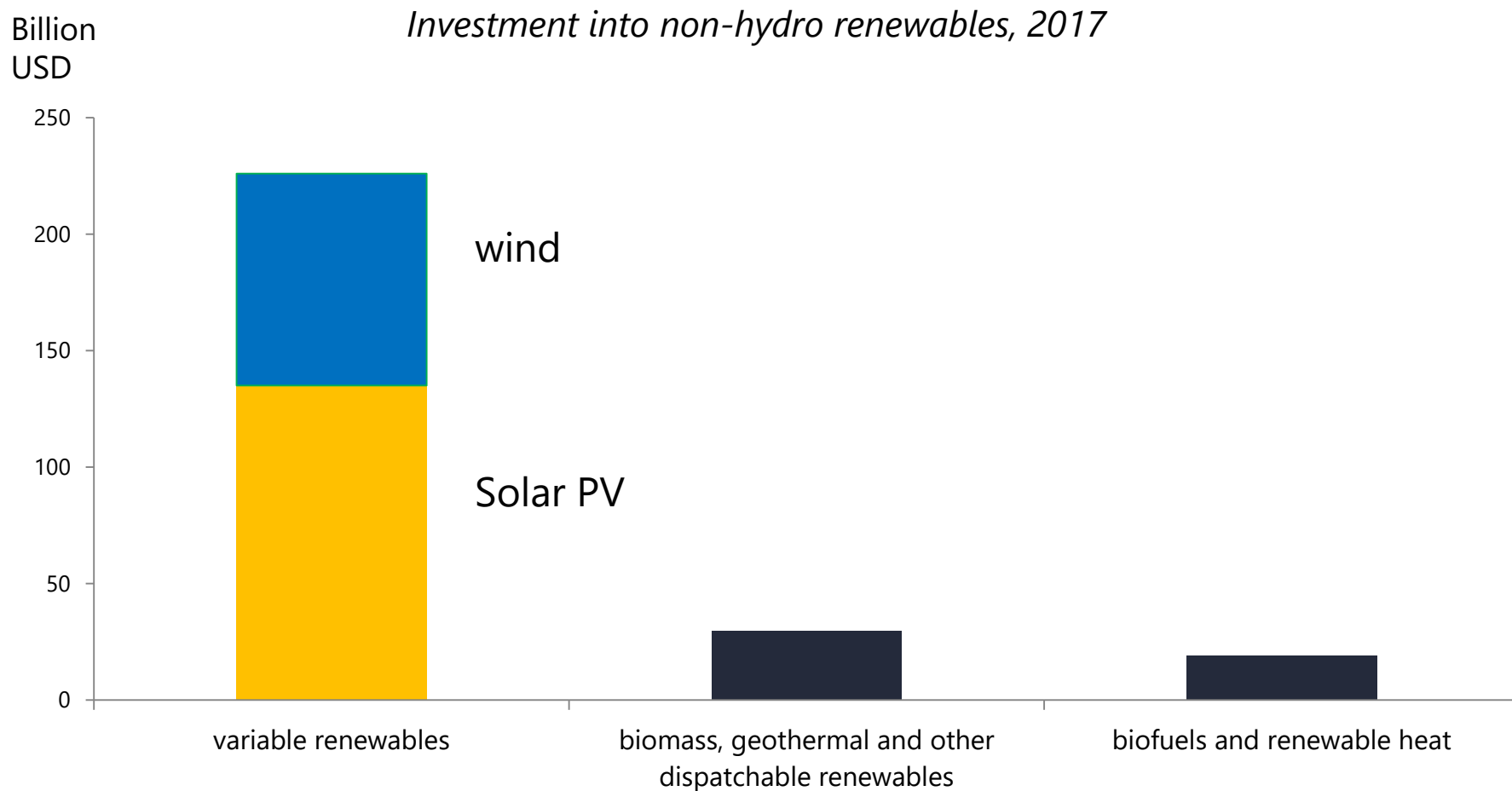
Laszlo Varro

# From New Policies to Sustainable Development



Improved energy efficiency and accelerated renewable deployment are the most important steps in the transition.

# A clean energy revolution or a wind and solar revolution?



The clean energy portfolio is increasingly dominated by wind and solar PV requiring a deep system transformation.

