

# Renewable Energy

What's next and why we need it

Akshiv Bansal

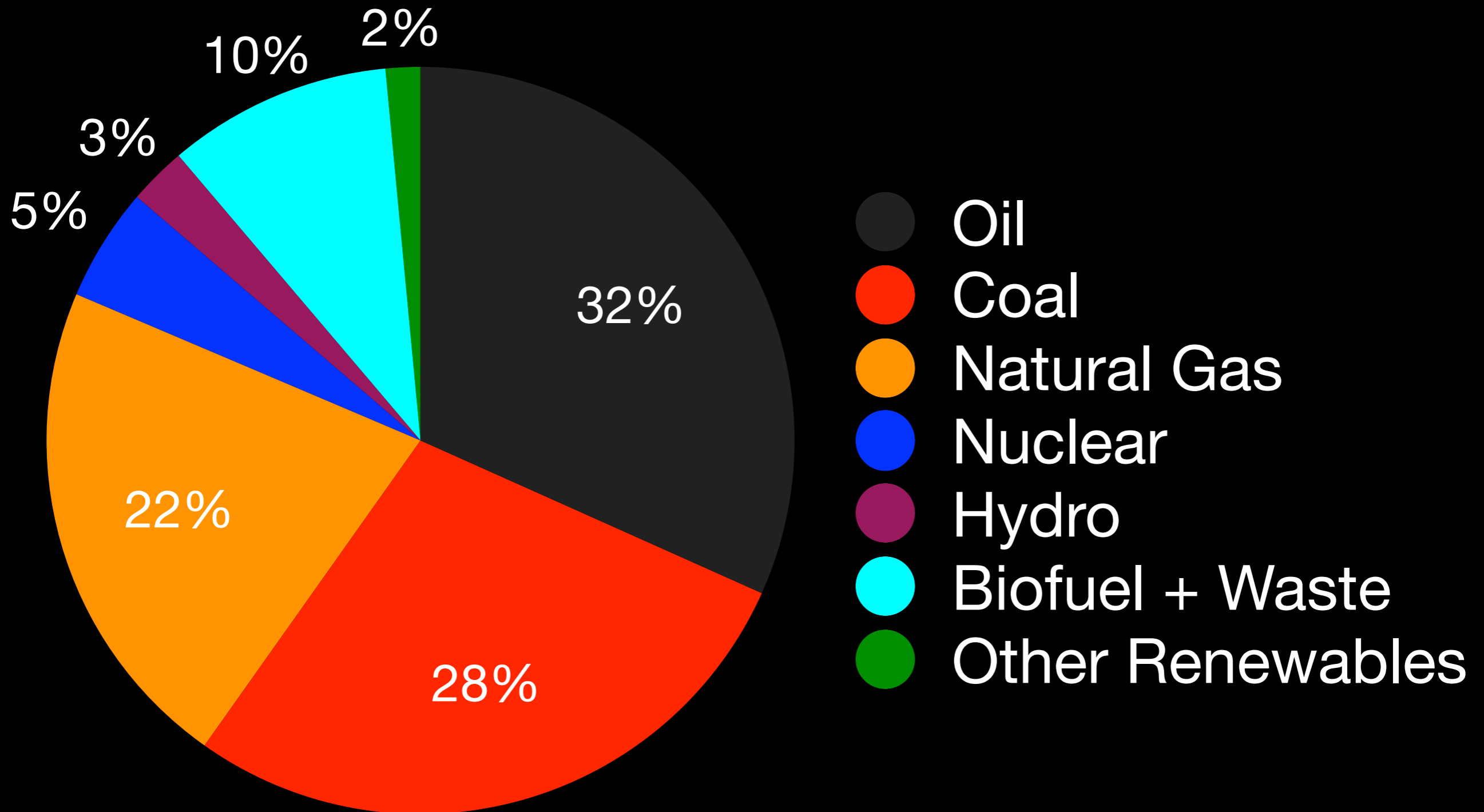
**1) Generation**



**2) Storage and Distribution**

# **1) The Generation Problem**

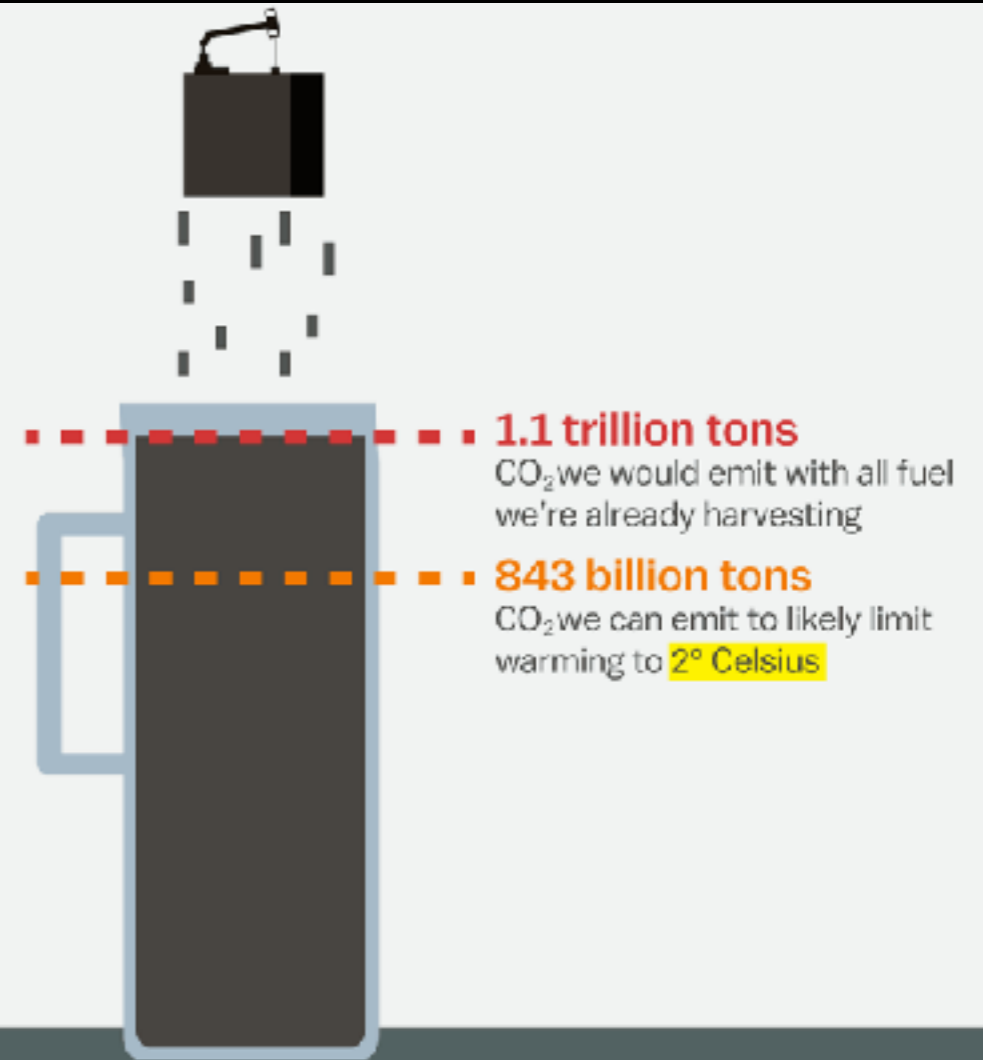
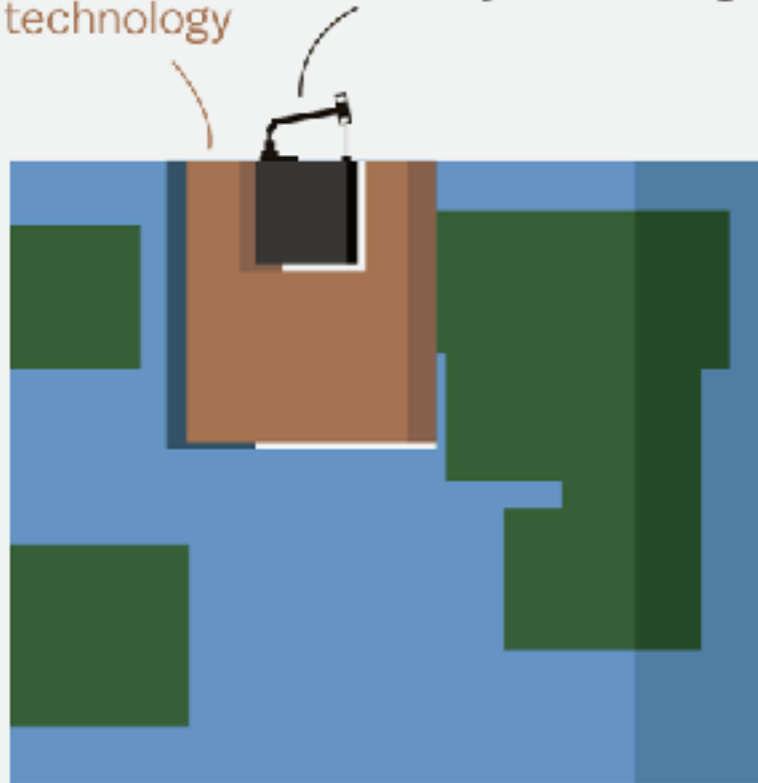
# State of the World



