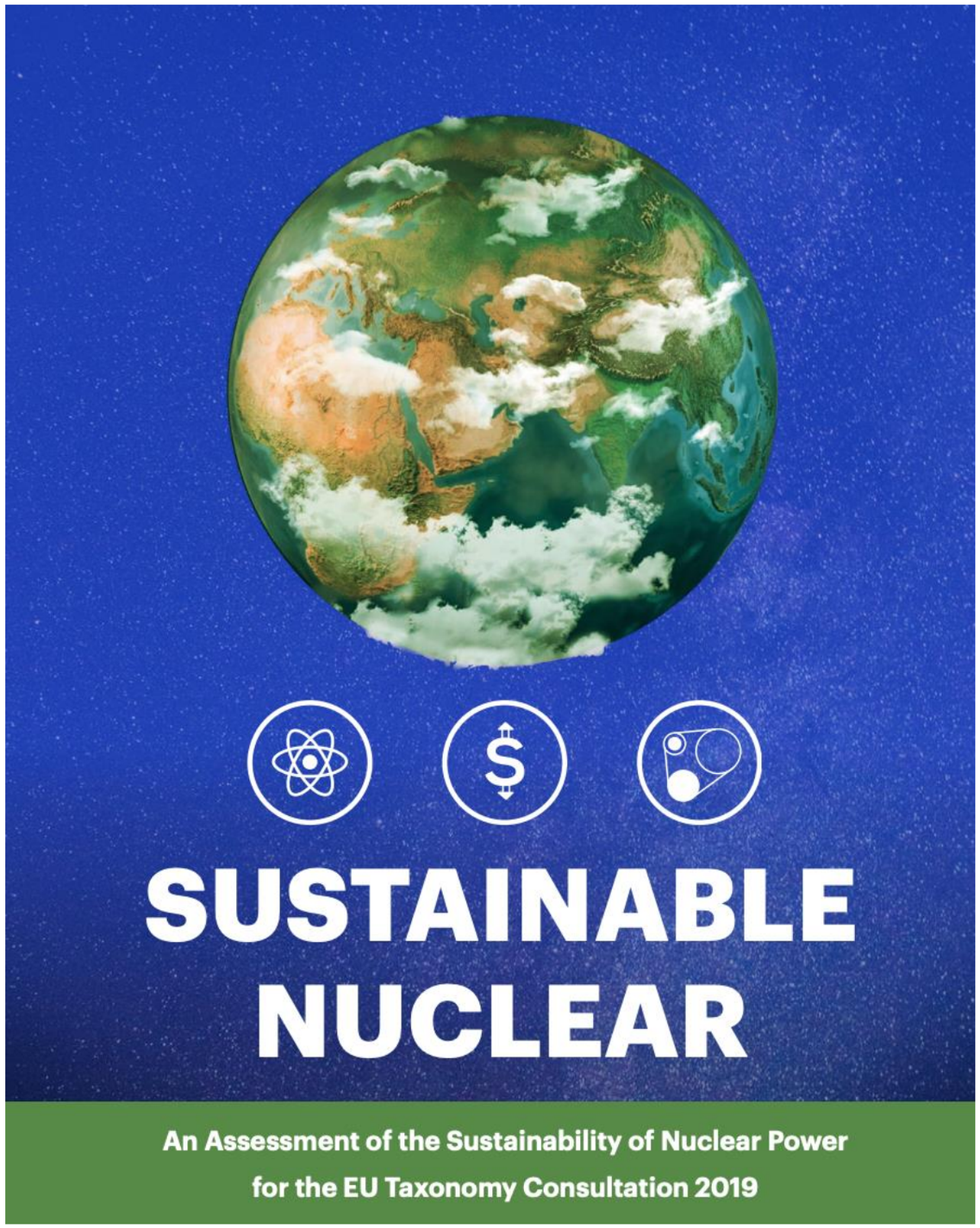
# ENERGY FOR HUMANITY

## THE THREE DIMENSIONS OF SUSTAINABILITY IN VIEW OF NUCLEAR POWER

KIRSTY GOGAN
GLOBAL DIRECTOR, ENERGY FOR HUMANITY
MANAGING PARTNER, LUCIDCATALYST

STOCKHOLM, JANUARY 2020




By

Lucid Catalyst

THINK ATOM

think deep decarbonization

**Authors**

Rauli Partanen

Staffan Qvist

Kirsty Gogan

Eric Ingersoll

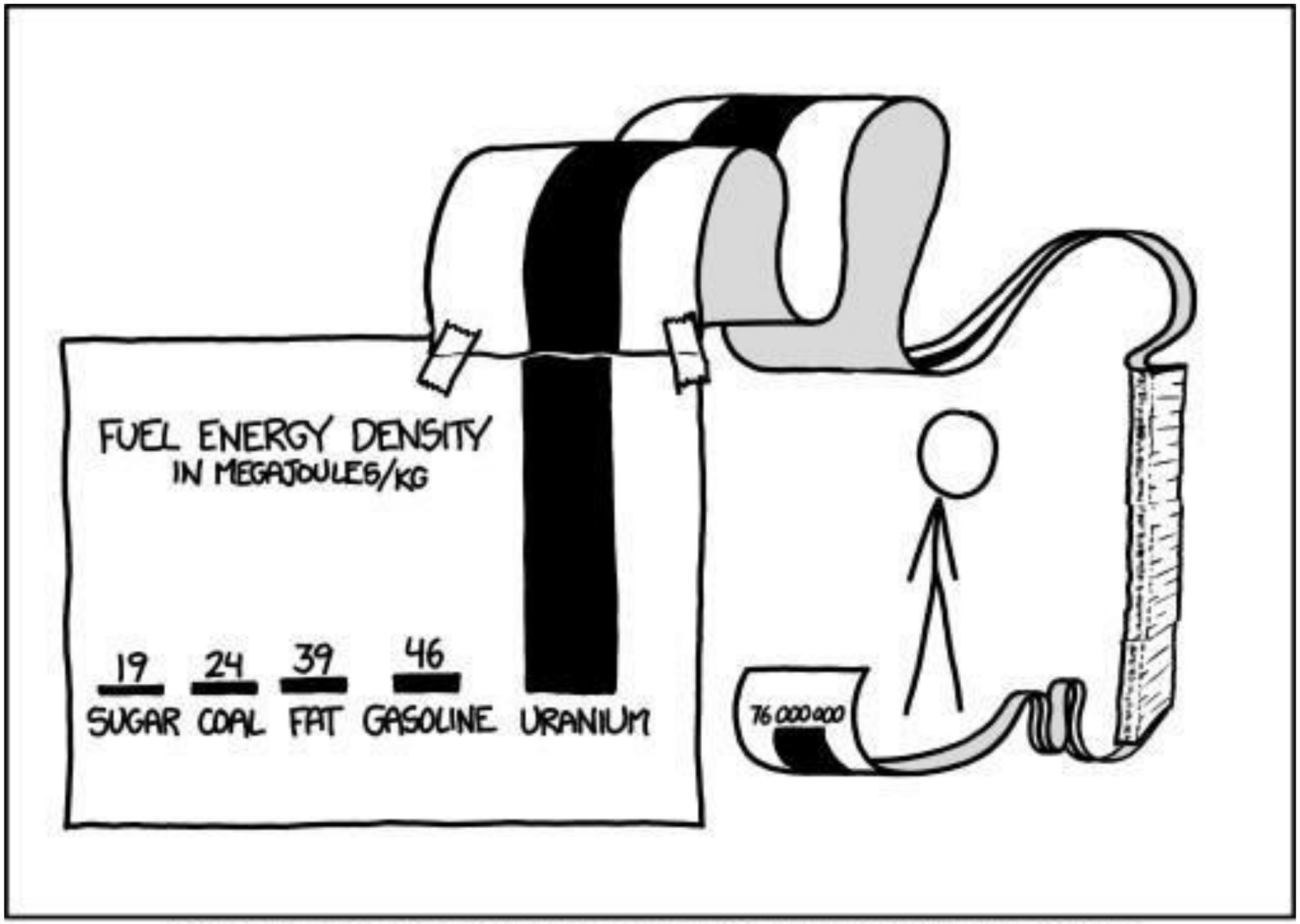
**Acknowledgements**

Thanks for the help, research and feedback to Adam Kanne, Daniel Westlén, Viljami Virolainen, Sophie Zienkiewicz, Jane Pickering, Valeire Faudon and others.

**Full Disclosure**

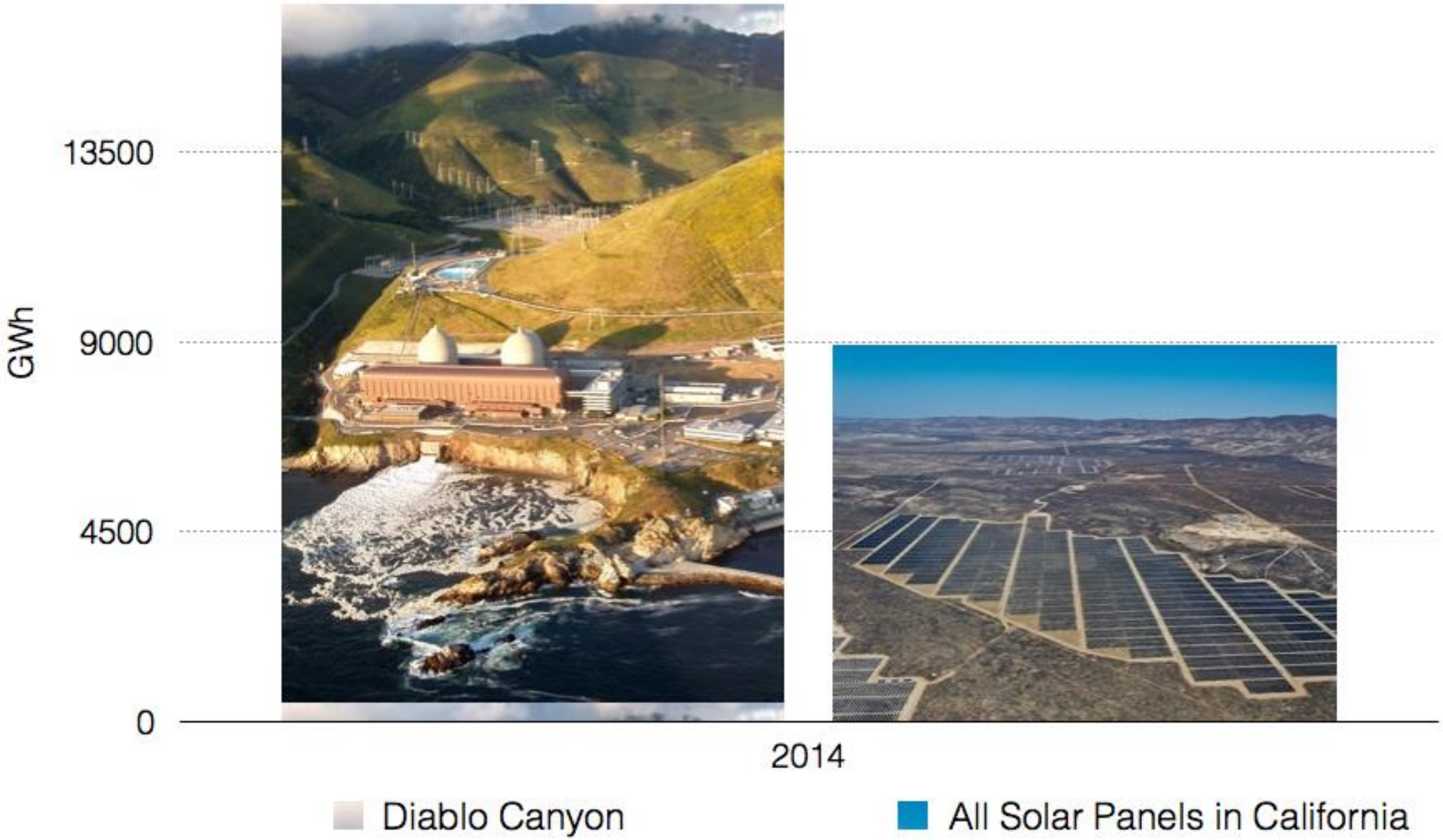
The authors of this assessment are independent experts and analysts in the fields of climate change, energy, nuclear energy and environment. The work was commissioned by LucidCatalyst Ltd. and the non-profit think tank Think Atom. The work was funded by EDF UK, with full editorial control remaining with the authors.

ENERGY FOR HUMANITY




SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY.*

# Energy density and protection of nature go hand in hand.




California Almanac, “In-State Generation by Fuel Type”
http://energyalmanac.ca.gov/electricity/electric_generation_capacity.html

ENERGY FOR HUMANITY_

# Hinkley Point C land area and energy output compared to other types of energy production sites

Hinkley Point C =

**430 acres**

**26TWh (terrawatt hours) per year**

This is estimated to be equal to around 7% of UK electricity consumption in 2025 and enough to power nearly 6 million homes.

Solar farms =

**130,000 acres**

Onshore wind farms =

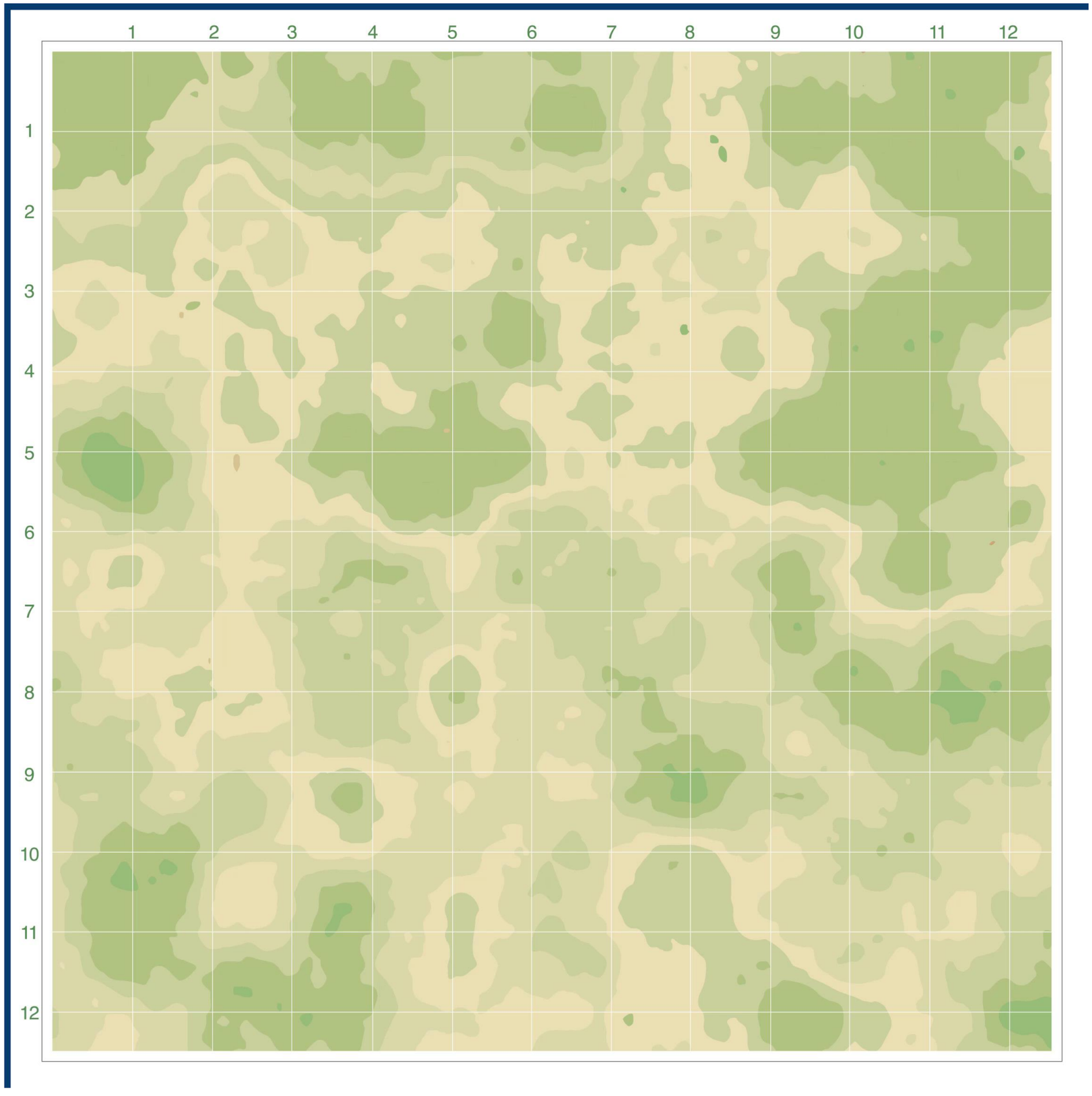
**250,000 acres***

*The footprint will depend on the location and turbine technology deployed. DECC estimates the footprint could be between 160,000 and 490,000 acres.