# Today's mature renewables benefited from decades of public R&D



The soviet space program as an early PV competitor

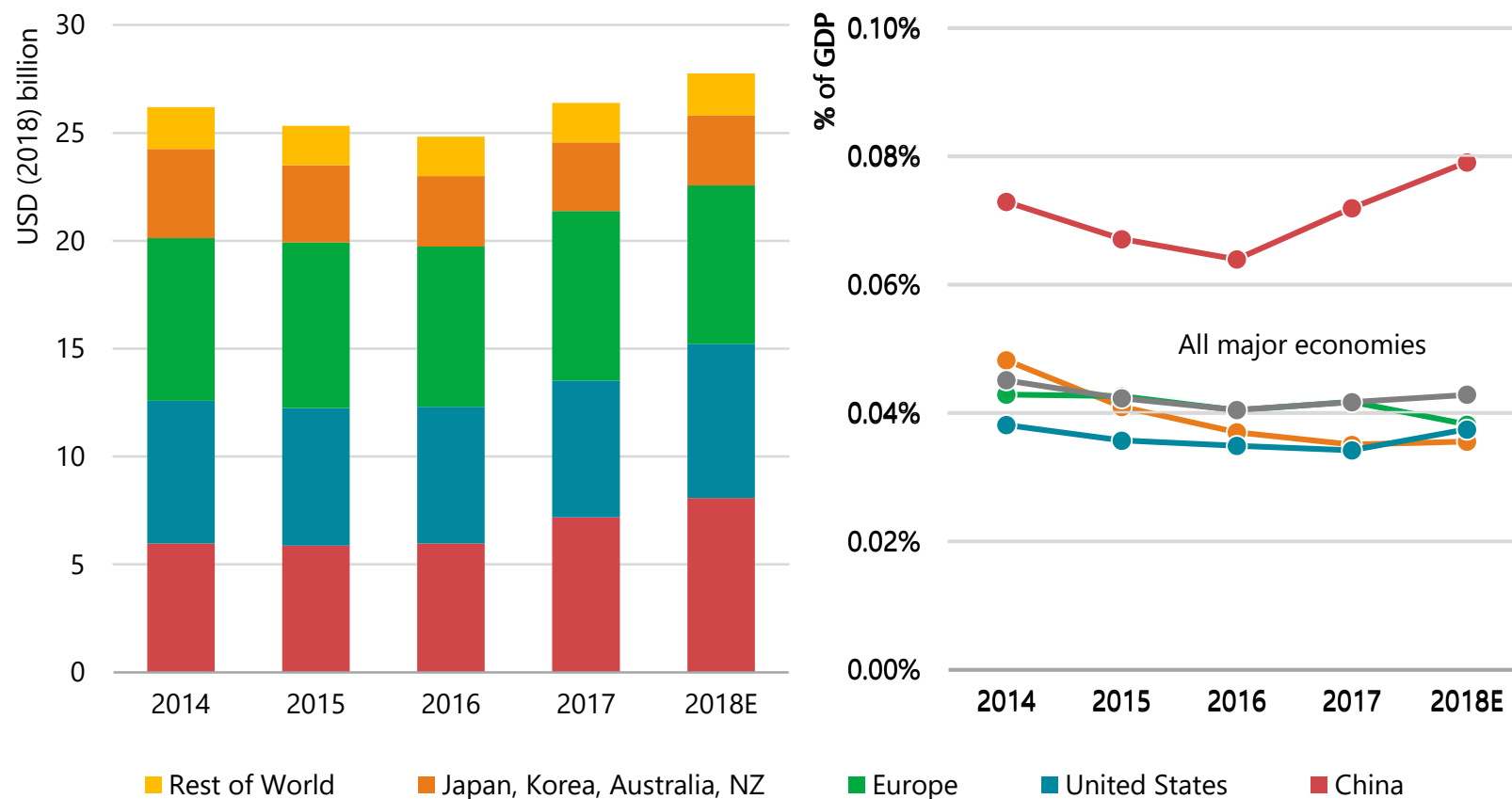


A Boeing experimental wind turbine funded by the Reagan Administration

**Public funding for innovation continues to play a key role to accelerate clean energy progress**

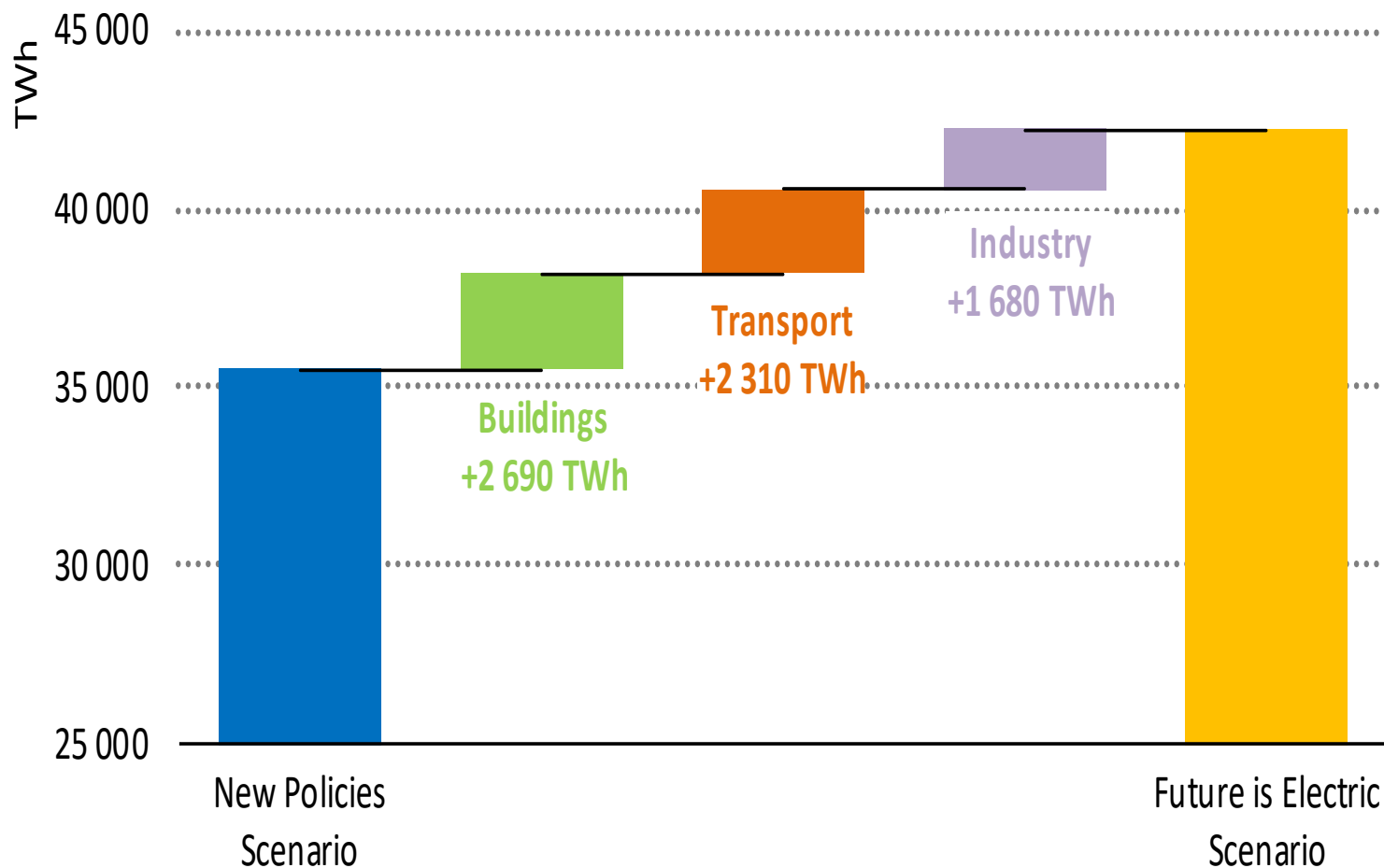