# What's the problem?

All the fossil fuel we've identified and can recover with current technology

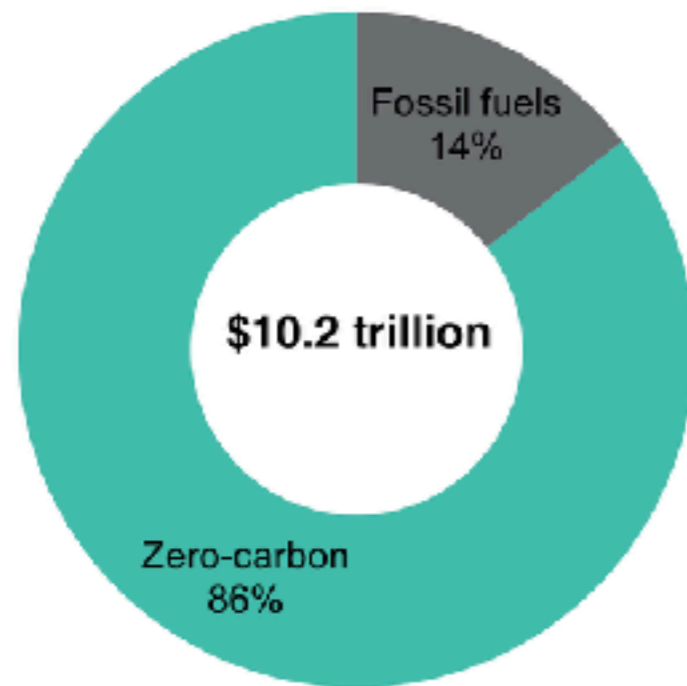
The portion we are currently harvesting



# Future?

## Solar and wind attract 73% of new investment in power generating capacity

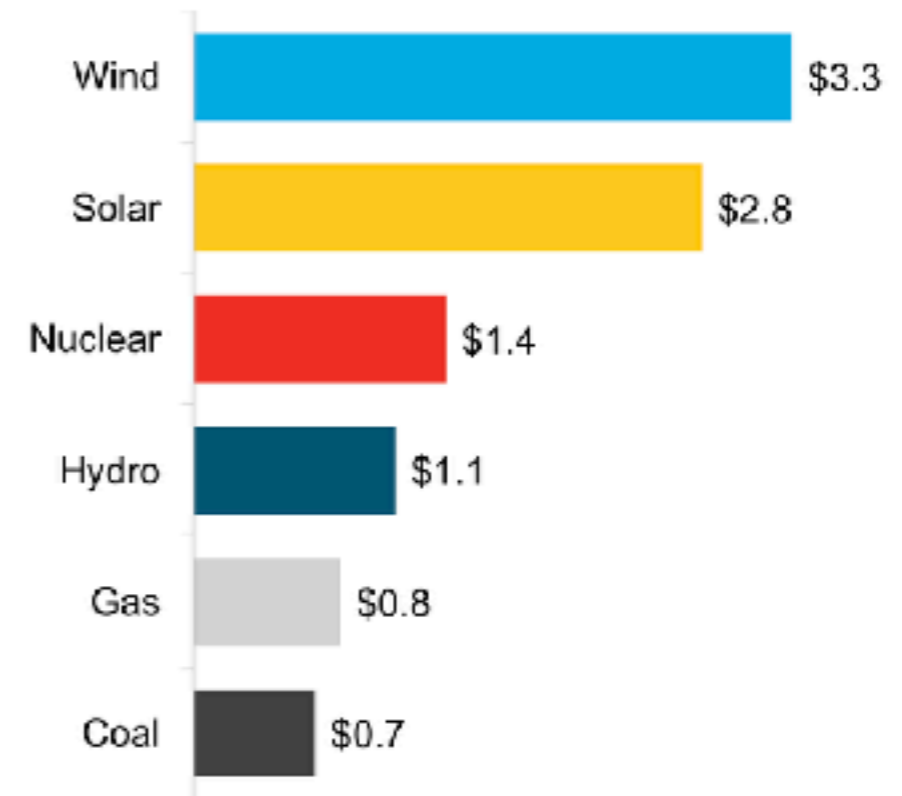
Investment, by technology, 2017-2040



Source: Bloomberg New Energy Finance

Investment, by technology, 2017-2040

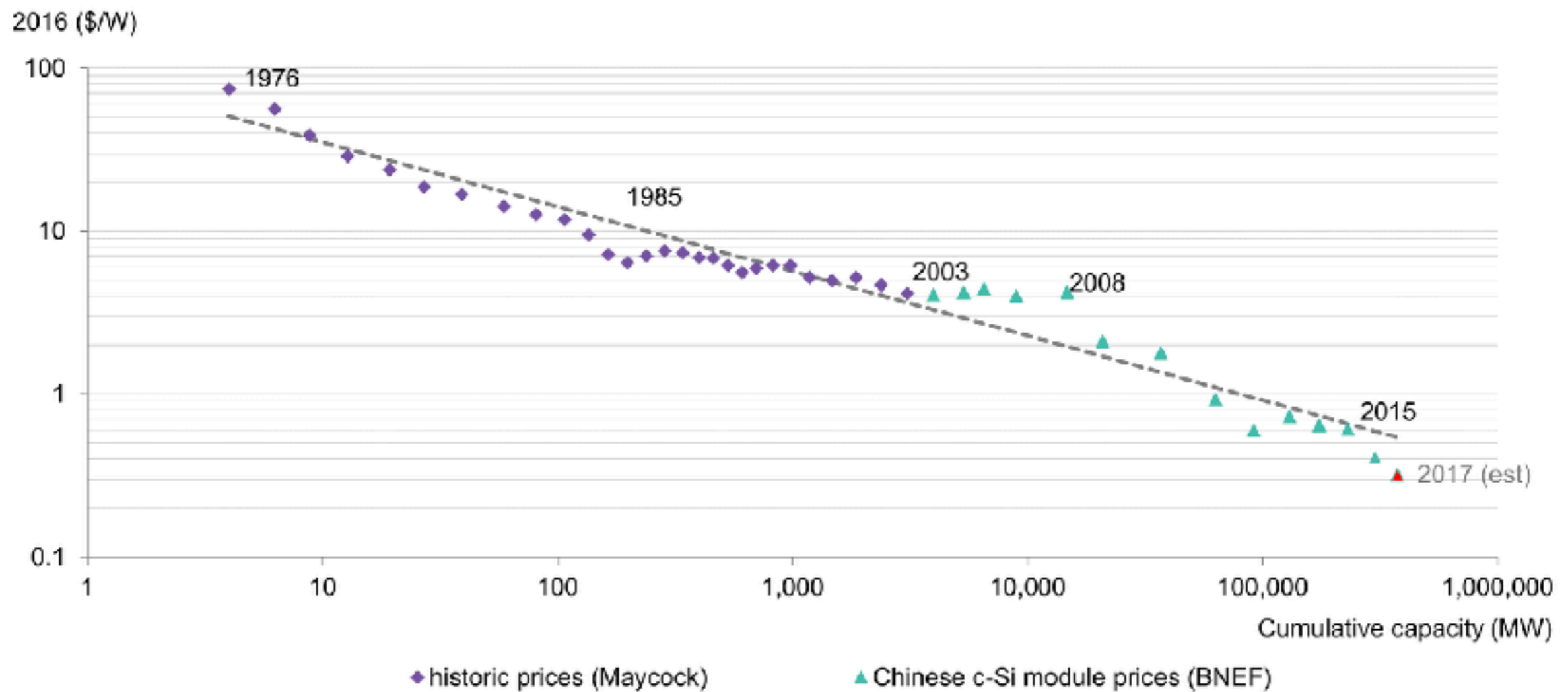
(\$ trillion - 2016 real)