Energy density and protection of nature go hand in hand

ENERGY FOR HUMANITY

ECO:LOGIC



# Efficiency

**Kilowatt hours of energy produced from 1kg of fuel**

## Coal

$O_6$

*Enough to power a 60 watt light bulb for **4 days***

## Nuclear

# 360,000

**(uranium)**

*Enough to power a 60 watt light bulb for **685 years***

ENERGY FOR HUMANITY

# But what about the waste?

ENERGY FOR HUMANITY

**Paris-Ortiz-Wines**
@ParisOrtizWines

Everyone: But what about the waste??

Me: What about it?

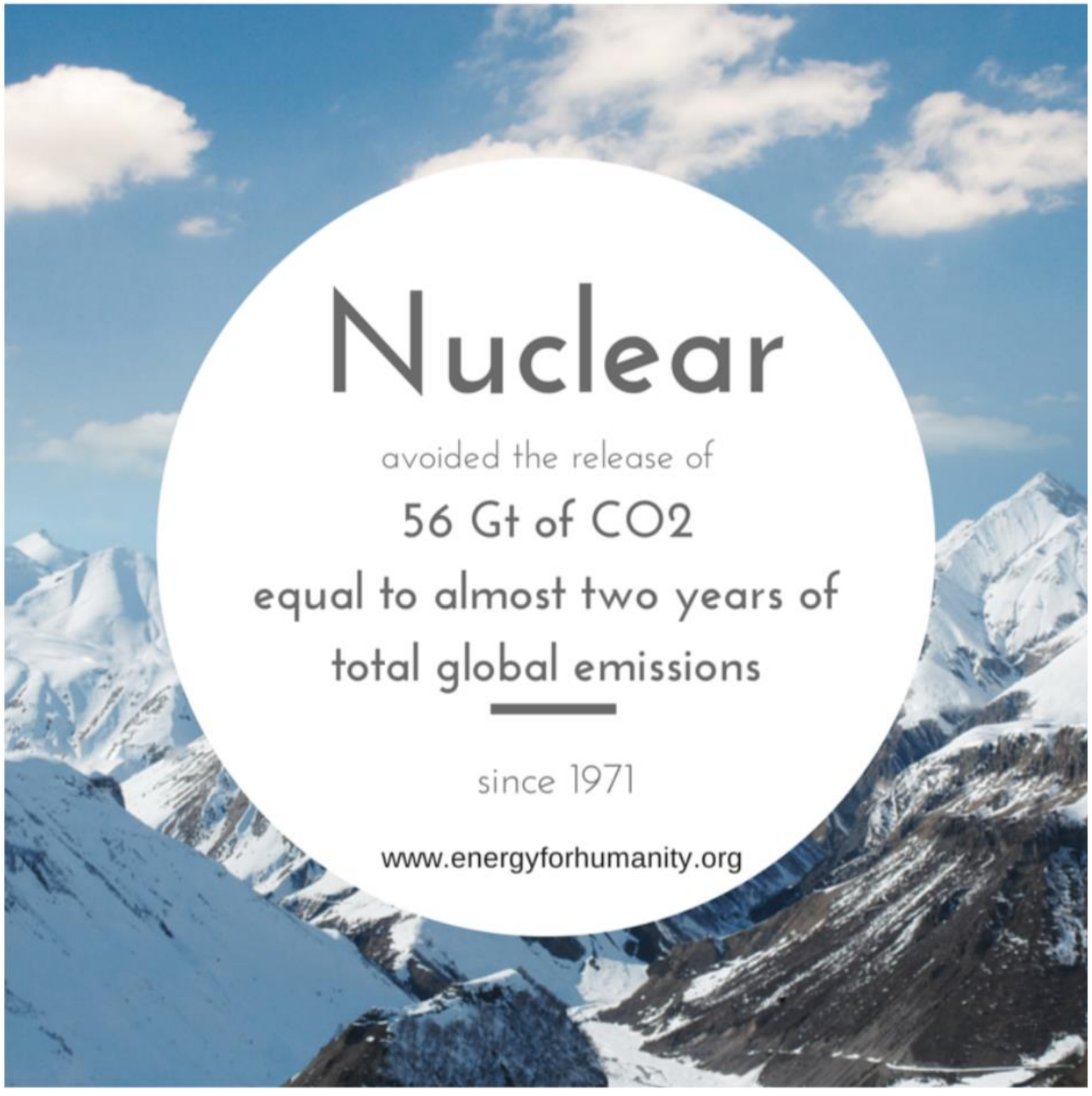
04:41 · 15/11/2019 · Twitter for iPhone

**537** Retweets **2,211** Likes

ENERGY FOR HUMANITY

**One person's total lifetime's volume of high level radioactive waste if they used nothing but nuclear energy for their whole life.**

ENERGY FOR HUMANITY

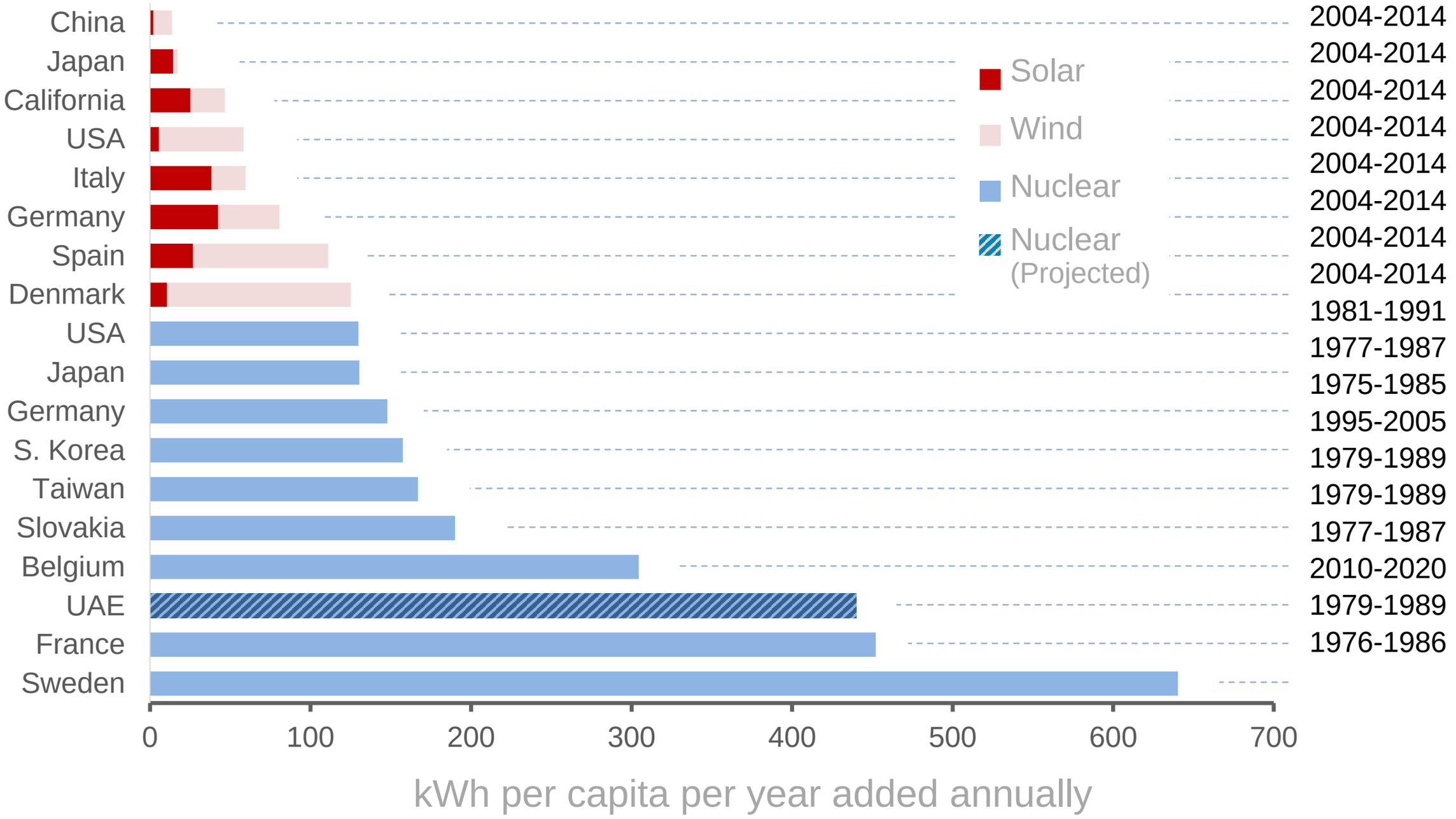



ENERGY FOR HUMANITY

# But isn’t it too slow

ENERGY FOR HUMANITY

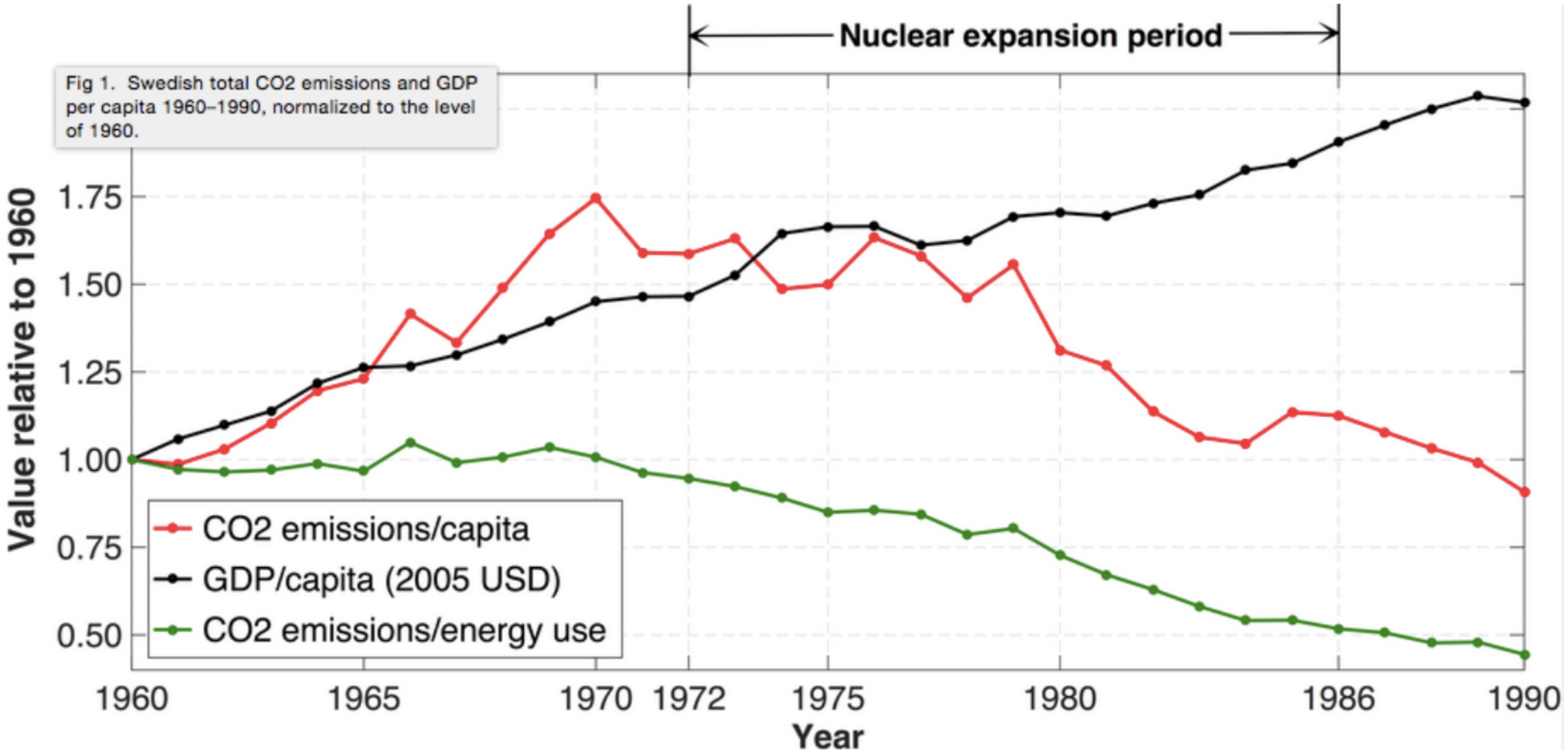
# How much clean generation can be added in 10 years?




Source: Cao et al., Science, August 2016.
UAE projections by WNA

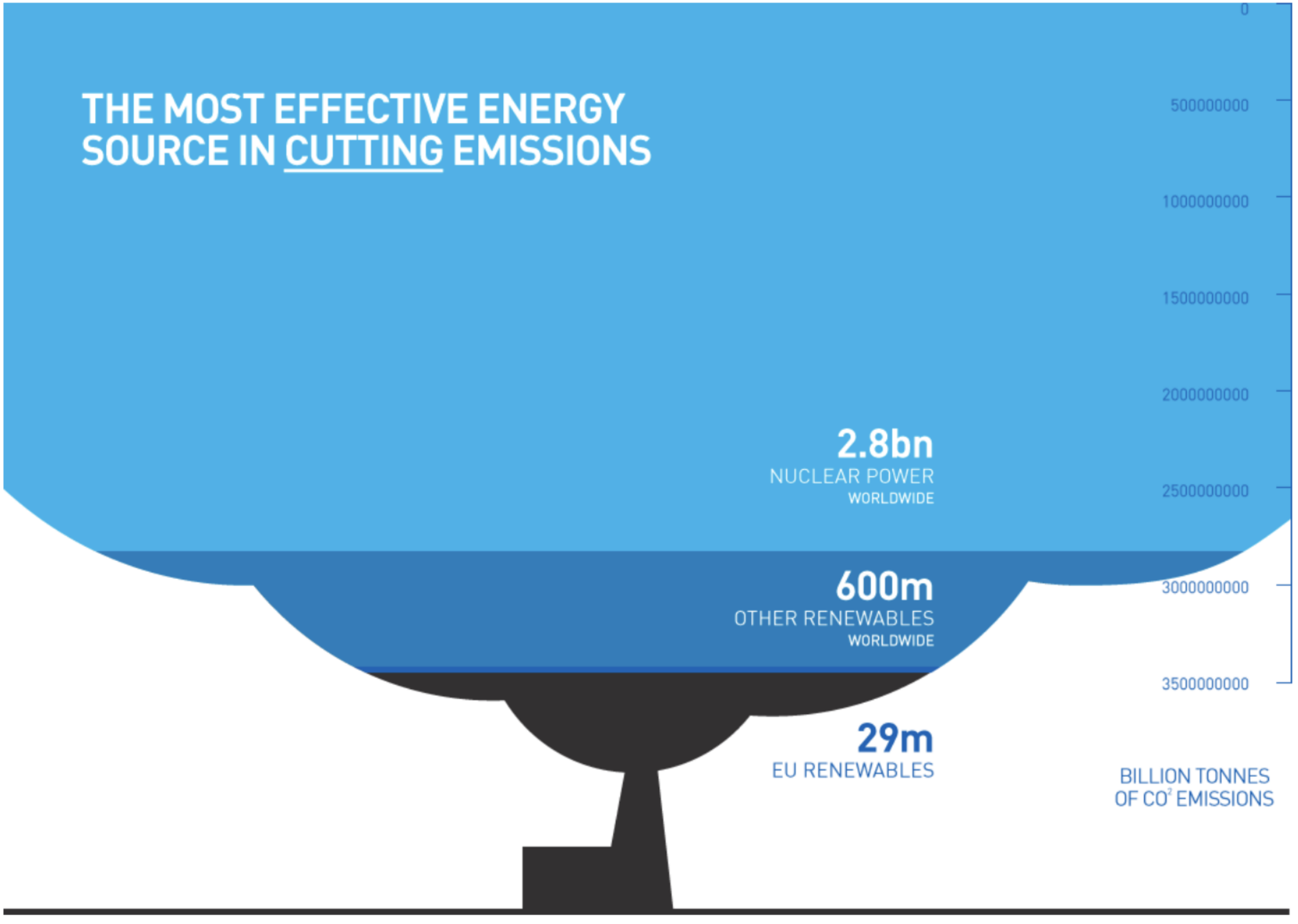
***"No other carbon-neutral electricity source has been expanded anywhere near as fast as nuclear."***