# Public energy RD&D spending is not expanding enough

Spending on energy RD&D by national governments, and as share of GDP



While public energy RD&D spending rose modestly in 2018, led by the United States and China, most countries are not spending more of their economic output on energy research.

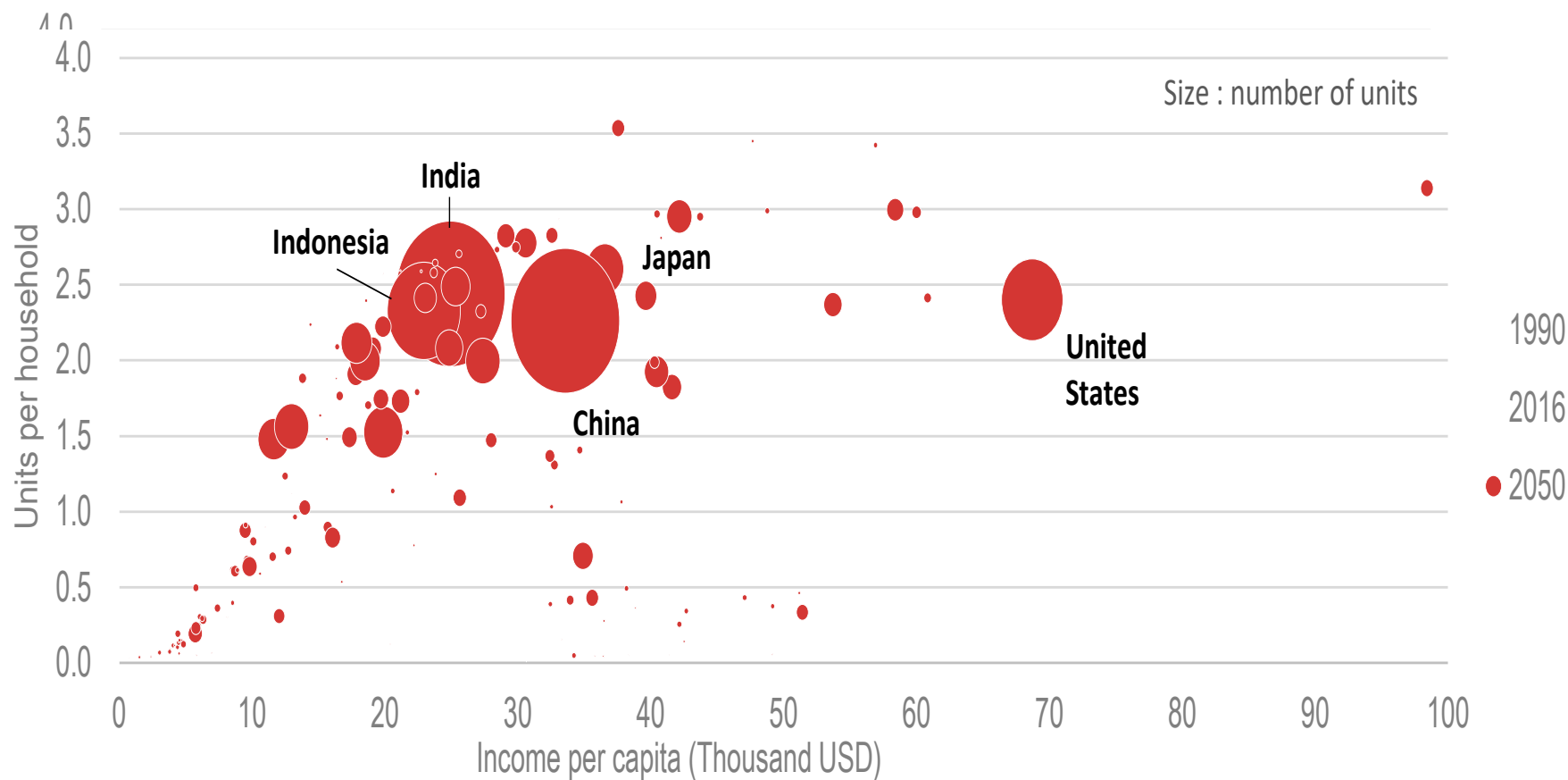
# Additional electricity demand in the Future is Electric Scenario