Source: Bloomberg New Energy Finance

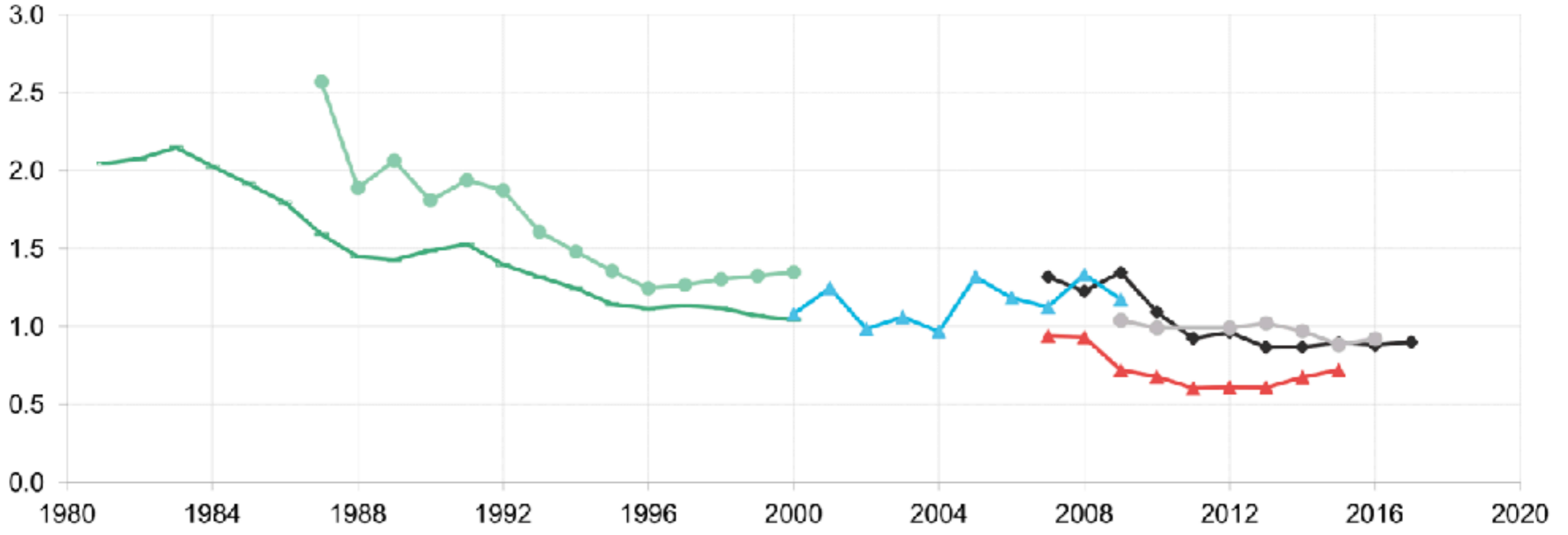
# Why bet on renewables?

## Solar technology is getting cheaper, faster



Source: Maycock, Bloomberg New Energy Finance

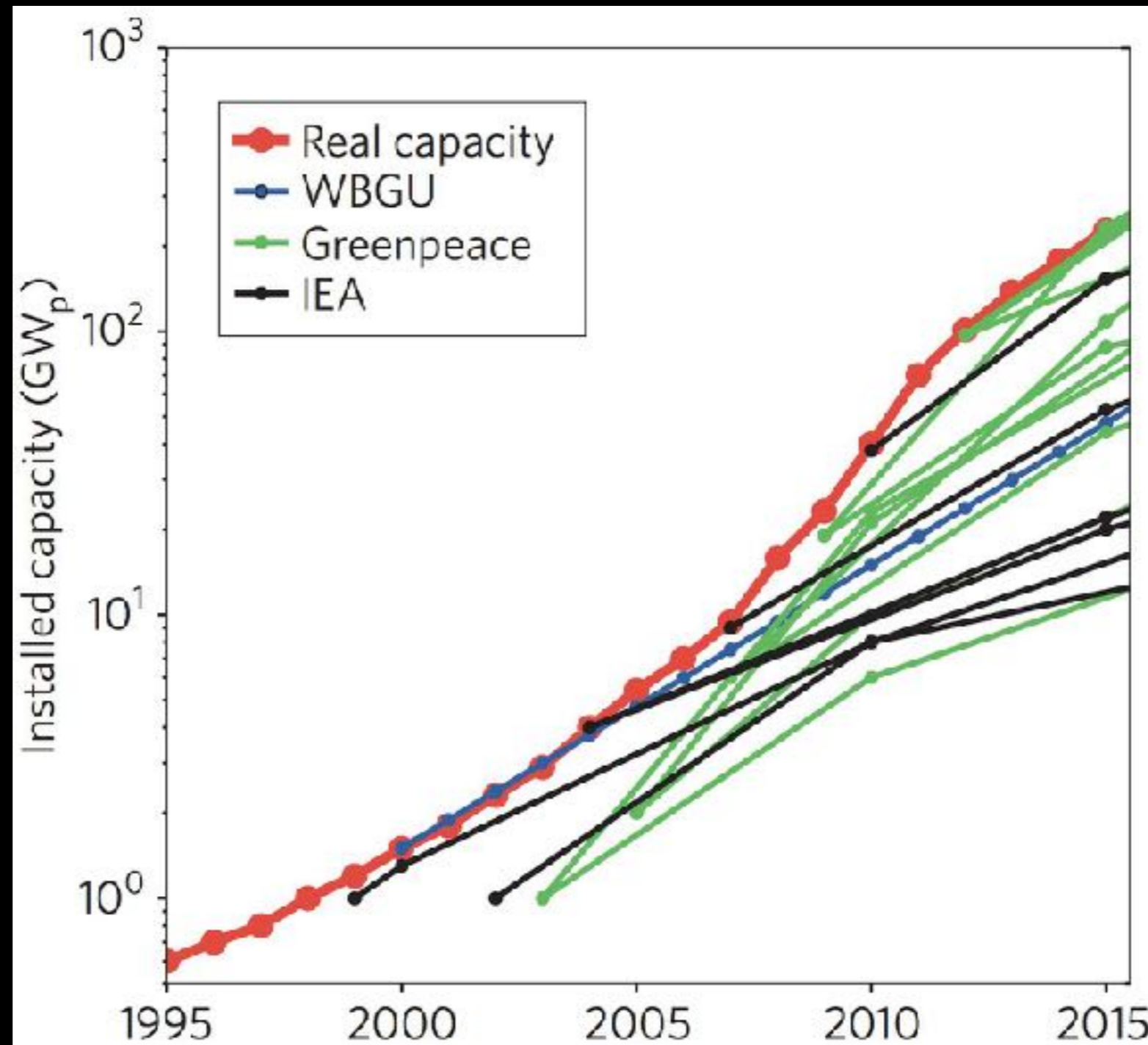
million Euro/MW



● Global (ex. China)    ● Germany (ExTool)    ● Denmark (Extool)    ▲ US (LBL)    ▲ China (BNEF)    ● Vestas global