Barry Brook and Staffan Qvist




ENERGY FOR HUMANITY

# THE MOST EFFECTIVE ENERGY SOURCE IN CUTTING EMISSIONS



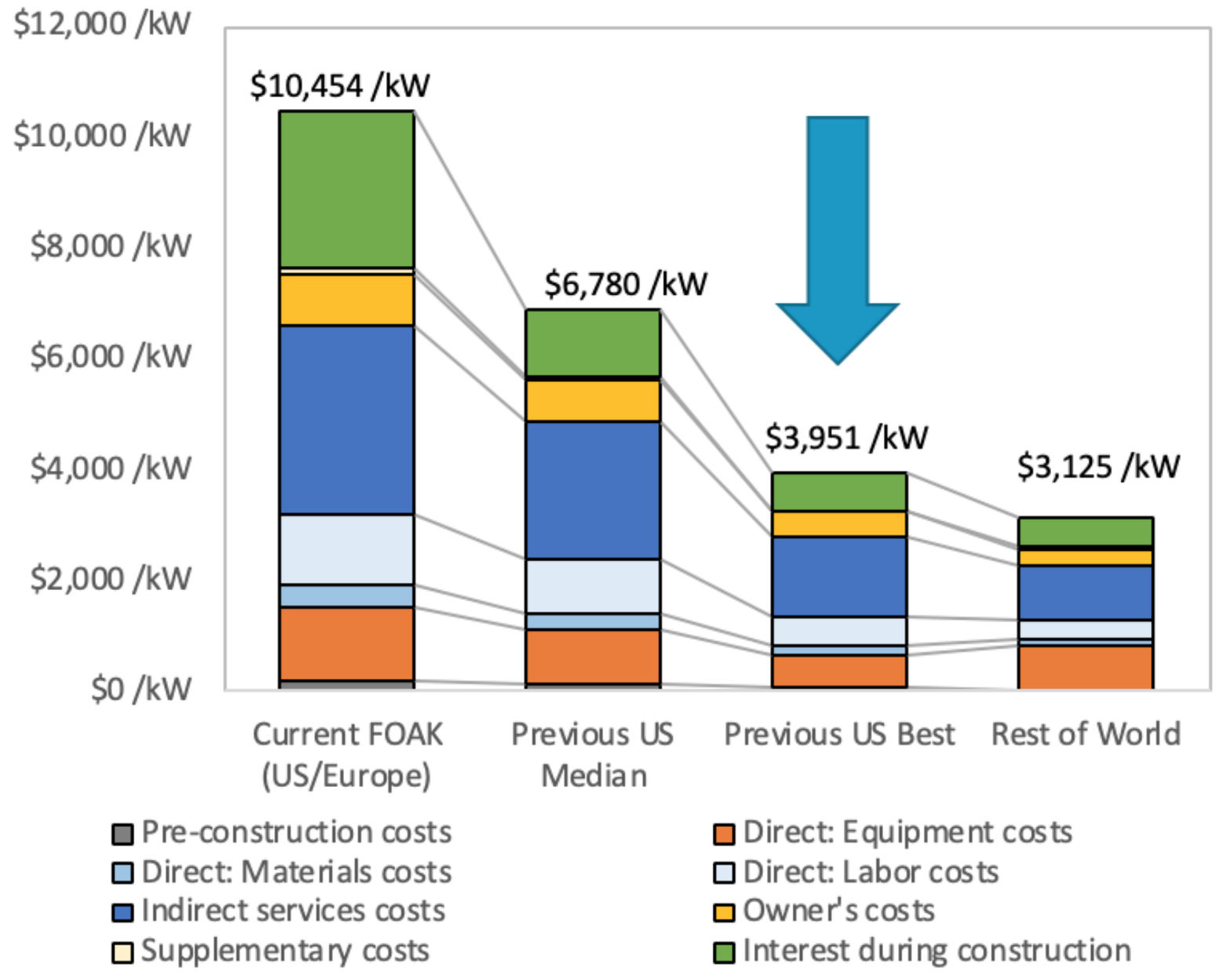

ENERGY FOR HUMANITY_

# But isn’t it too expensive?

ENERGY FOR HUMANITY

# The US achieved large number of cost-effective nuclear plants in the past

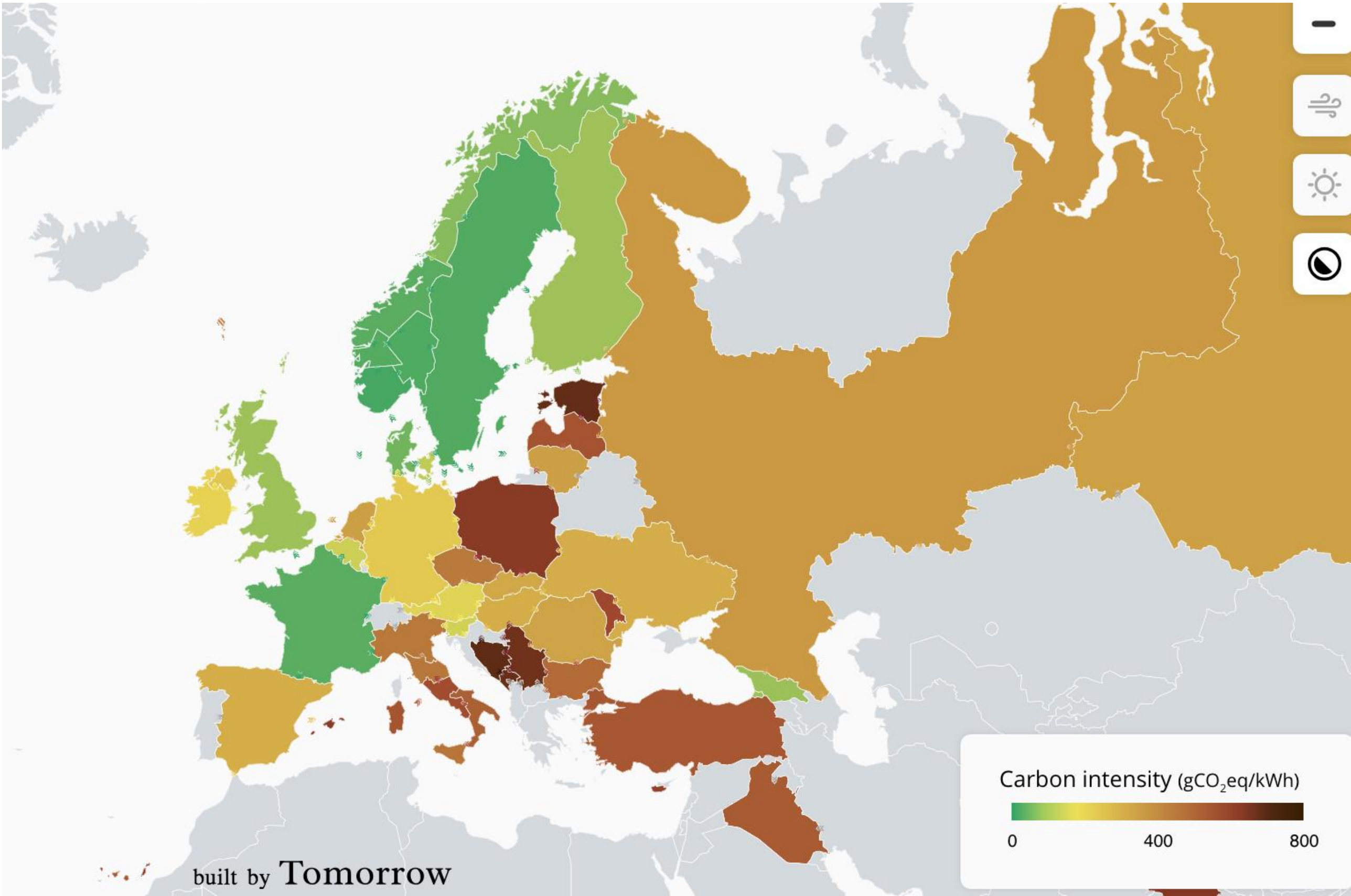
- Policy environments *strongly* affect the cost of building plants
- Continuity
- Standardization
- Interaction with safety regulator
- Investment by and depth of supply chain
- Cost of capital
- Experienced project delivery organizations