Building electrification generates more demand but transport represent a disruptive change in business models and system operation

# An emerging middle class in hot climates

*Evolution of global air conditioner ownership*



**A strong effort on air conditioner efficiency will be essential to mitigate demand impacts**

# Bringing electricity to the transport sector

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*Electrification of cars*



*Hydrogen and electro fuels for heavy vehicles*

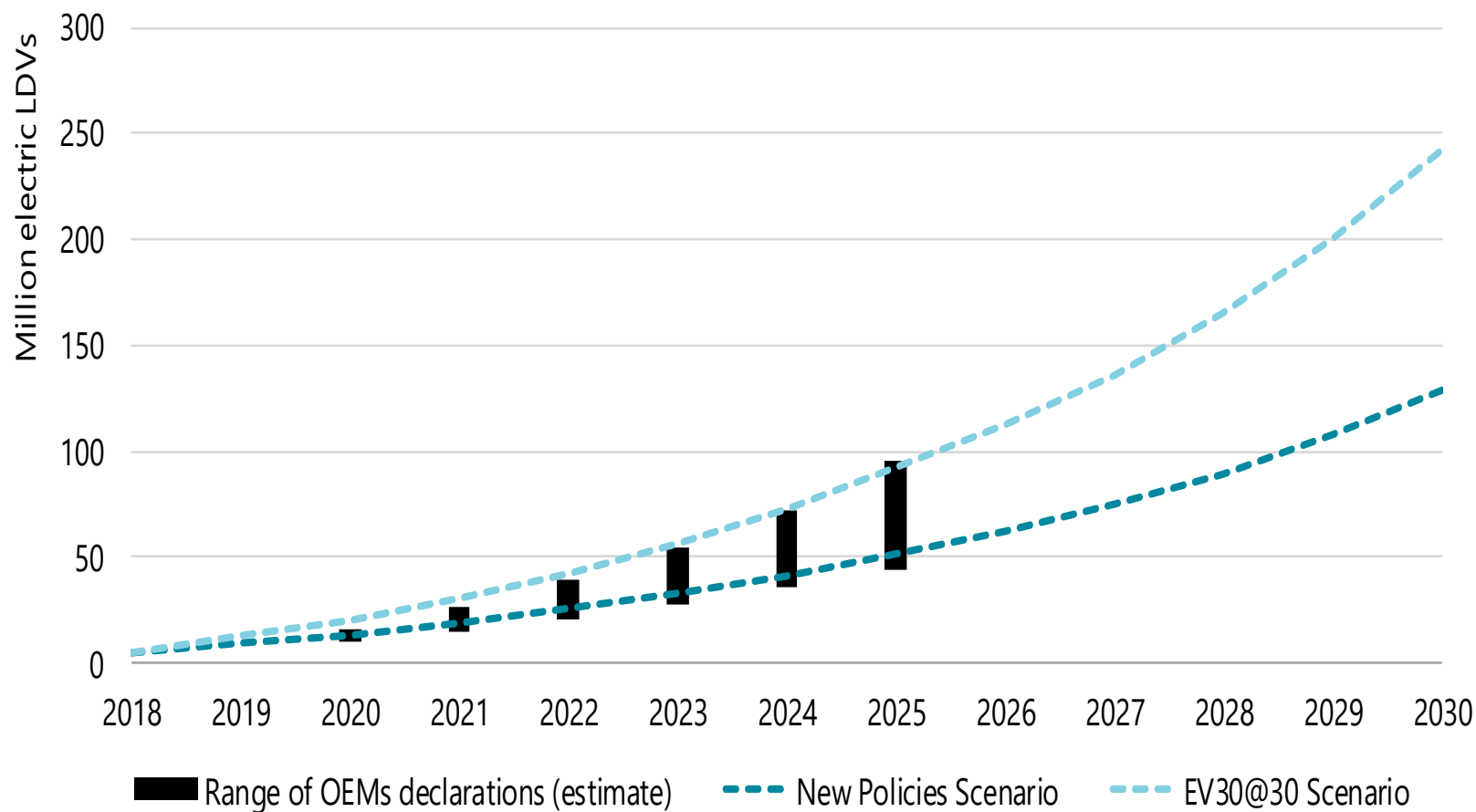


*Modal shift to electrified railways*

**China is leading transport electrification, but the current scale has only a minor impact on global oil demand**



# OEM targets for electric cars



**The OEM commitments will need to be followed through to put transport on a sustainable path.**

# EVs and the power system: part of the problem or part of the solution?

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EVs queuing for supercharging in peak periods

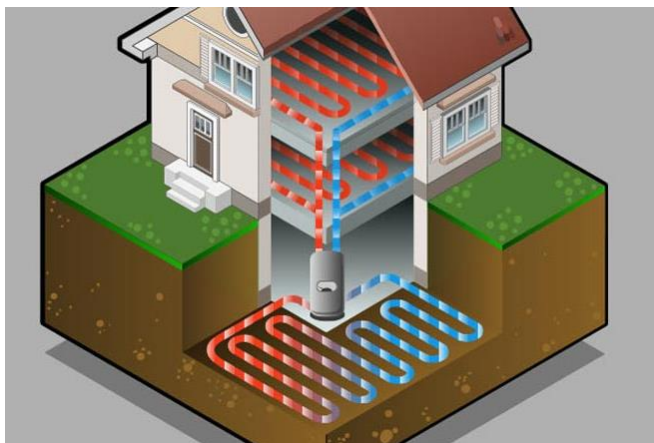


EVs used as flexible grid management tools



Coordinated smart charging can save up to 300 GW generation capacity, bypass difficult network upgrades and ensure that the cars are fed low carbon electricity