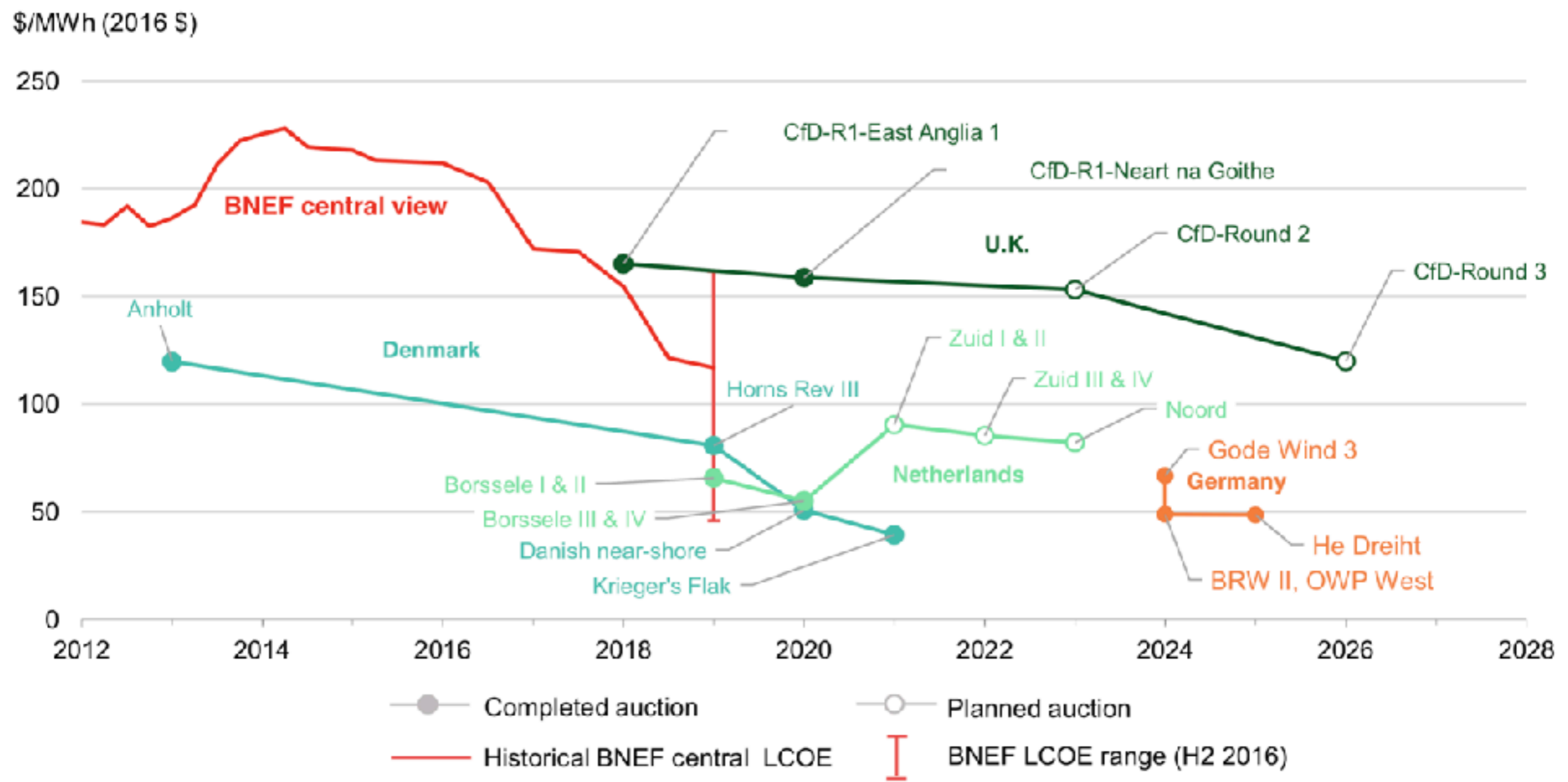


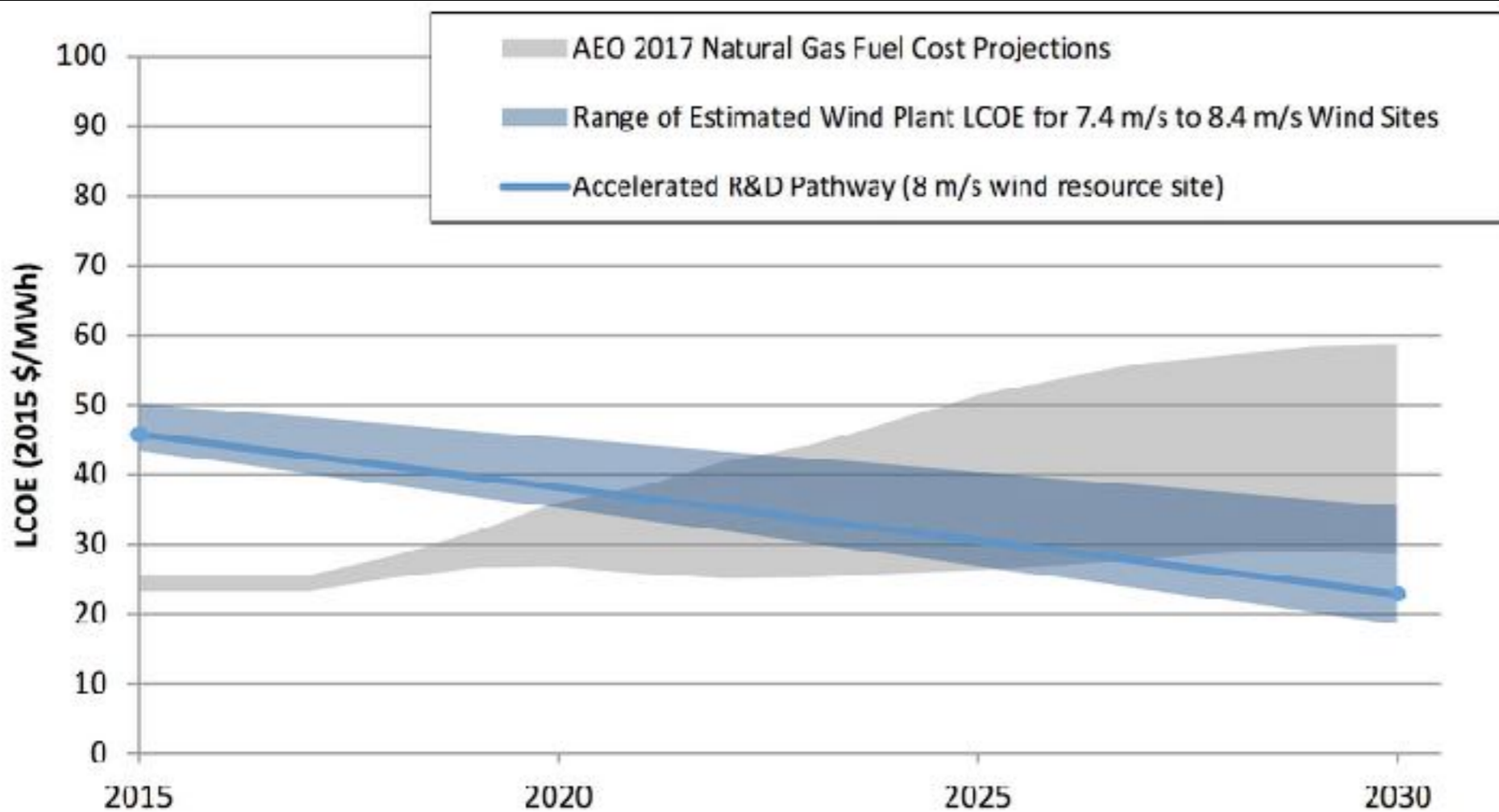
# We have consistently been wrong



The underestimated potential of solar energy to mitigate climate change, Nature Energy 2017