# What does success look like?

ENERGY FOR HUMANITY

# Energy for Humanity: European Climate Leadership Report. Measuring the Metrics that Matter



# What do we need?

ENERGY FOR HUMANITY_


# Prosperity

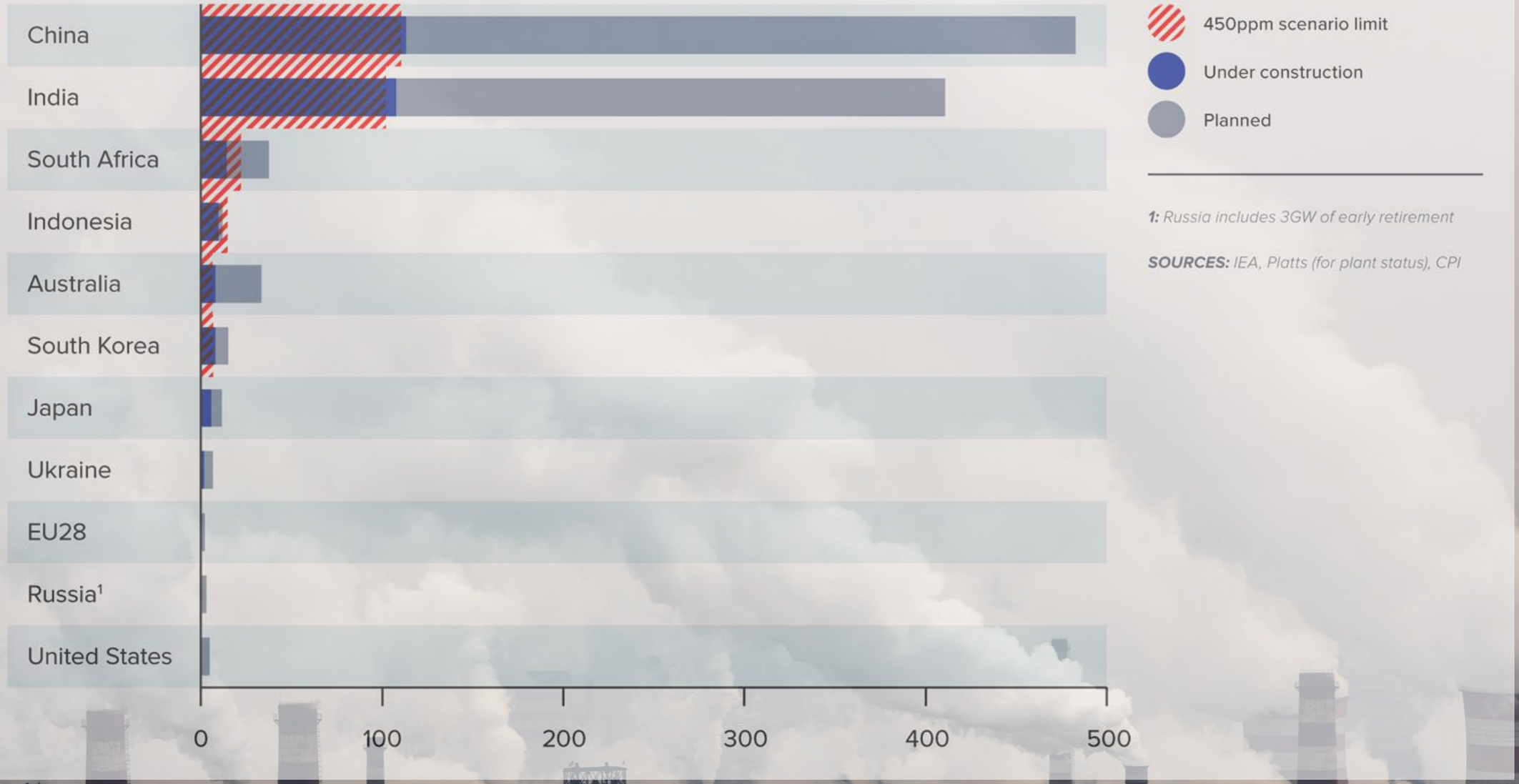
# Decarbonization

# What is the reality today?

ENERGY FOR HUMANITY_

3.5 billion people live in large cities now and by 2050 it will be 7-8 billion


Powered by coal

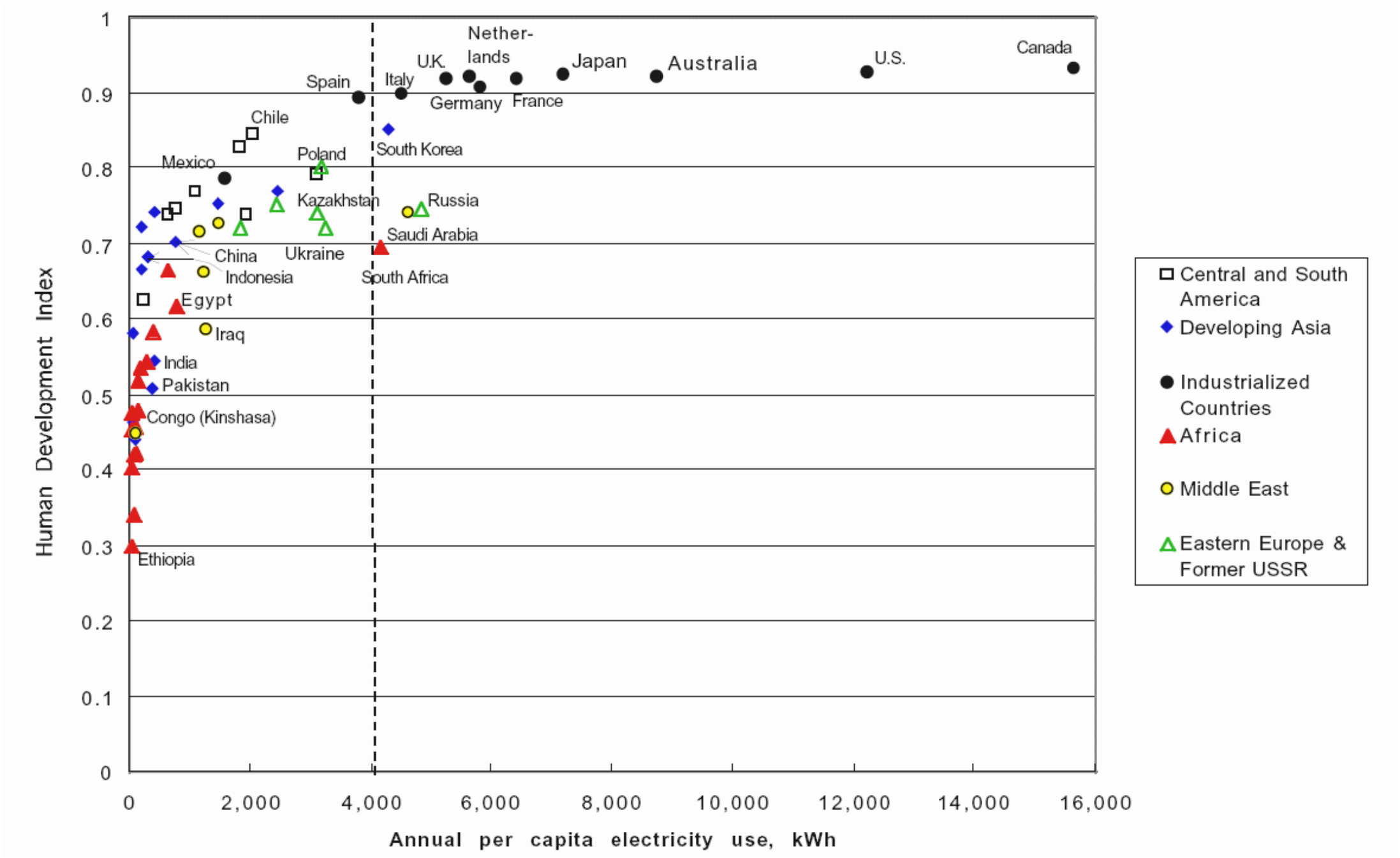



# Coal capacity is still increasing

# Protests can’t solve the problem

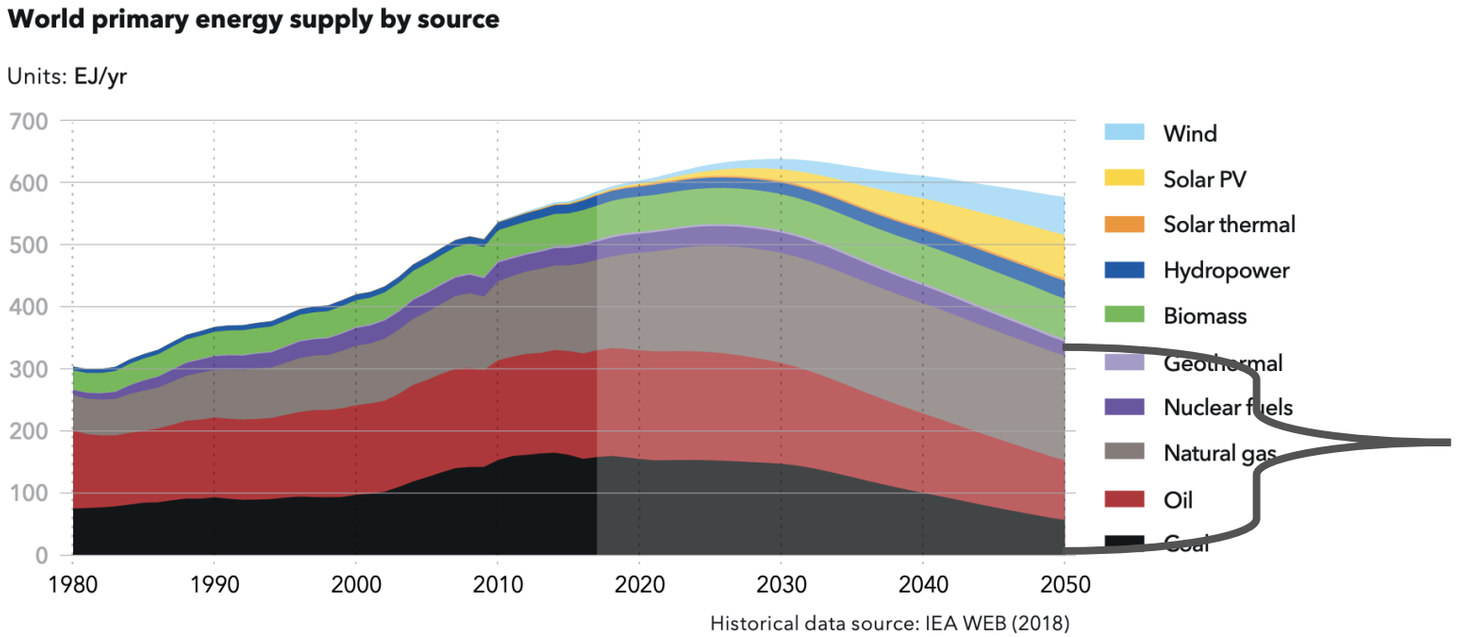
# Coal is the way out of poverty

# INCREASED ENERGY ACCESS IS DEVELOPMENT



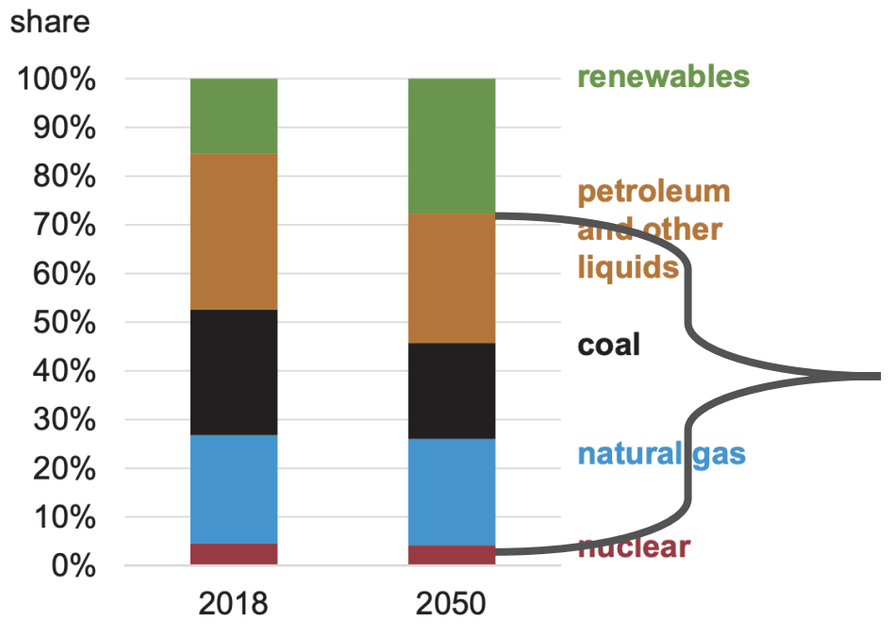

ENERGY FOR HUMANITY

# Even in projections of massive growth of renewables, a majority of primary energy is still fossil in 2050




60% Fossil in 2050

Source: DNV 2019



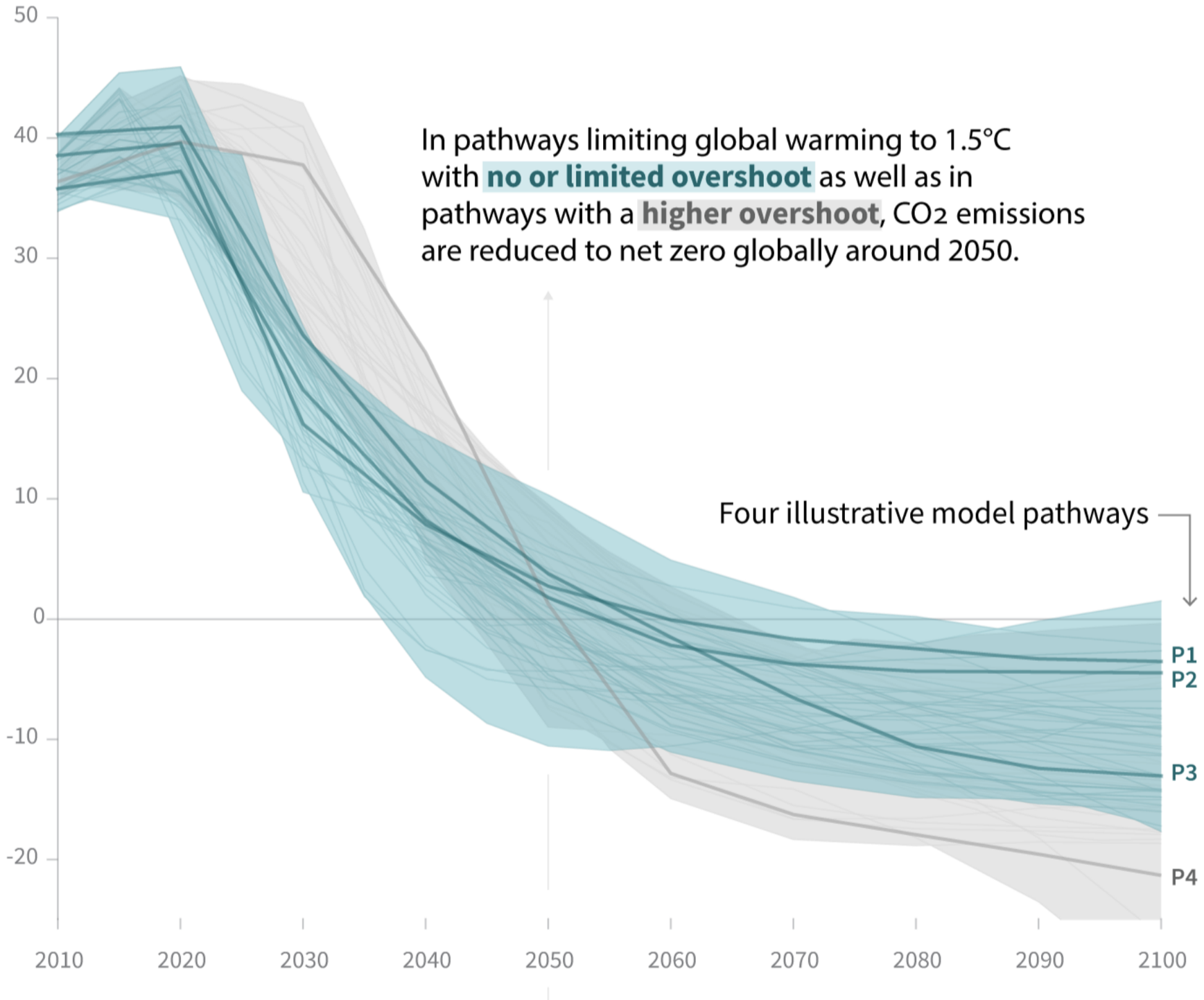

>60% Fossil

Source: EIA 2019

ENERGY FOR HUMANITY

# Global total net $CO_2$ emissions

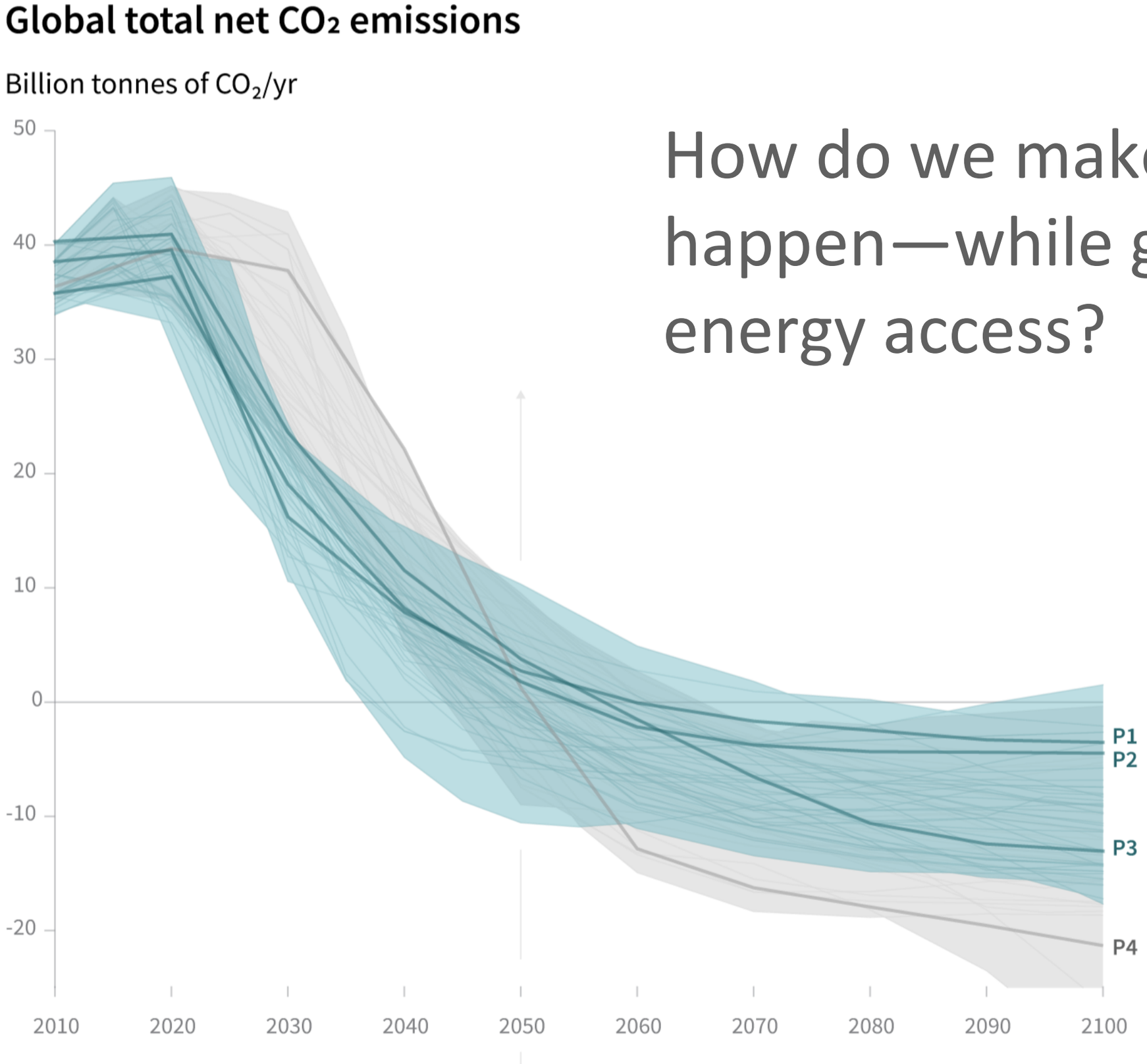