# Renewables in building heating requires strong policy



Convert to electric heating and use renewable electricity directly

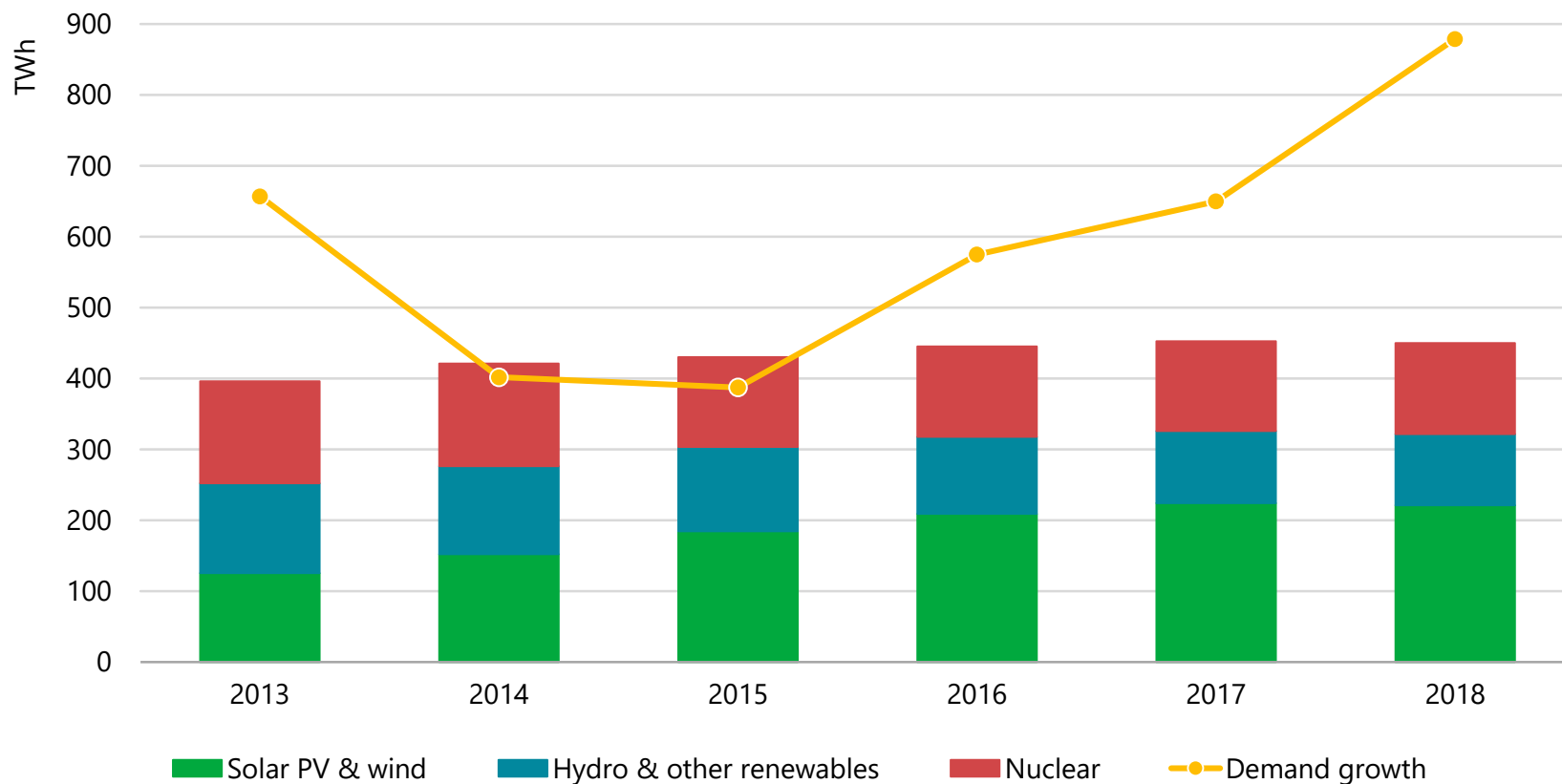


Keep the pipeline network for biogas and for hydrogen/PtG from renewable electricity

**The two pathways have different advantages and barriers