# Installed Wind Capacity





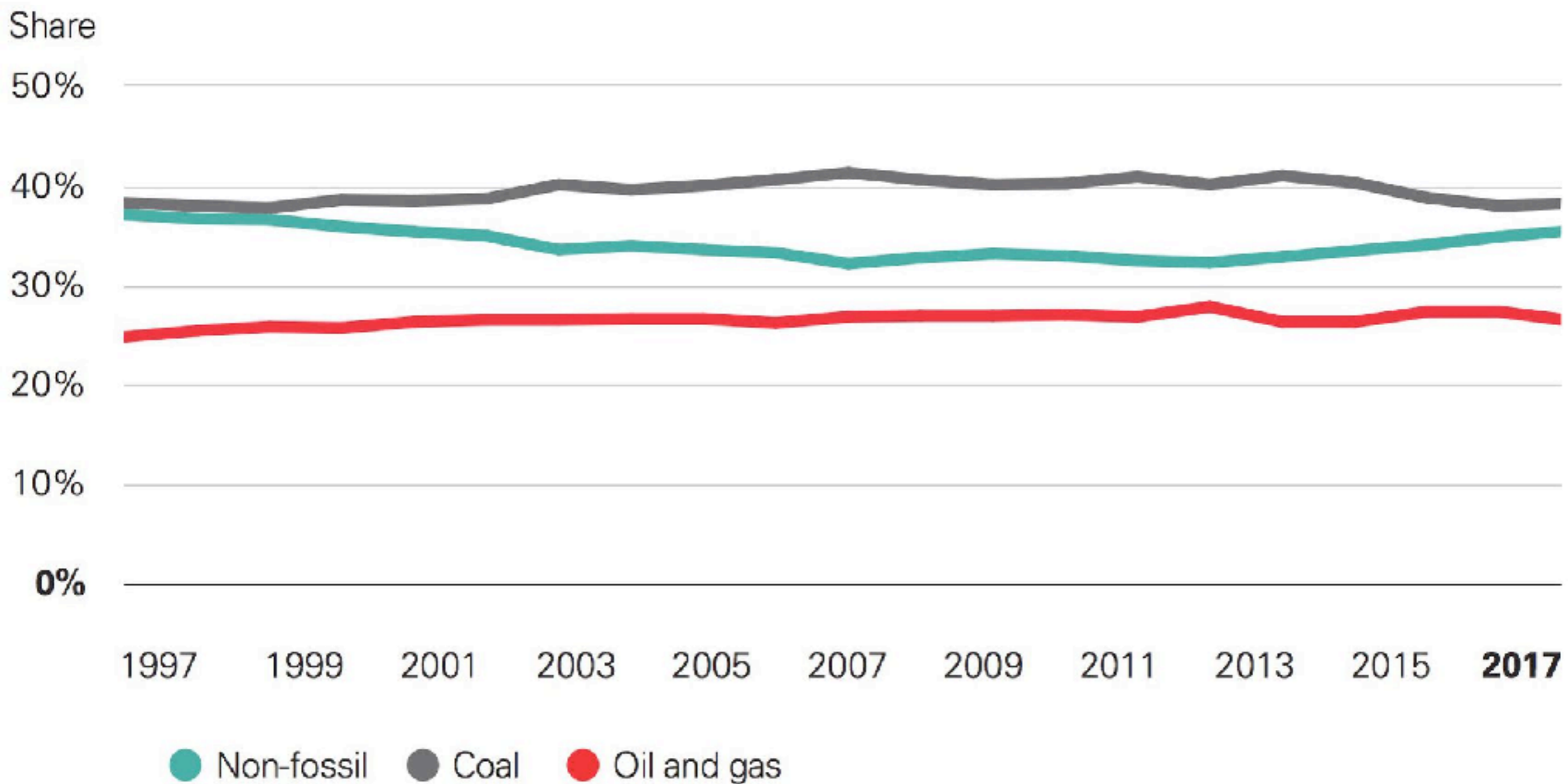
**Figure 8. Projected costs for the SMART wind power plant at a range of different wind resource sites using the accelerated R&D pathway relative to future natural gas prices**