Billion tonnes of $CO_2$/yr




Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

ENERGY FOR HUMANITY_

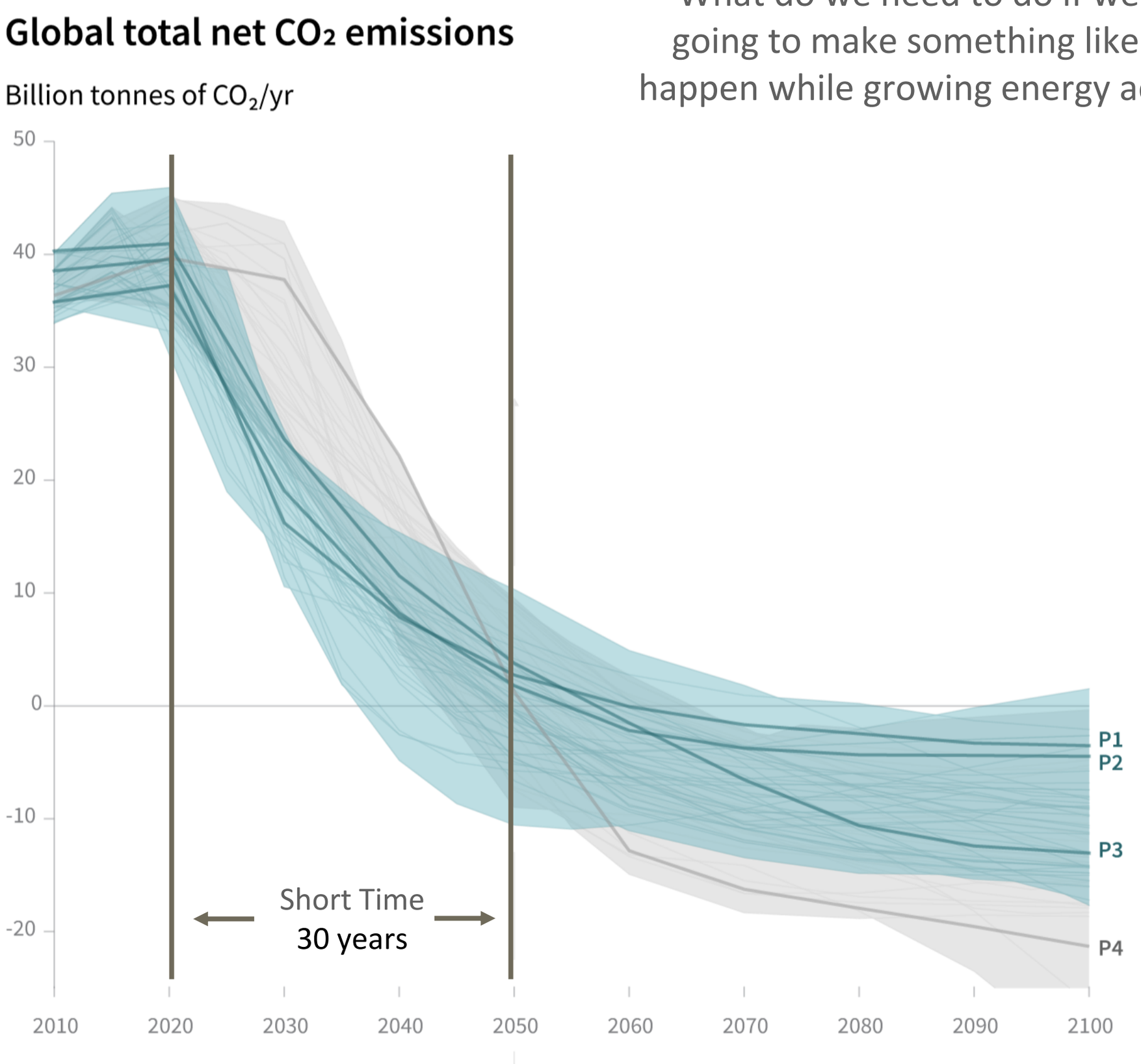



Source: IPCC Special Report on Global Warming of 1.5C 2018

# How do we make this happen—while growing energy access?

ENERGY FOR HUMANITY

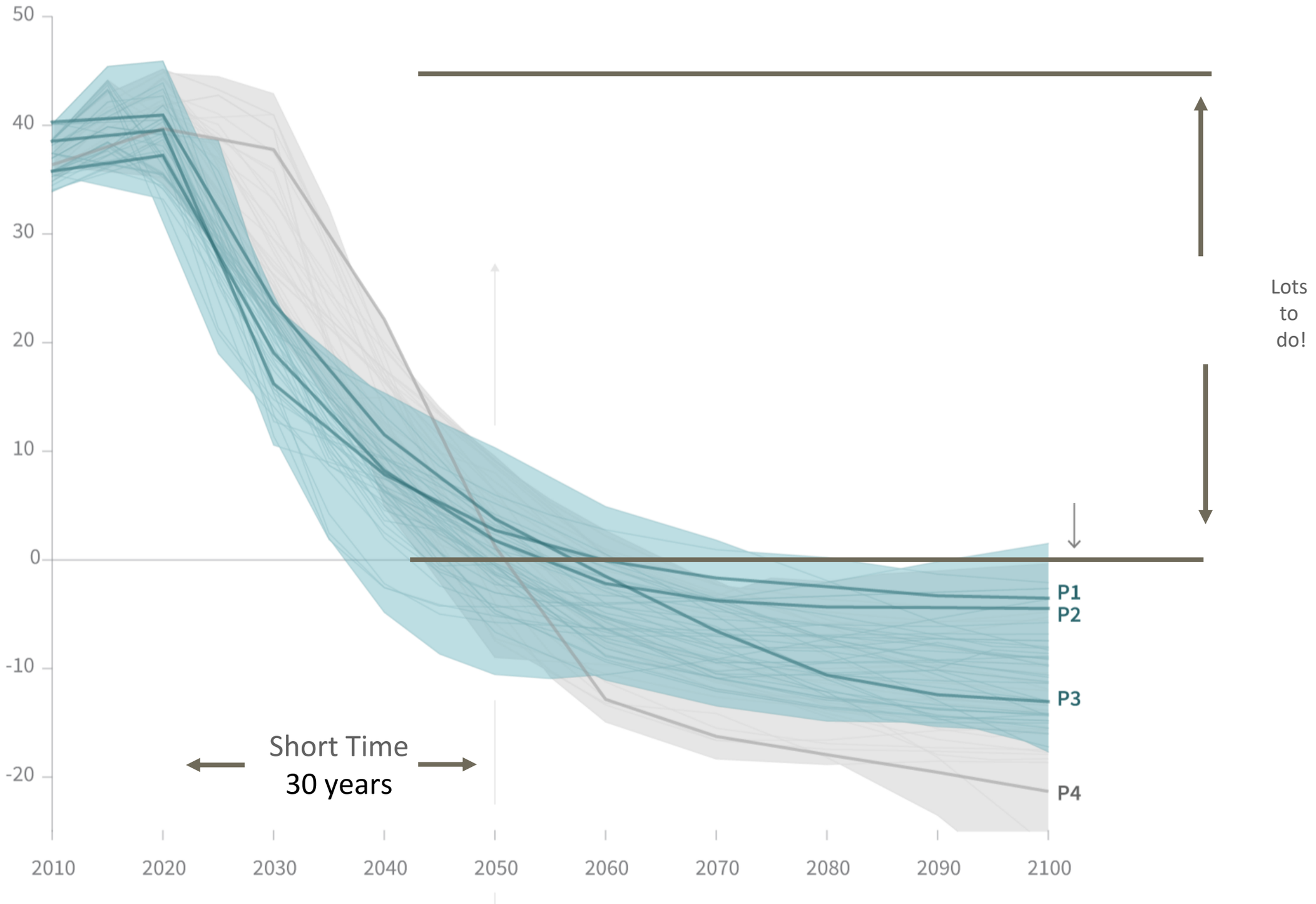
What do we need to do if we are going to make something like this happen while growing energy access?




Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?



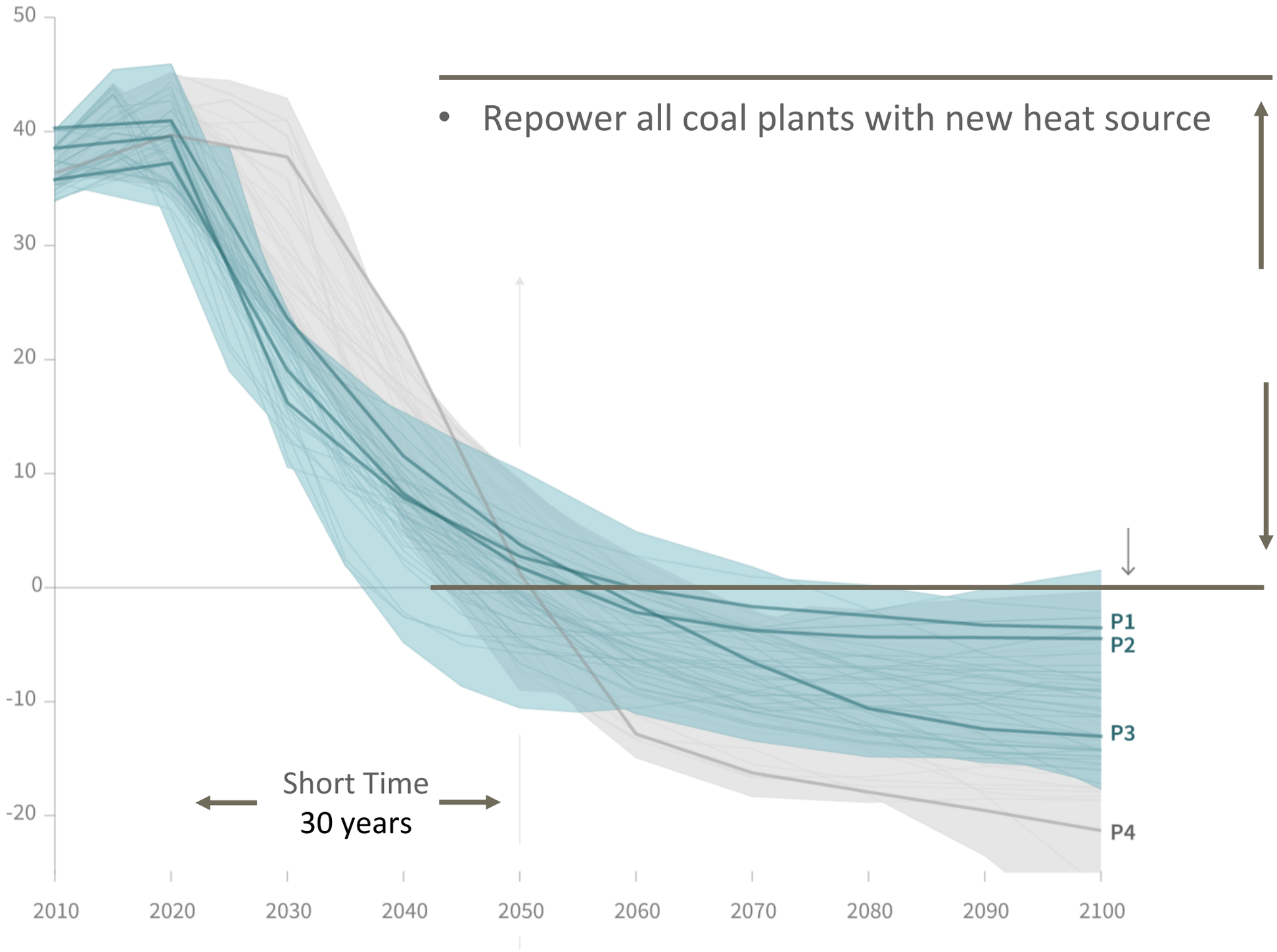

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?

- Repower all coal plants with new heat source

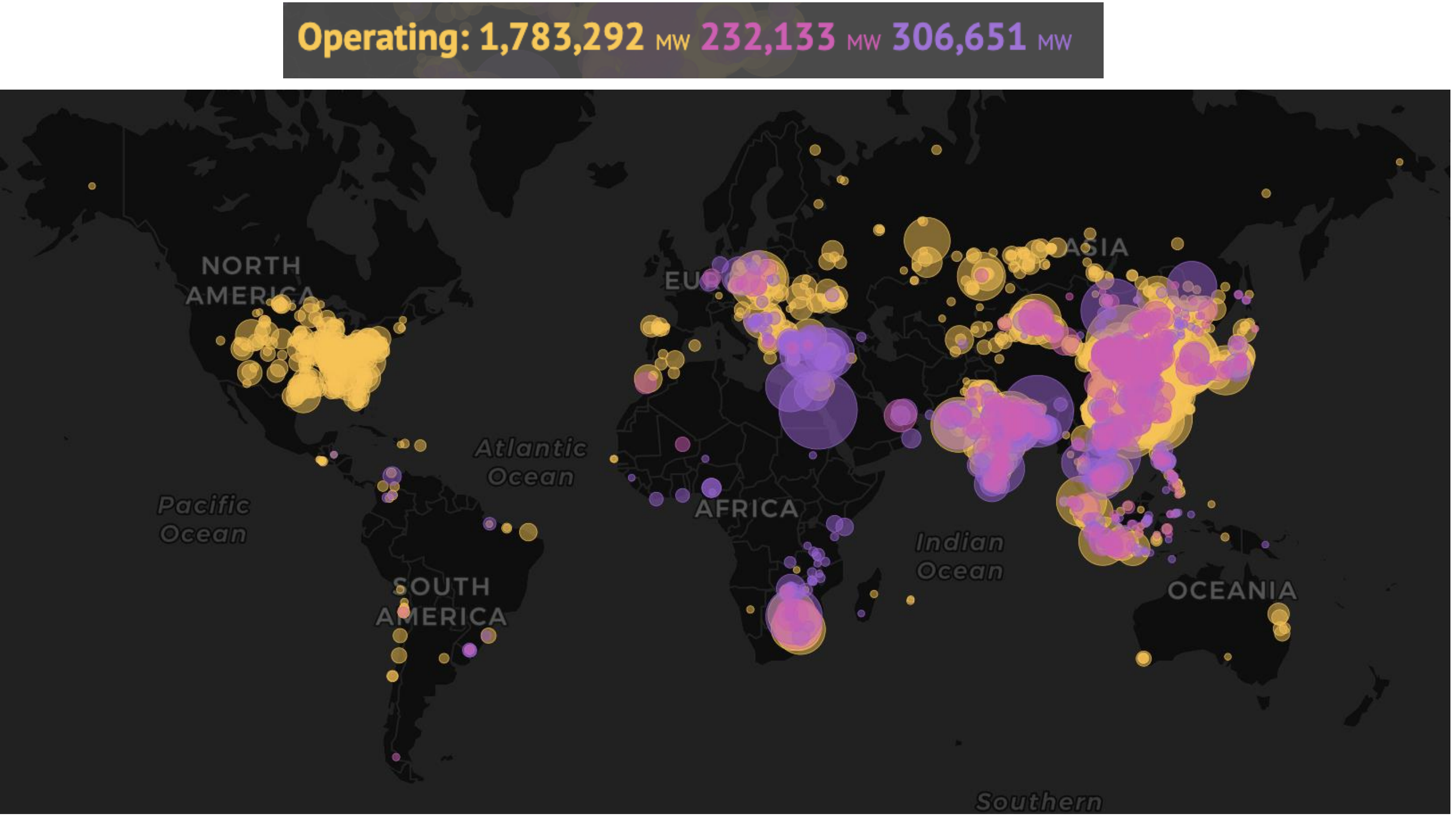
Lots to do!




Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

# FUTURE COAL—MORE THAN 5,000 PLANTS



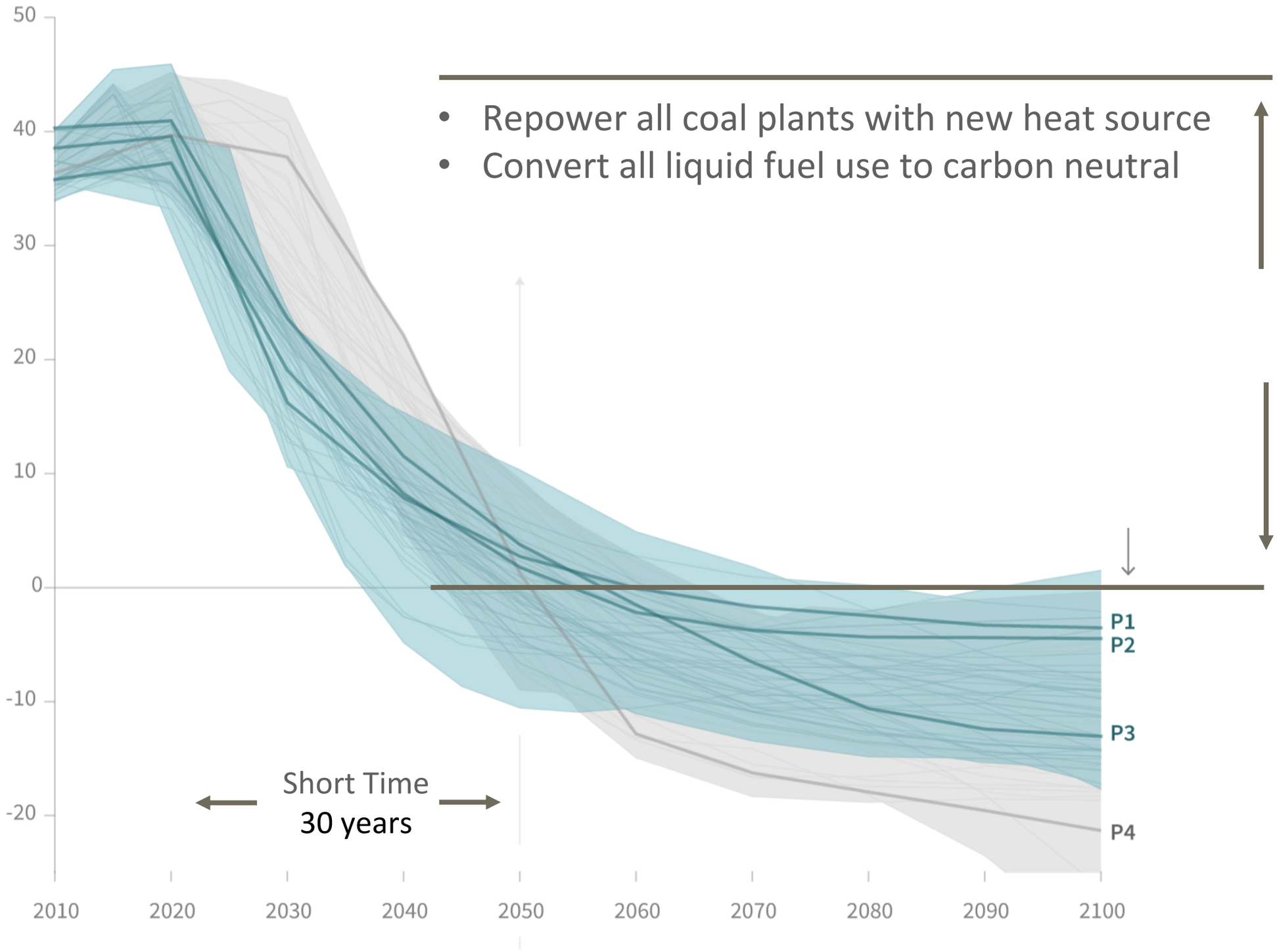

Source: Carbon Brief

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?

- Repower all coal plants with new heat source
- Convert all liquid fuel use to carbon neutral

Lots to do!