and policy choices can depend on regional characteristics**

# Low carbon generation deployment stagnates at 1.5% of global power demand, lower than average demand growth

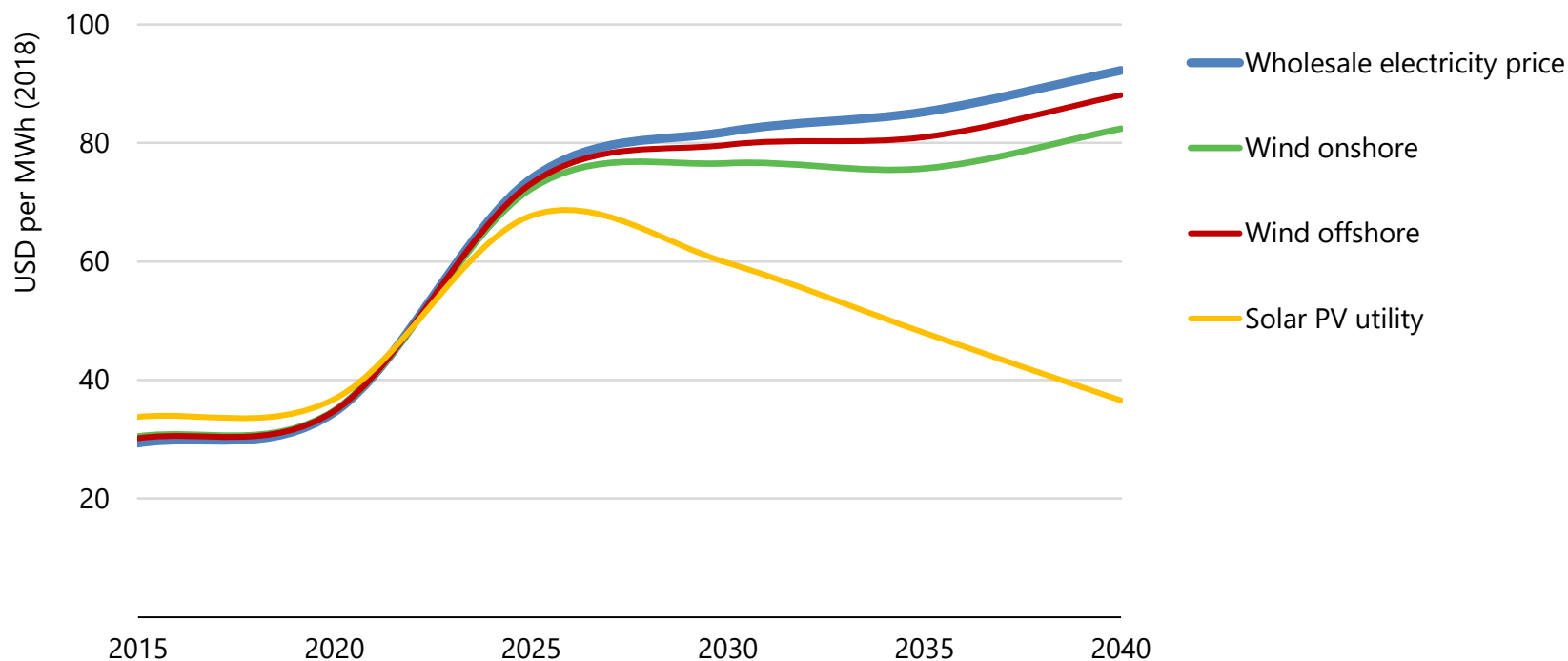
*Expected generation from low-carbon power investments compared to electricity demand growth*