Learning

Policy Support

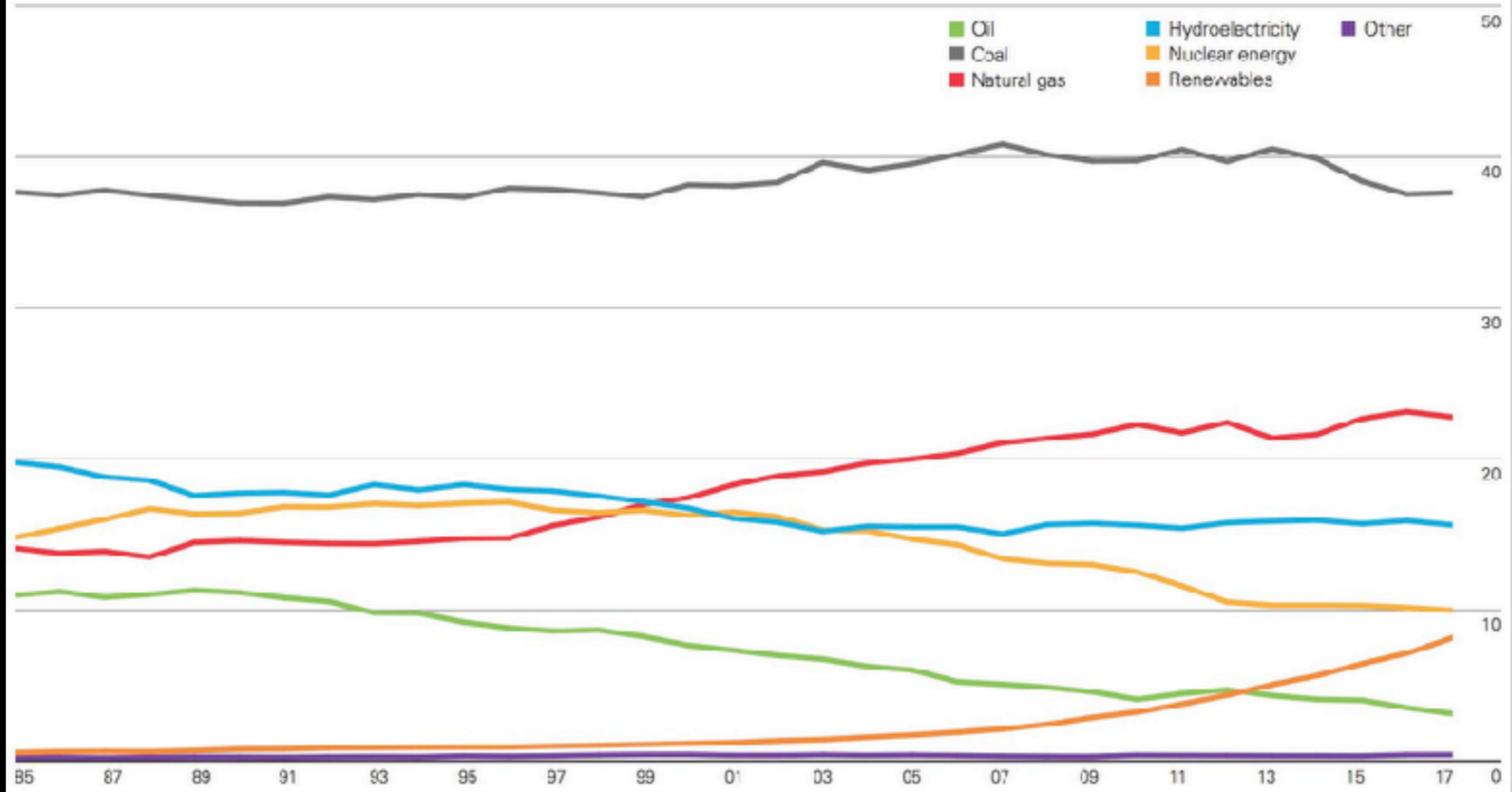
Bullish on  
Other Renewable

## Fuel shares in power generation



# Share of global electricity generation by fuel

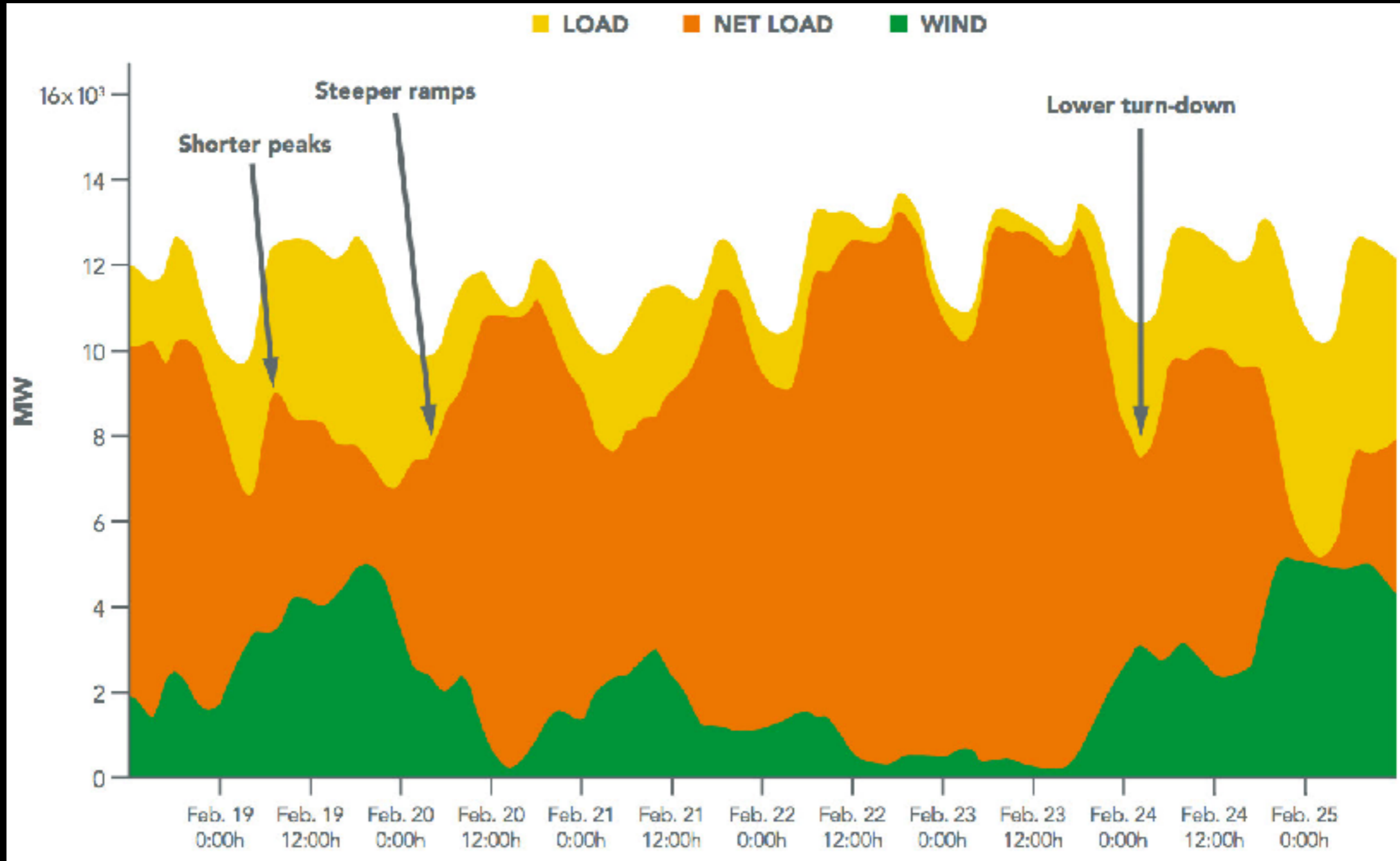
Percentage





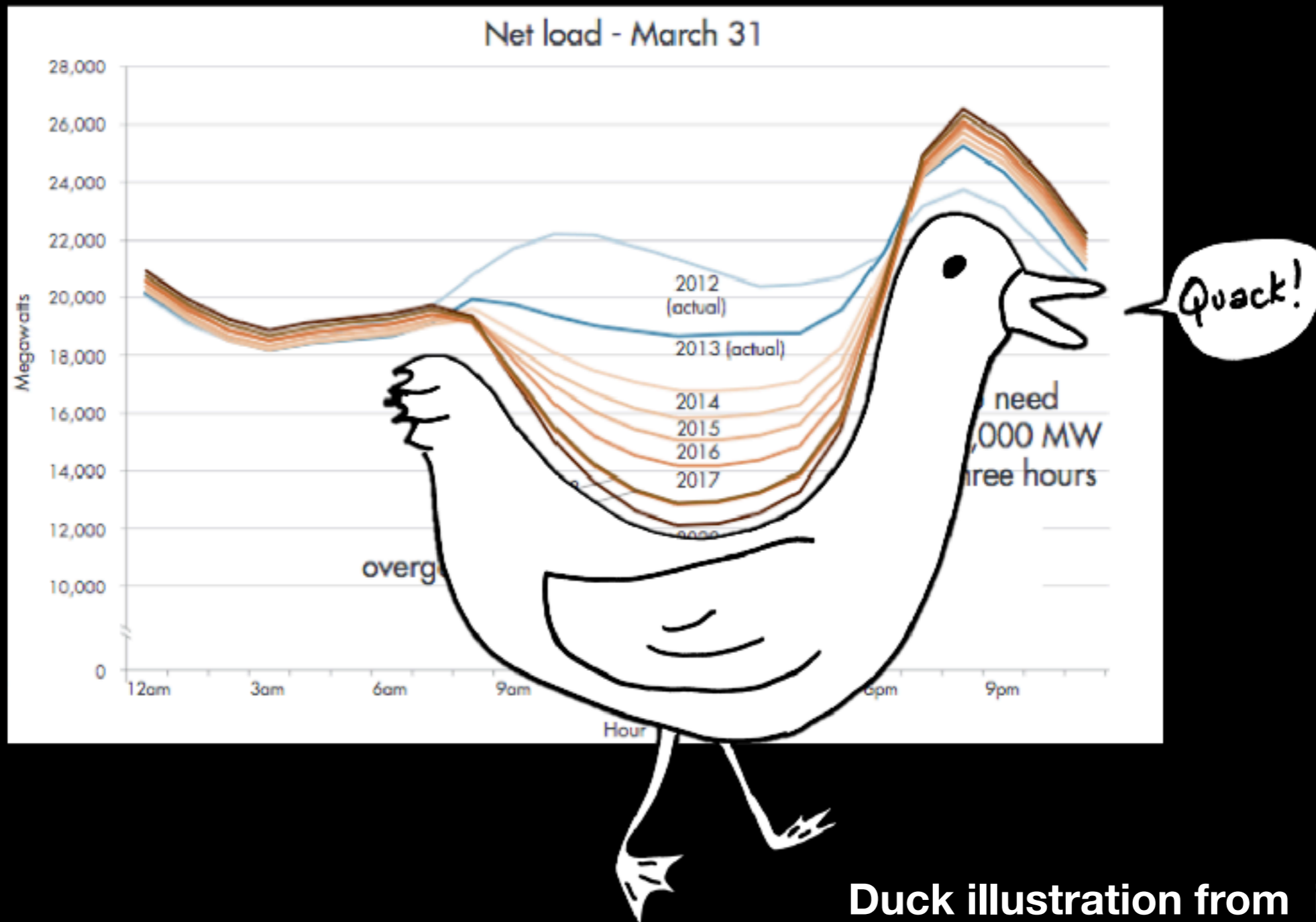
## 2) The Storage Problem

# Variability





# Ducks?

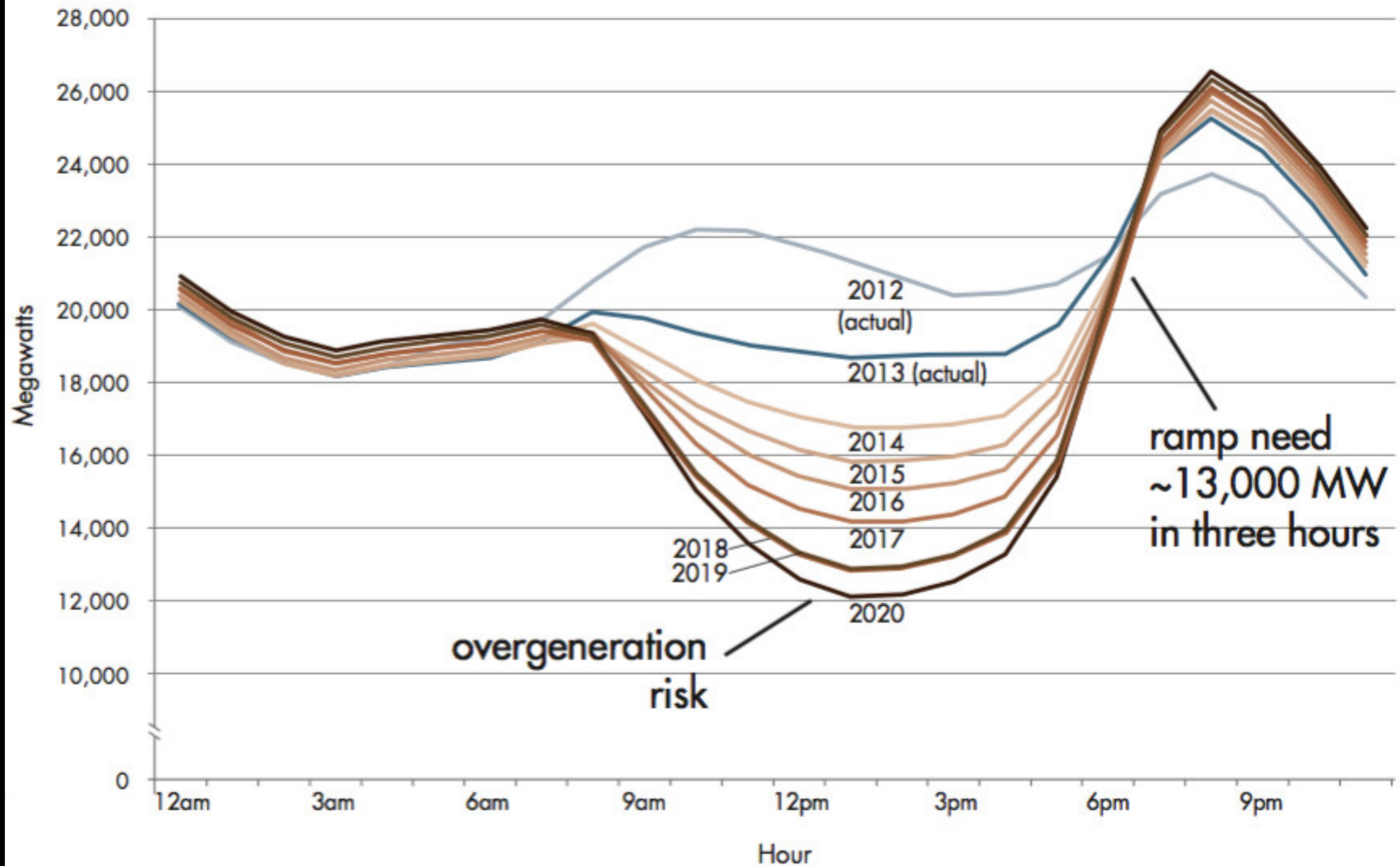


Duck illustration from inside energy  
California Independent Systems Operators

[https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables\\_FastFacts.pdf](https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf)