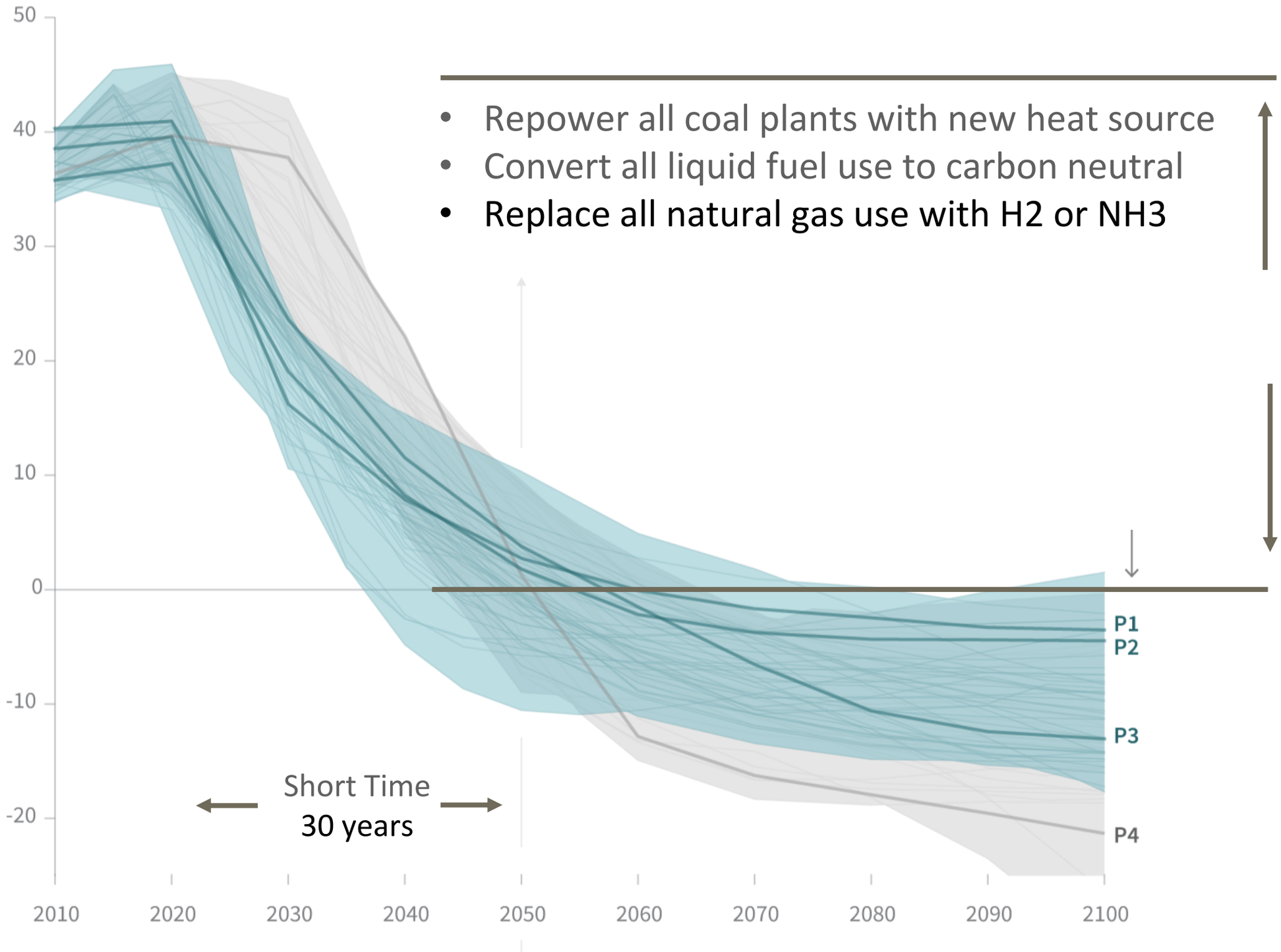

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?

- Repower all coal plants with new heat source
- Convert all liquid fuel use to carbon neutral
- Replace all natural gas use with H2 or NH3

Lots to do!



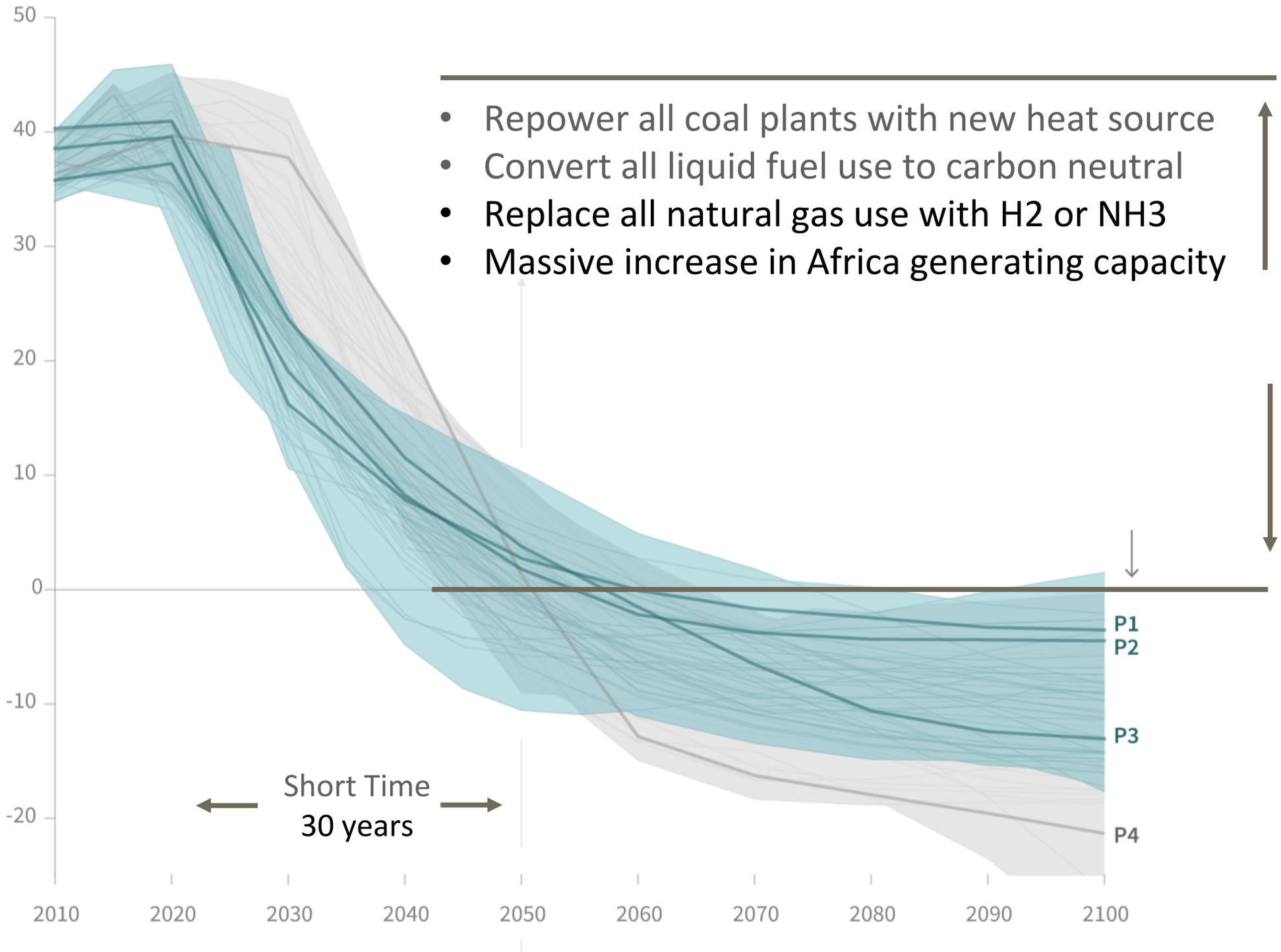

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?

- Repower all coal plants with new heat source
- Convert all liquid fuel use to carbon neutral
- Replace all natural gas use with H2 or NH3
- Massive increase in Africa generating capacity

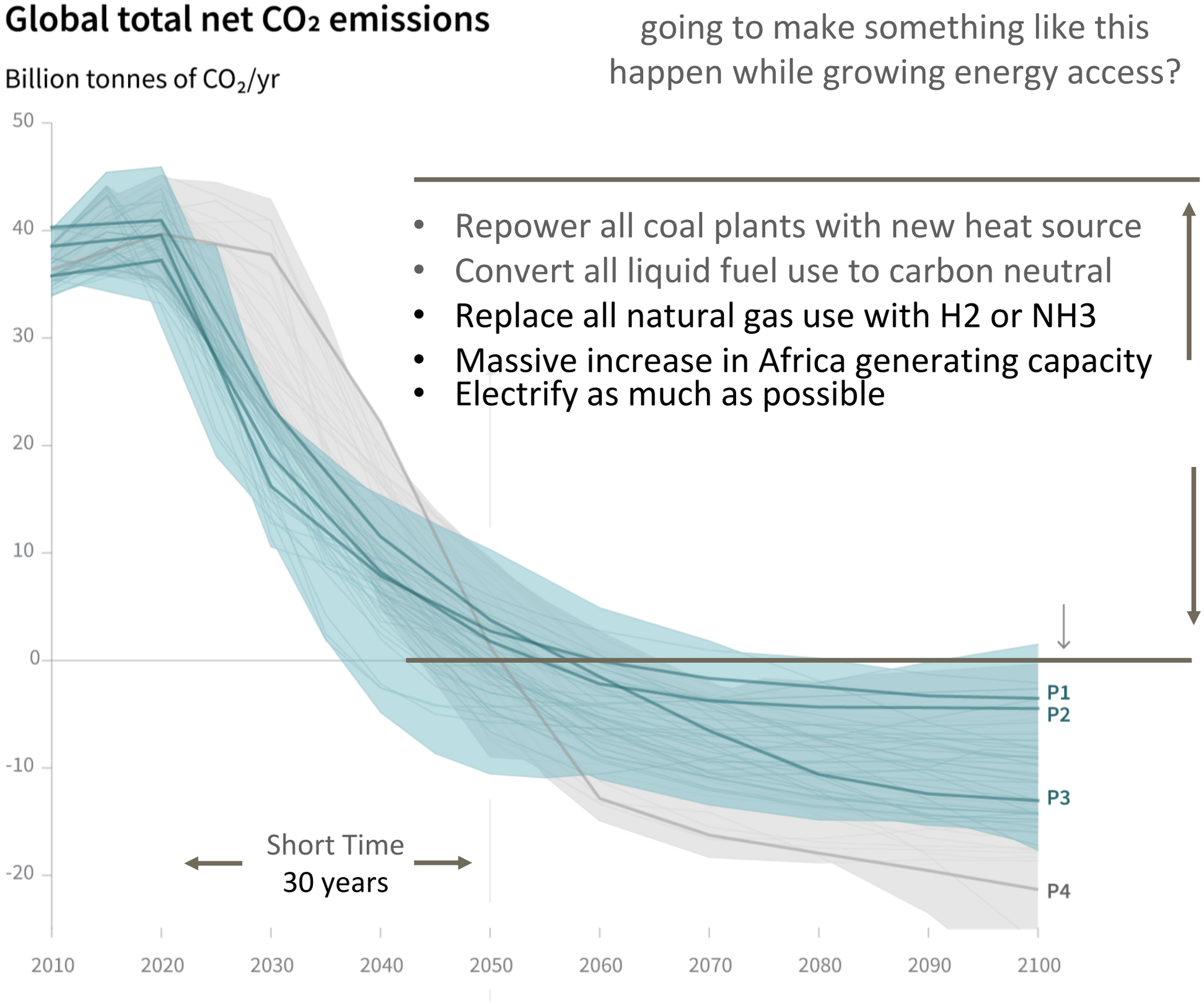
Lots to do!




Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?



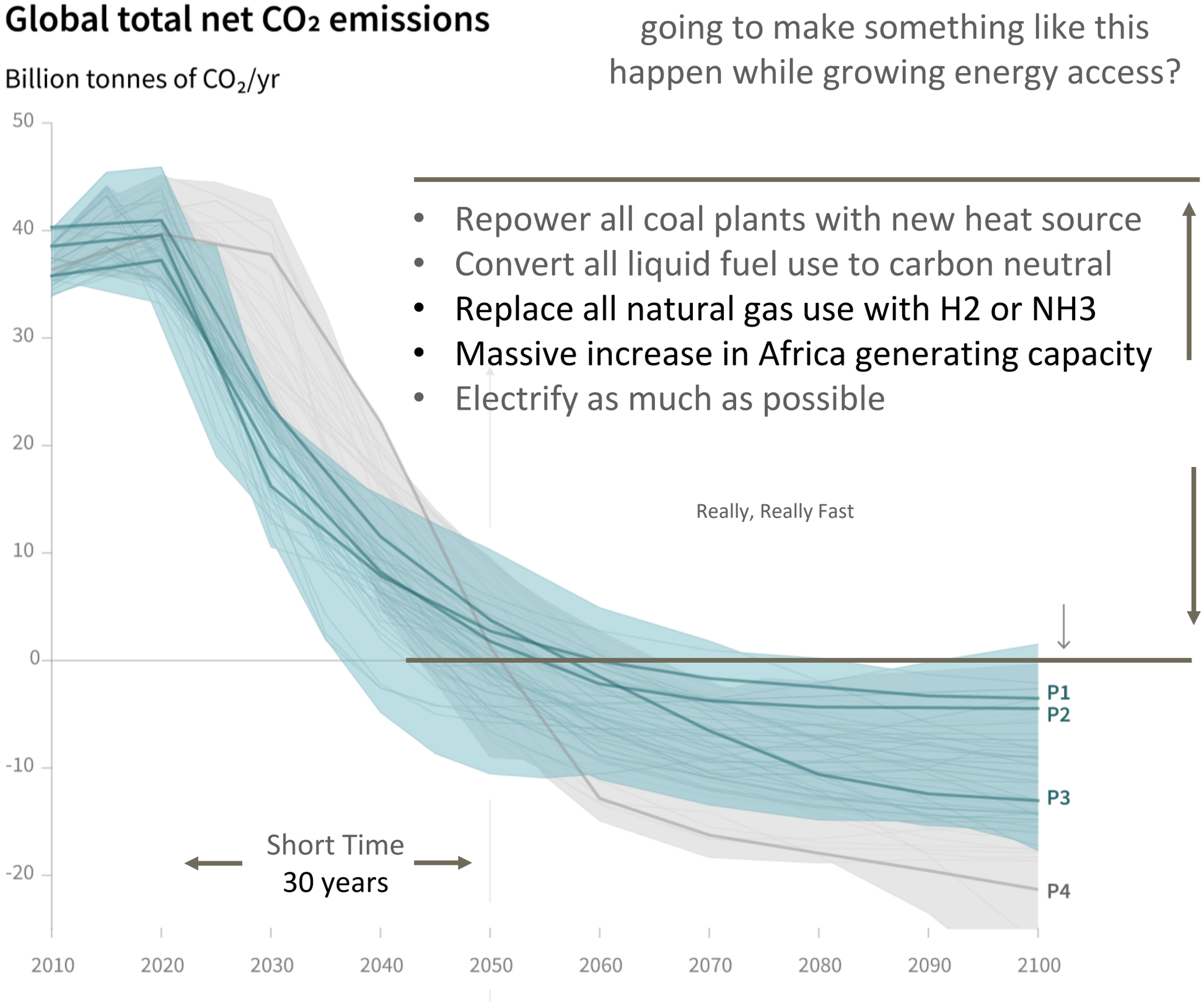

- Repower all coal plants with new heat source
- Convert all liquid fuel use to carbon neutral
- Replace all natural gas use with H2 or NH3
- Massive increase in Africa generating capacity
- Electrify as much as possible

Lots to do!

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

What do we need to do if we are going to make something like this happen while growing energy access?




- Repower all coal plants with new heat source
- Convert all liquid fuel use to carbon neutral
- Replace all natural gas use with H2 or NH3
- Massive increase in Africa generating capacity
- Electrify as much as possible

Lots to do!