**Despite the success of wind and solar the slowdown of nuclear and hydro creates a powerful headwind for low carbon deployment**

# Investment policy will need to overcome value erosion

*Electricity prices and average wholesale revenues in the EU low nuclear SDS case*



Increasing flexibility, grid expansion and storage investment will be needed to overcome correlation of especially solar production. Wind benefits from winter peak demand in Europe



# Decentralized renewables?



**The large majority of wind and solar deployment is utility scale and grid connected**

# The electricity network: a key area of technological and regulatory innovation



**Grid investment expands by 50% in SDS with digitalization and better market design facilitating renewable integration**

# Efficient markets unlock the value of flexibility



*Residential batteries aggregated to provide frequency response, Germany*



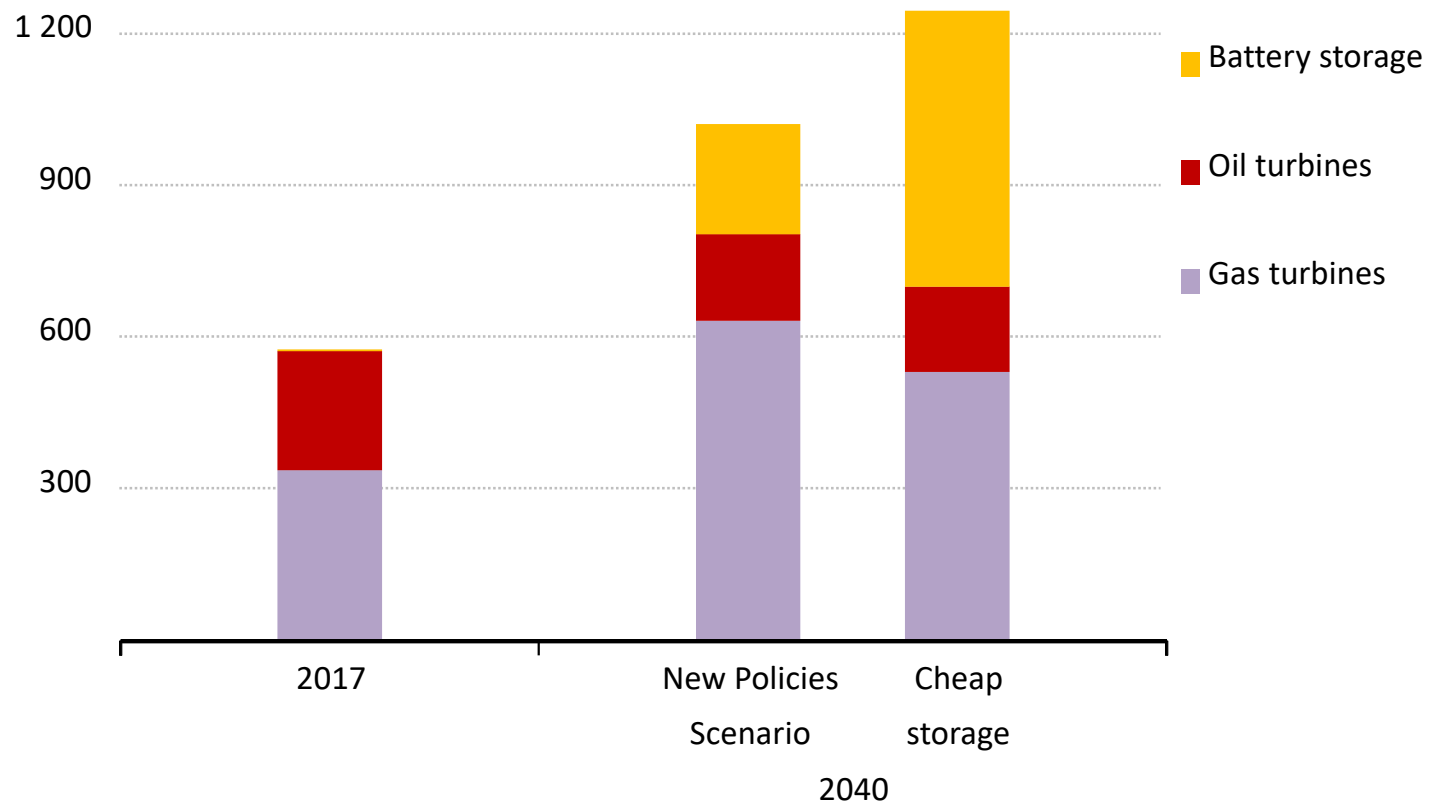
*Distributed storage solutions substituting for transmission upgrades, New York*