**Figure 2: The duck curve shows steep ramping needs and overgeneration risk**

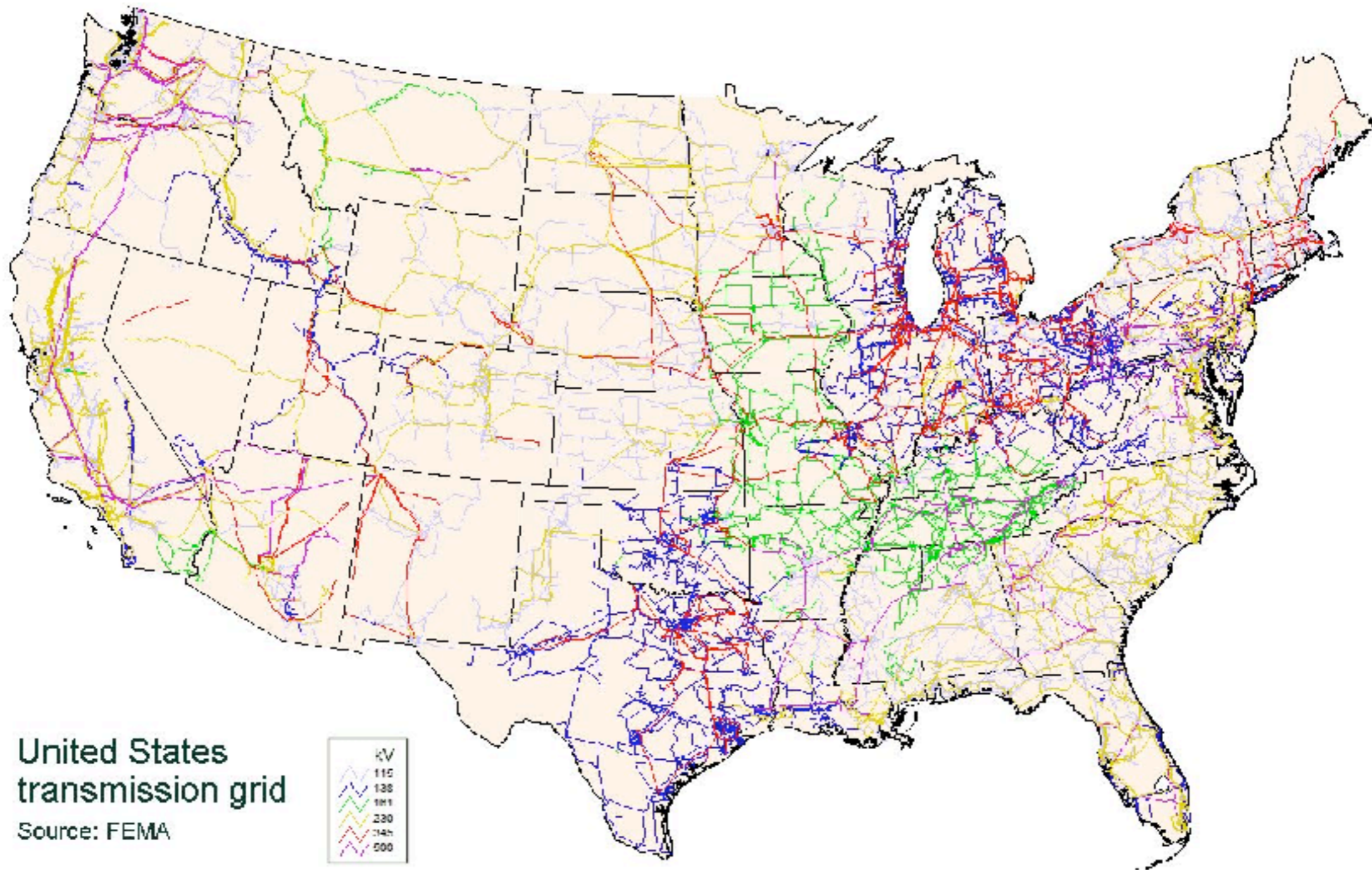
Net load - March 31



# Other Issues

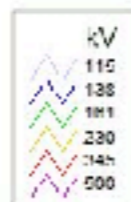
- Predictability
- Synchronous Generation
- Location, location, location
- Resistance to collaboration and flexibility