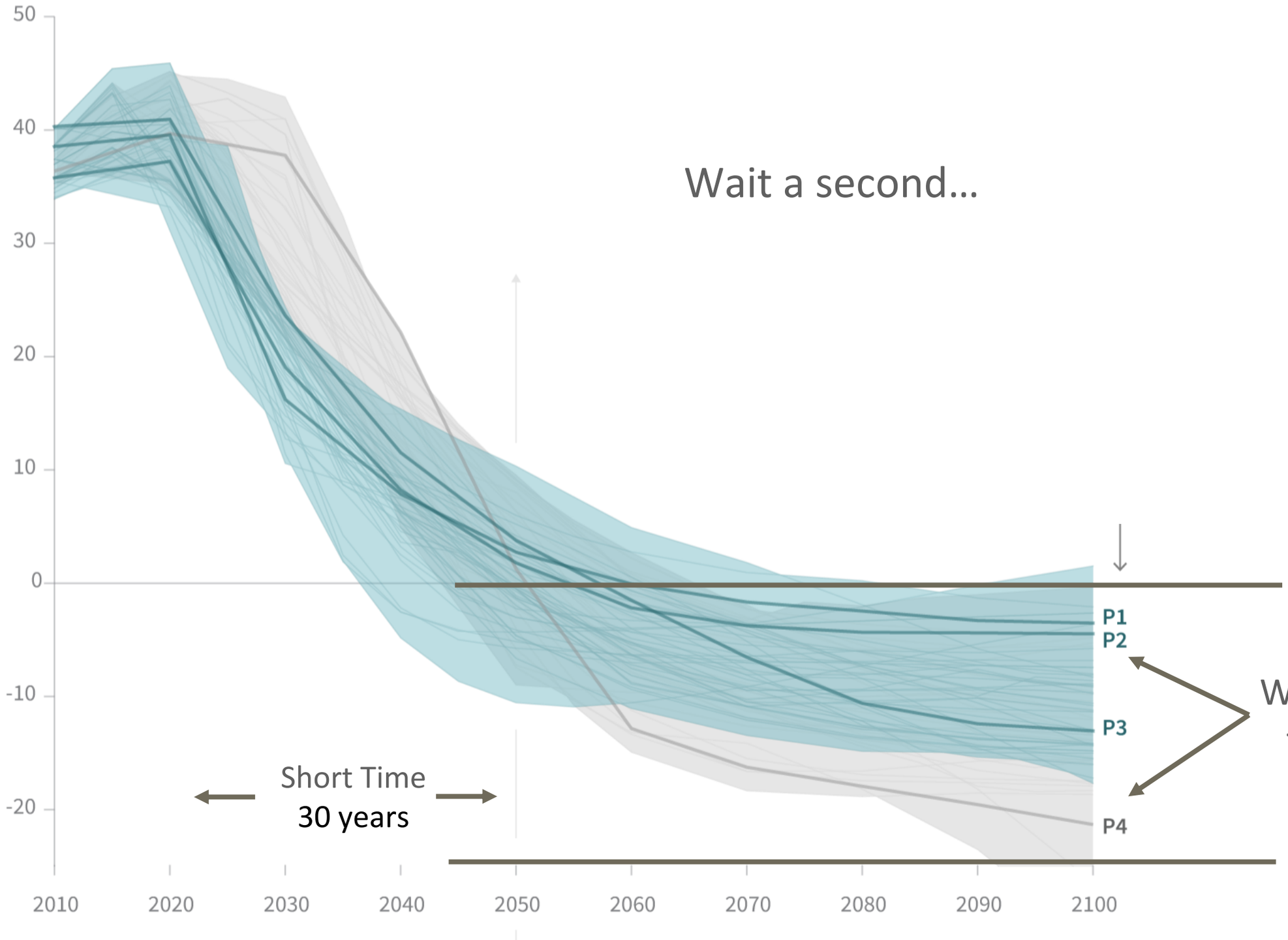
Really, Really Fast

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

## Global total net $CO_2$ emissions

Billion tonnes of $CO_2$/yr



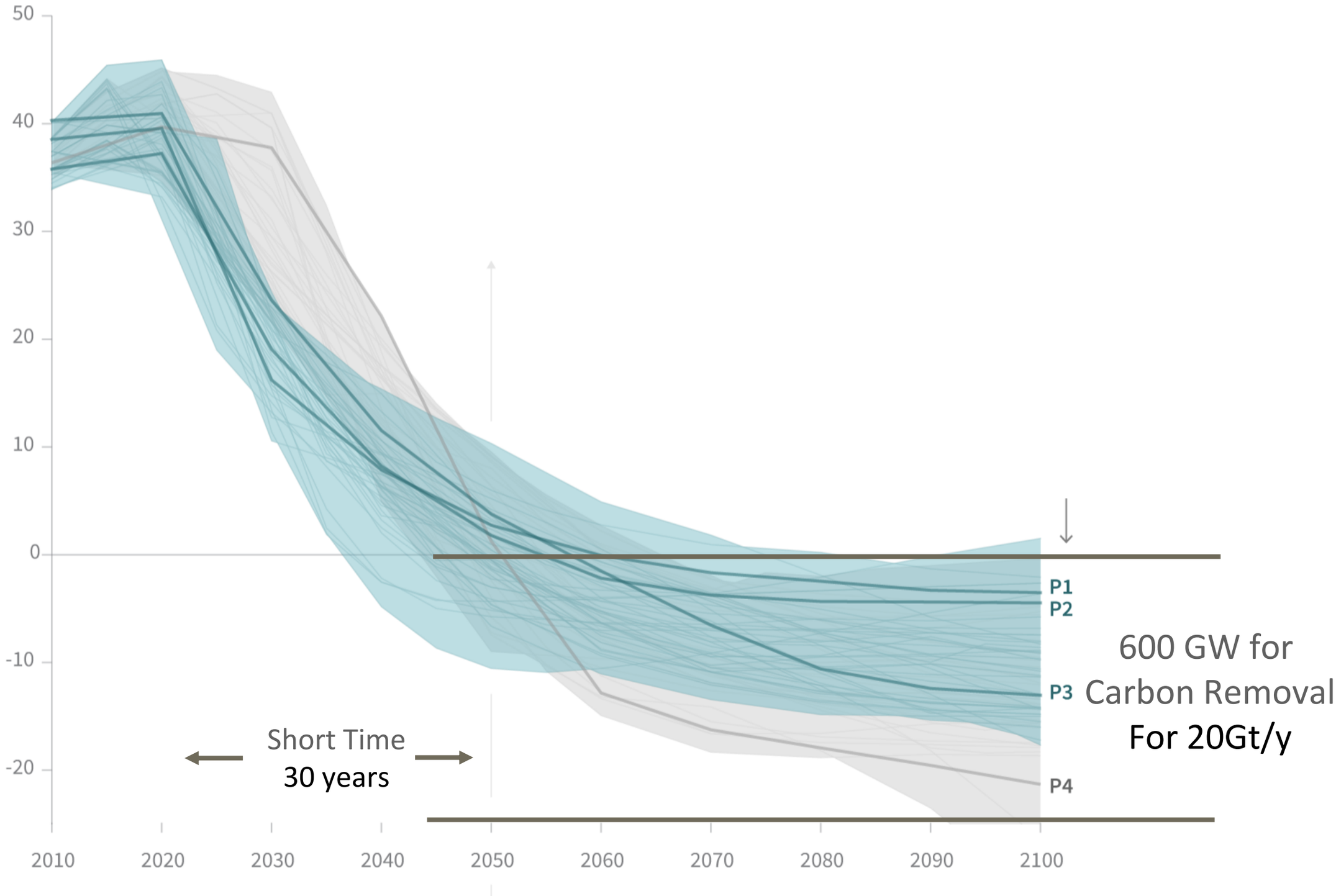

Wait a second…

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

# Global total net $CO_2$ emissions

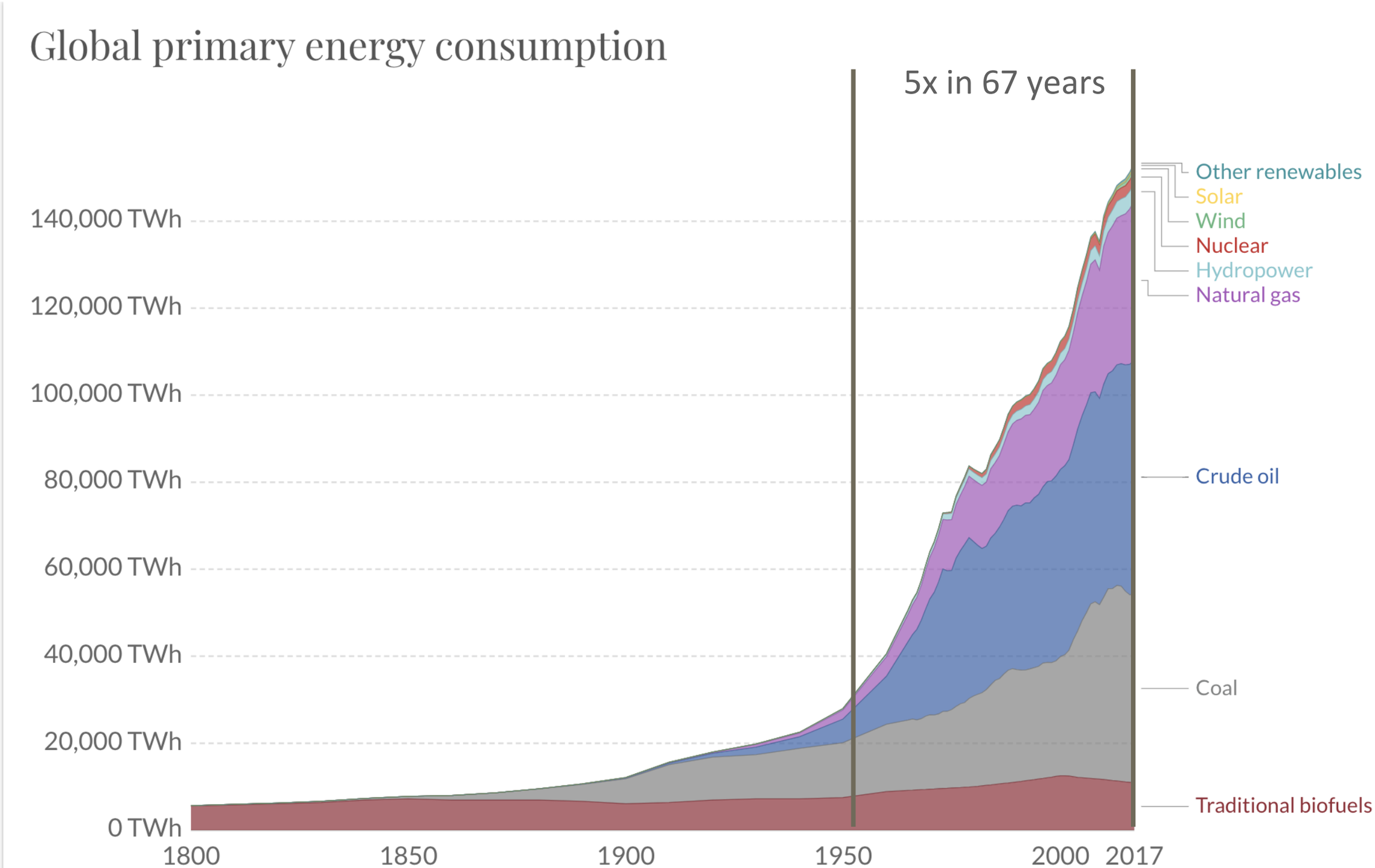
Billion tonnes of $CO_2$/yr




Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY

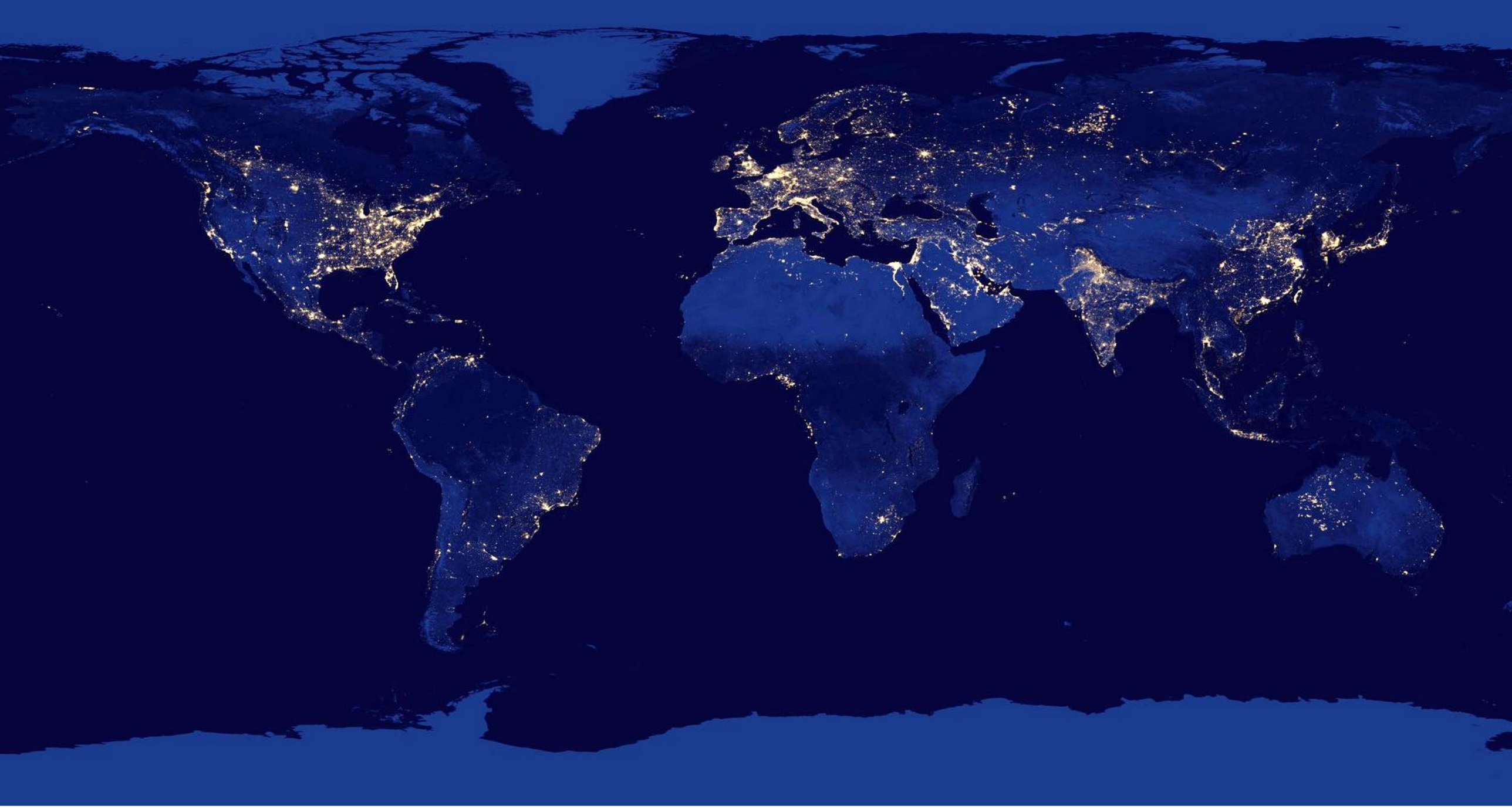
# WE’VE DONE SOMETHING LIKE THIS BEFORE




Source: Vaclav Smil (2017) and BP Statistical Review of World Energy



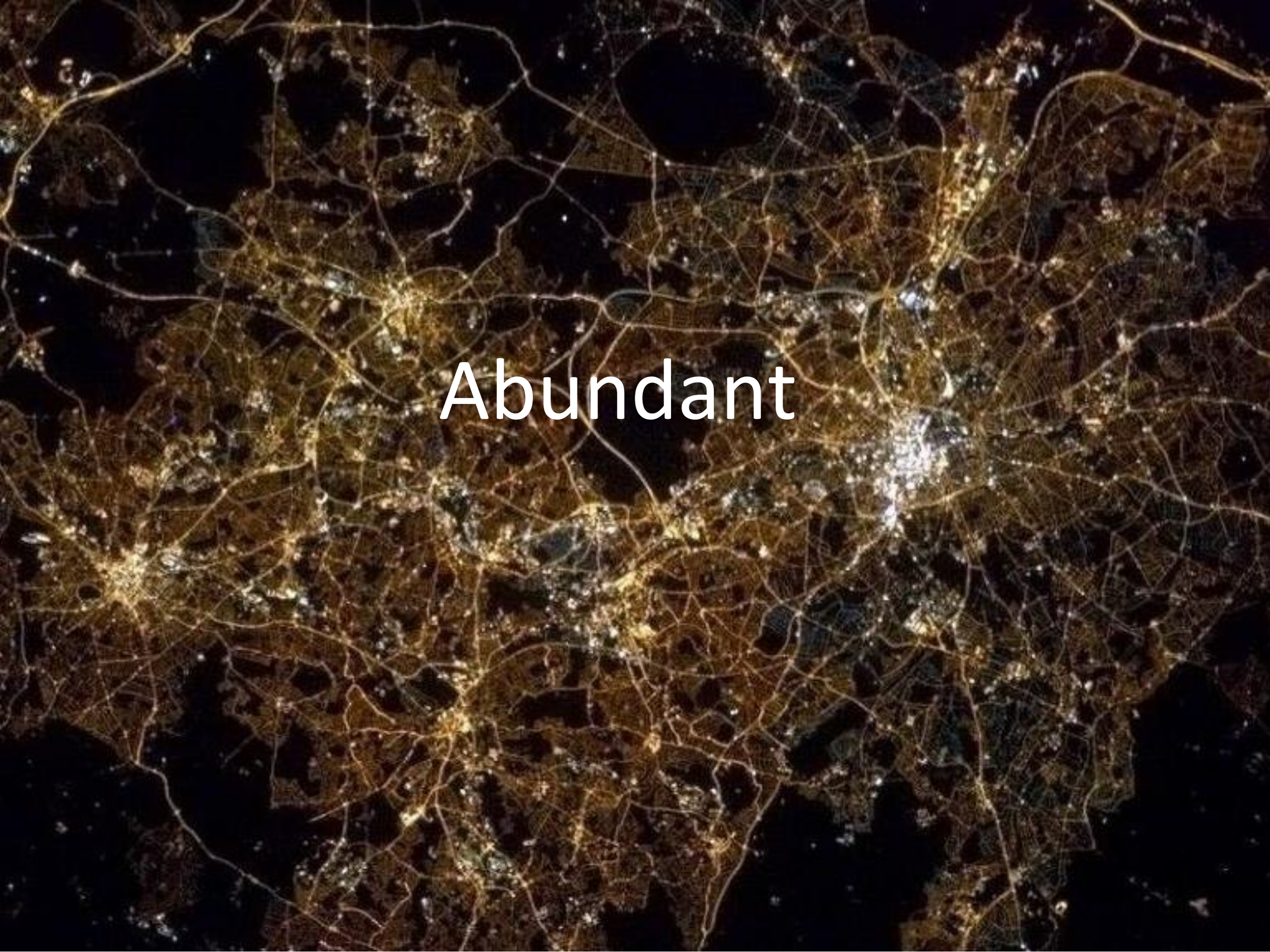
ENERGY HUMANITY



# The world needs genuine zero-carbon substitutes for coal, oil, and gas

ENERGY FOR HUMANITY_

# Cheap


Abundant


Clean

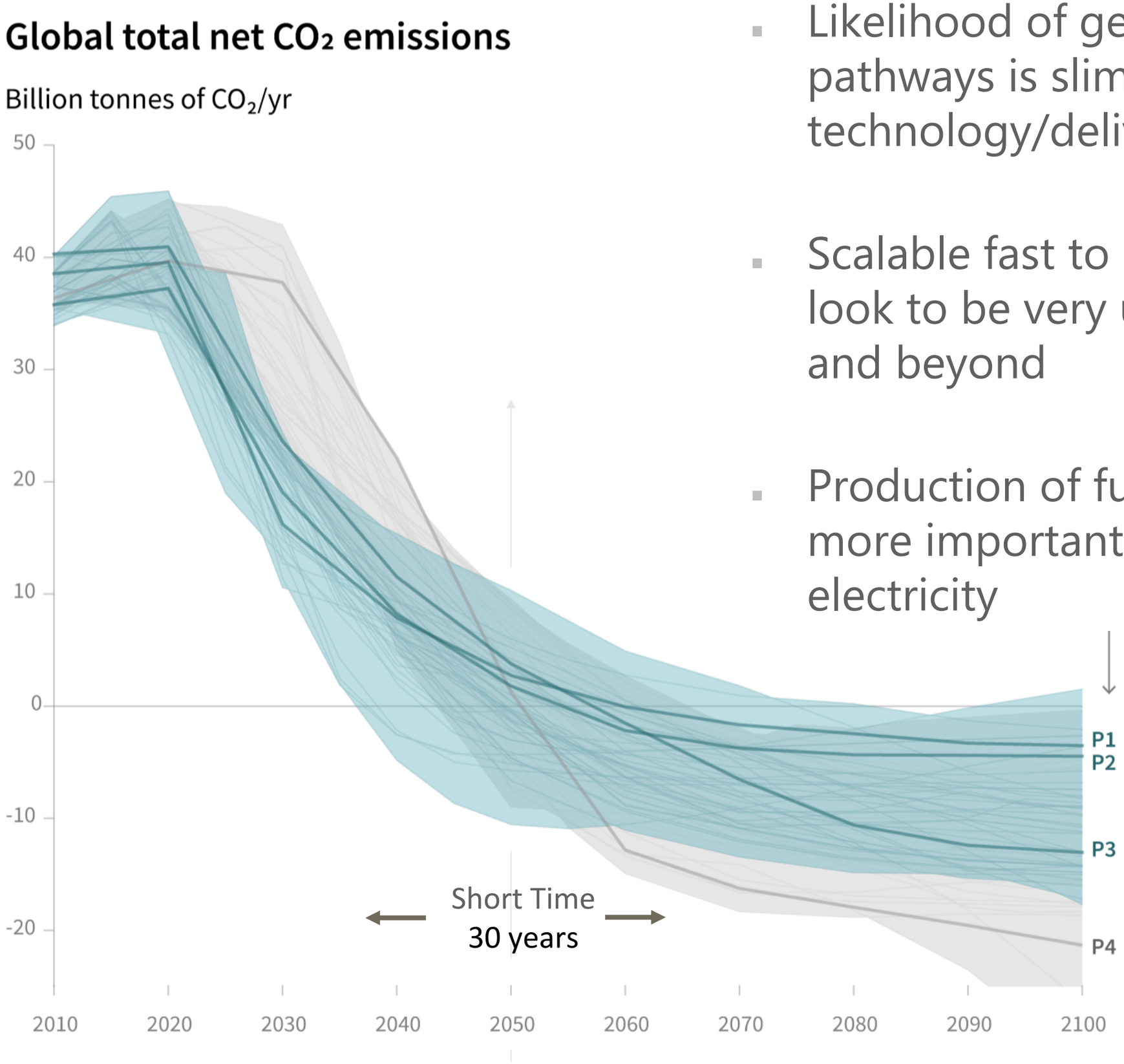
Reliable

# Safe

# Fast to deploy

# Able to repower existing coal plants

ENERGY FOR HUMANITY




- Likelihood of getting on these pathways is slim without much better technology/delivery models