Regulation and lack of price signals are more important barriers for smart energy systems than IT



# Even ultra cheap batteries don't eliminate the need for dispatchable capacity

## *Dispatchable capacity in 2040*



**With an average storage time of 4 hours the key application of batteries is frequency control and network bottleneck management**

# 100% renewables or 100% low carbon energy?

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## Nuclear

- Very efficient use of land and transmission capacity
- Baseload capacity especially for winter peak demand systems

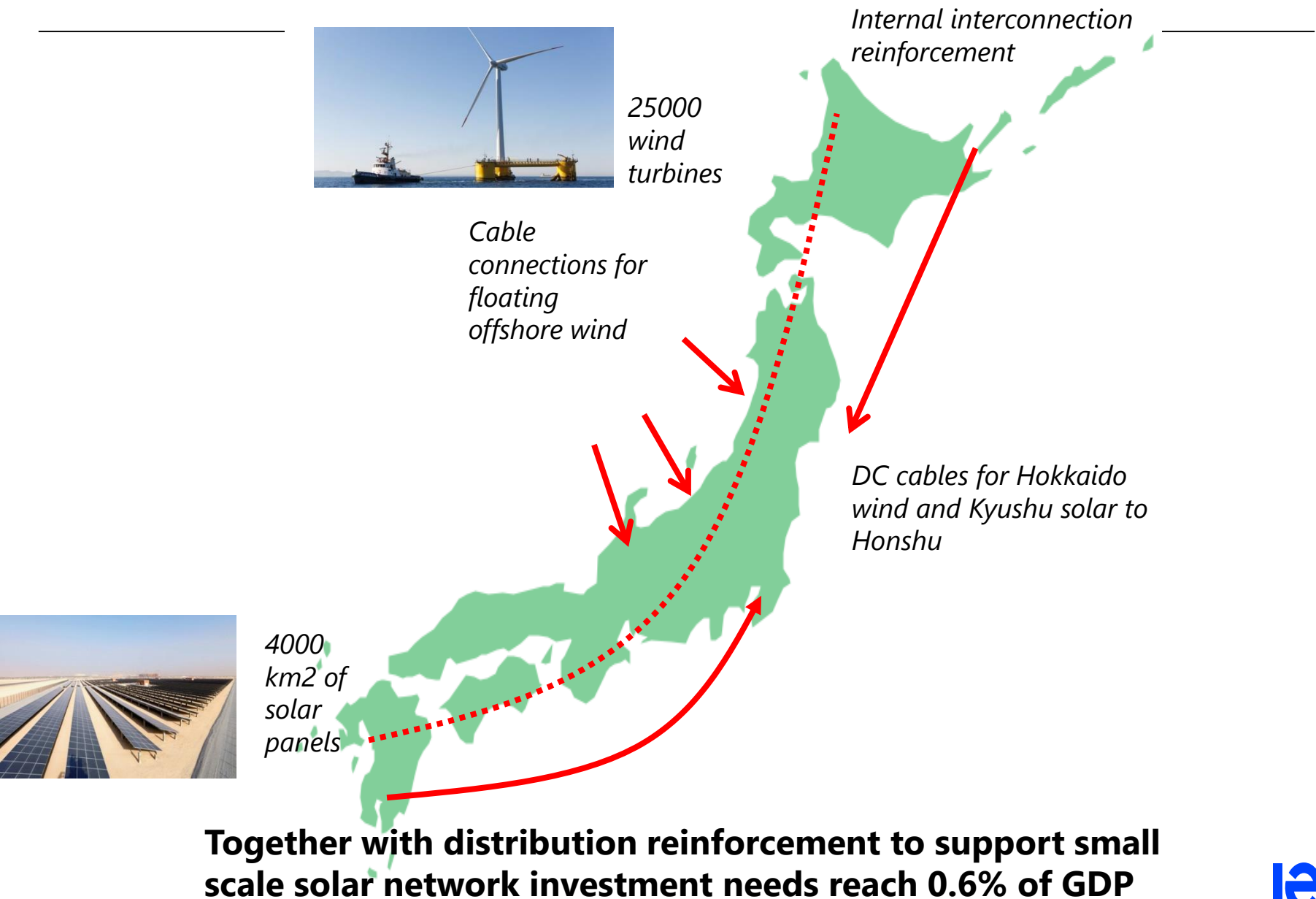


## CCUS

- Turning conventional dispatchable plants low carbon
- Energy intensive heavy industry
- Negative emissions

**In countries that chose to use these technologies a diversified low carbon portfolio including nuclear and CCUS offers significant infrastructure and energy security benefits**

# What would it take to reach climate targets in Japan without nuclear?



# Four key opportunities for scaling up hydrogen to 2030