United States  
transmission grid

Source: FEMA

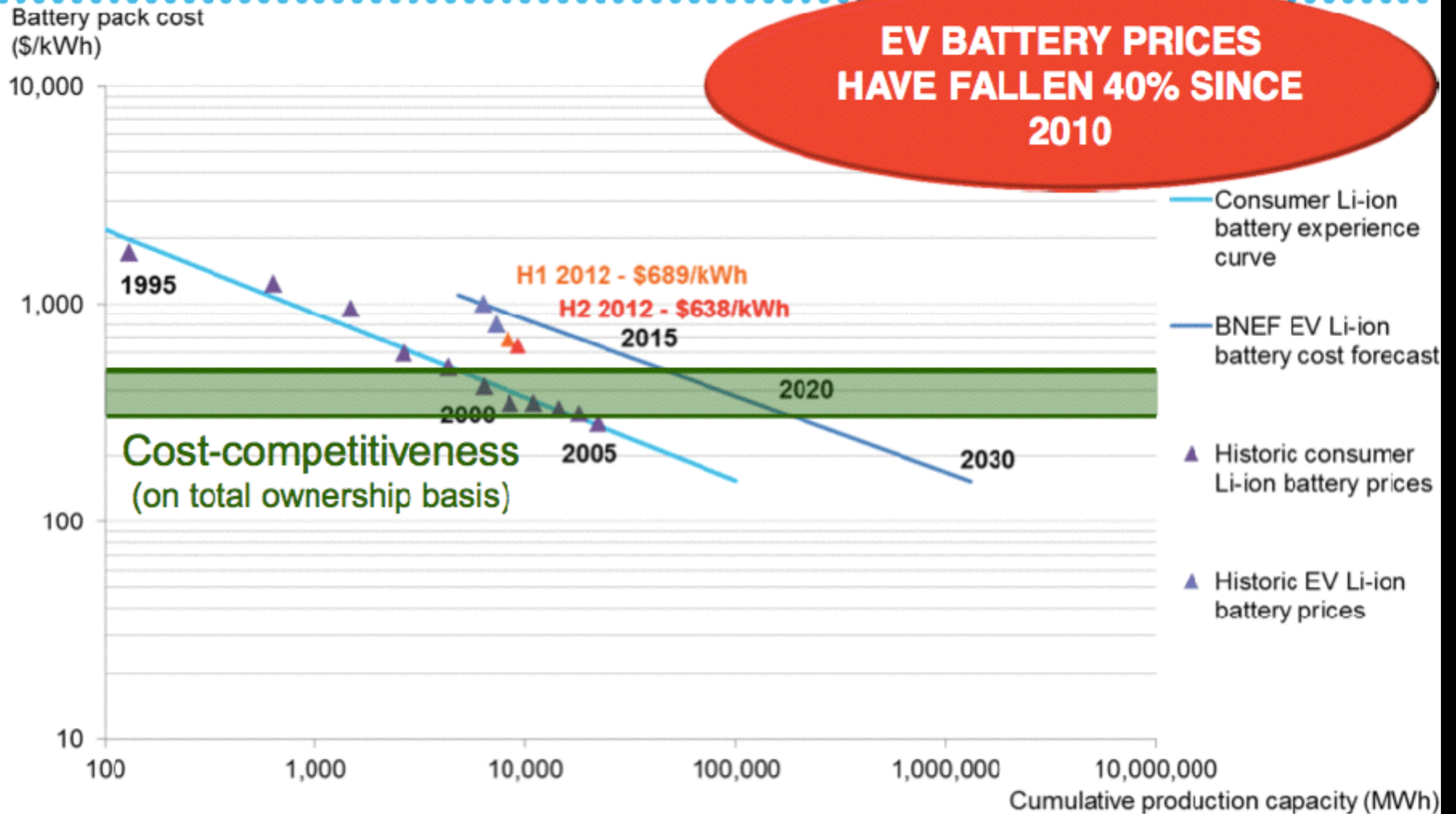


# PICK 2

## Batteries?

- Dense
- Cheap
- High Power Output
- Durability

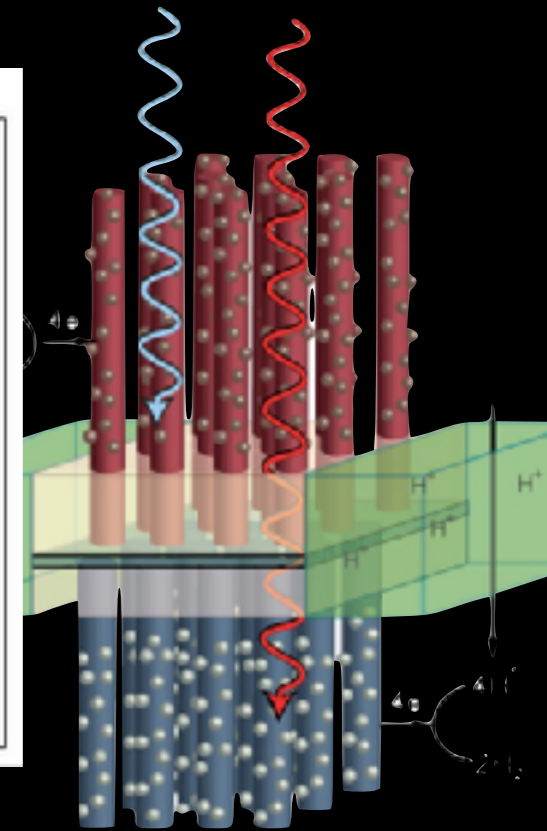
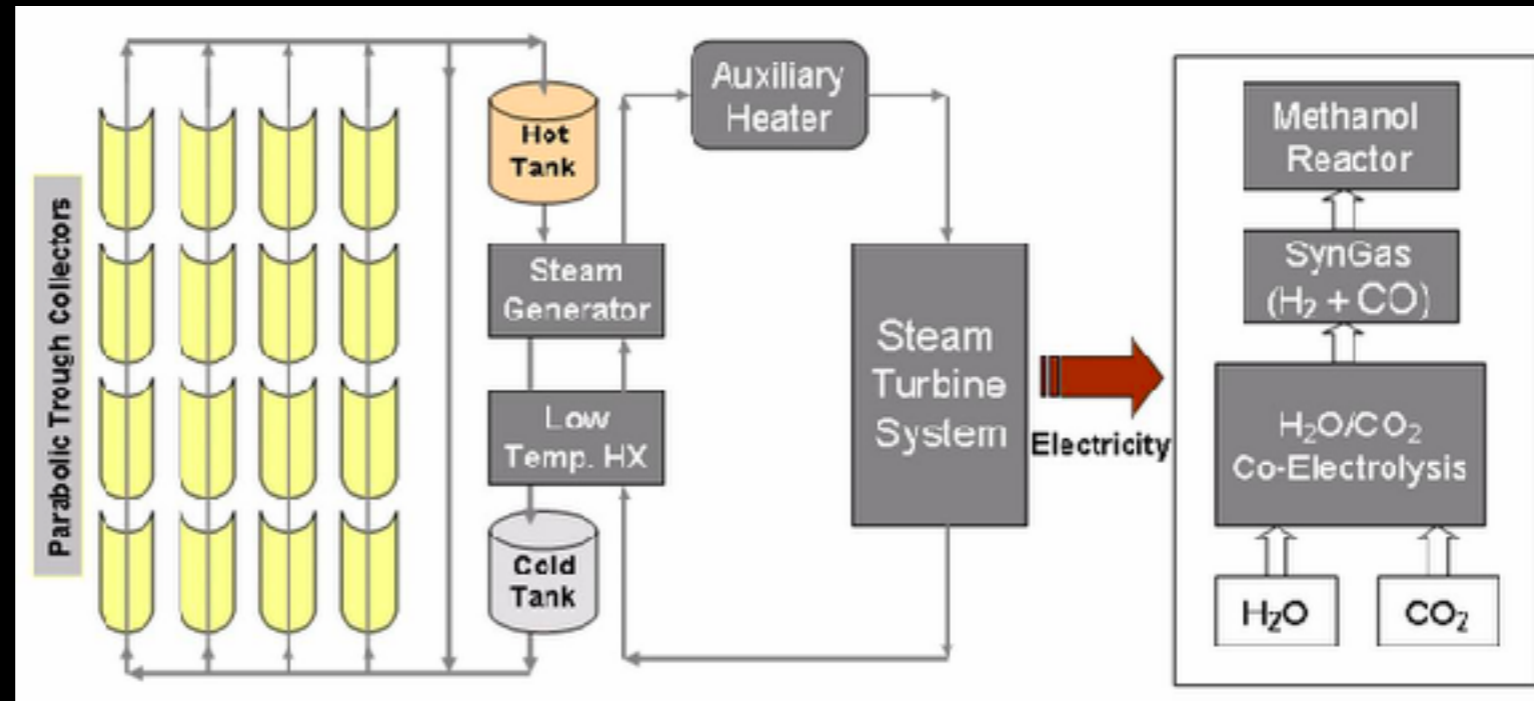
# LITHIUM-ION BATTERY EXPERIENCE CURVE



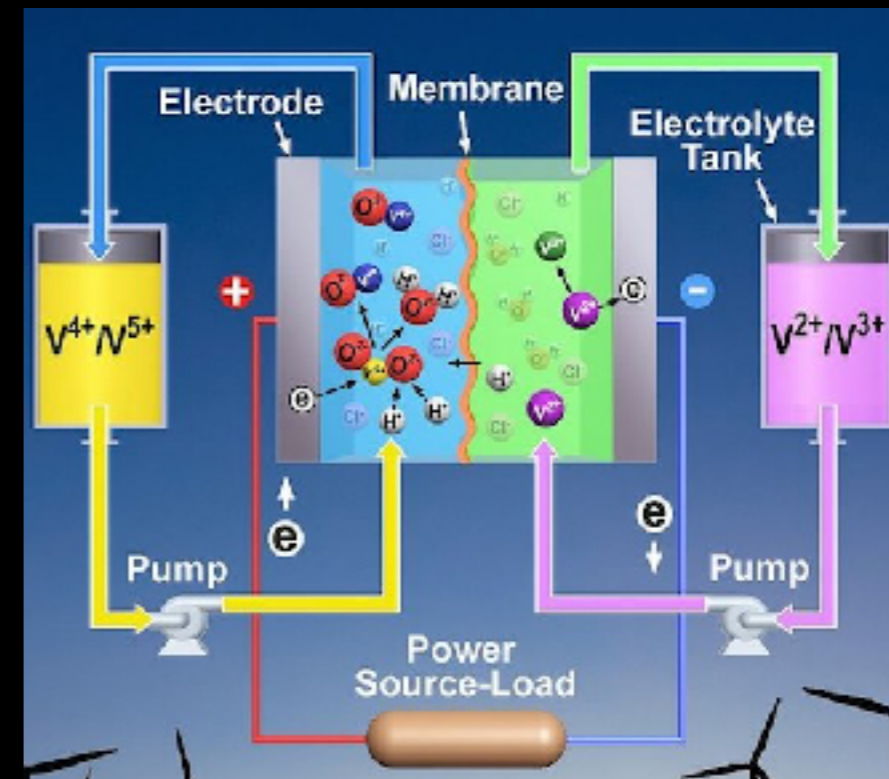
Source: Battery University, MIT, IIT, Bloomberg New Energy Finance

# Other Ideas

## Solar Fuels



Artificial  
Photosynthesis



Flow Batteries



## **Vanadium Flow Battery Juices Onion Plant**

**<http://www.powermag.com/vanadium-flow-battery-juices-onion-plant/>**