- Scalable fast to deploy energy sources look to be very useful in the 2030's and beyond
- Production of fuels and heat may be more important than production of electricity

Source: IPCC Special Report on Global Warming of 1.5C 2018

ENERGY FOR HUMANITY_

# But nuclear is so unpopular

ENERGY FOR HUMANITY


Station
Travel Enquiries
US STATION
NUCLEAR A
AND THINKS

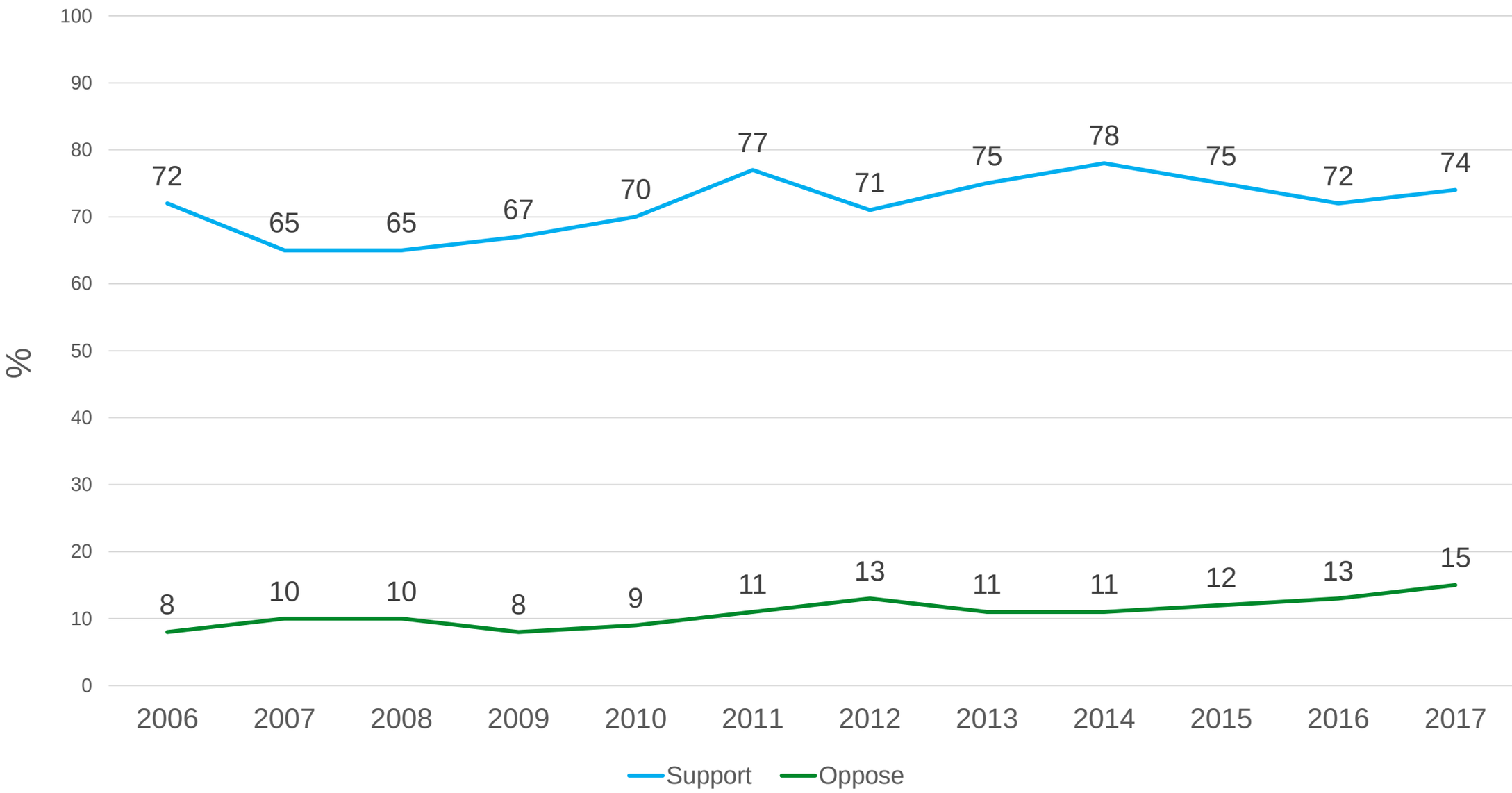

WOMEN AGAINST THE
BOMB


NUCLEAR
DISARMAMENT


WOMEN MARCH FOR PEACE.
WOMEN UNITE for PEACE.

# UK QUARTERLY TRACKING DATA (2017)

## More people support nuclear as part of the low carbon energy mix

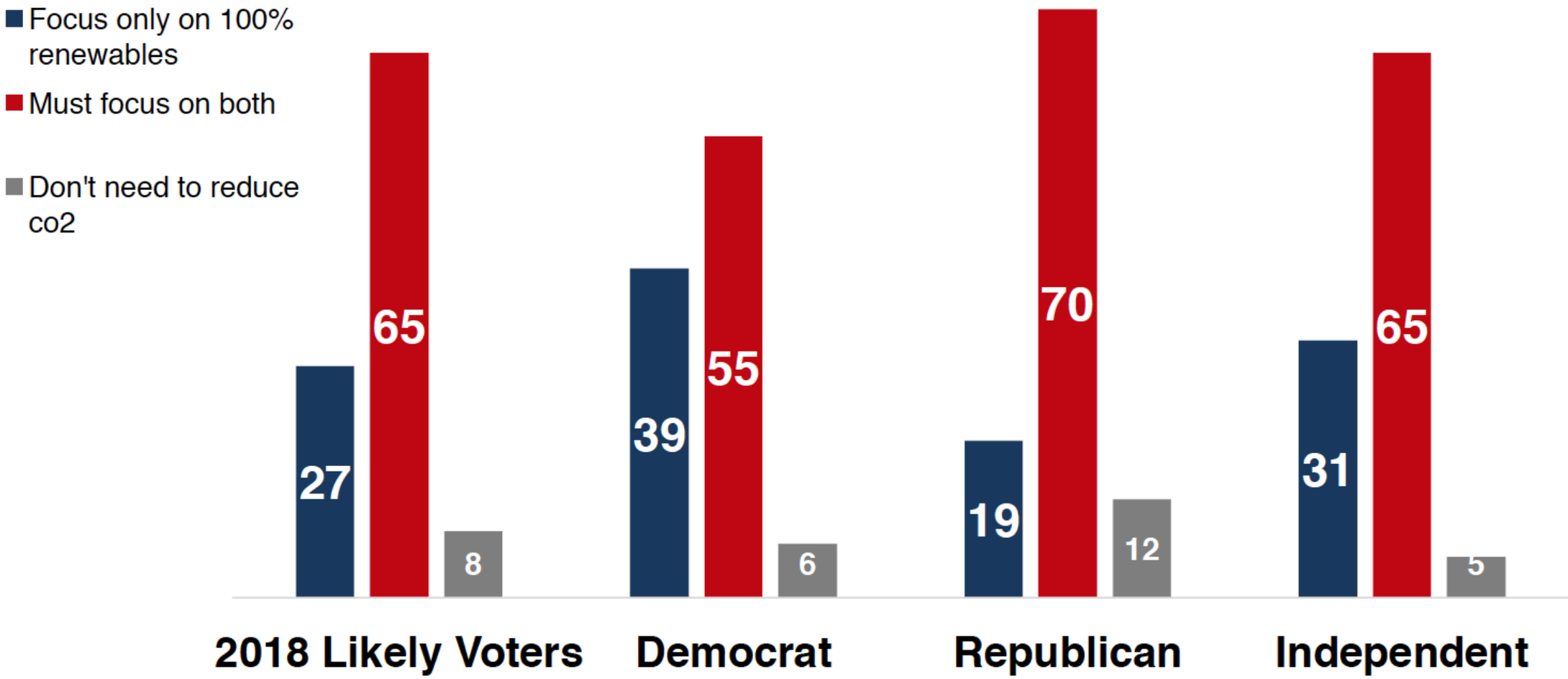



**Source: YouGov**

# Support for “all-of-the-above” low carbon is strong across party lines—with support highest among Republicans and Independents.

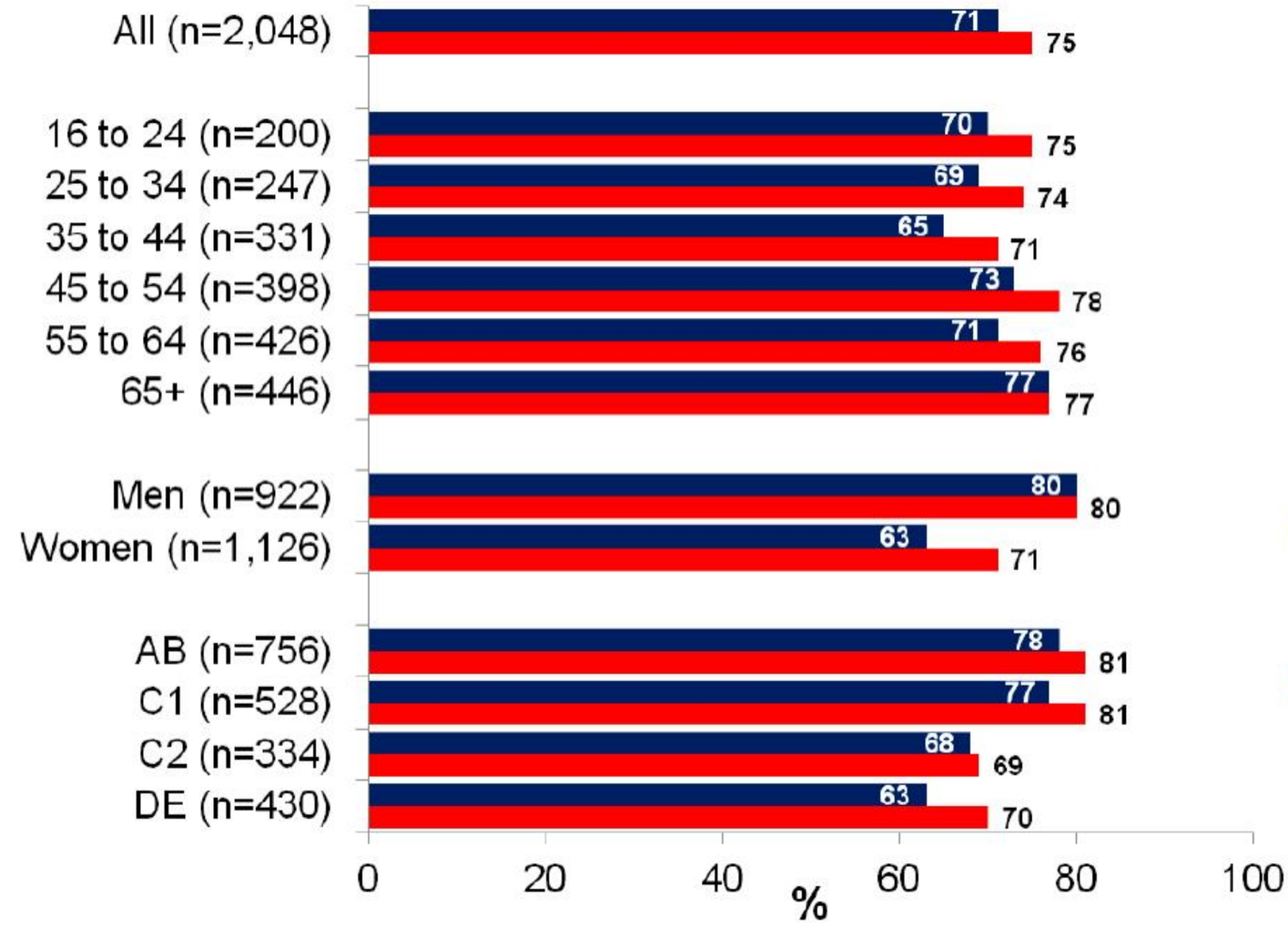
## 100% Renewables Only vs. Focus on Both Low Carbon & Renewables

(by 2016 votes and party identification)




SOURCE: SKDK (CATF)

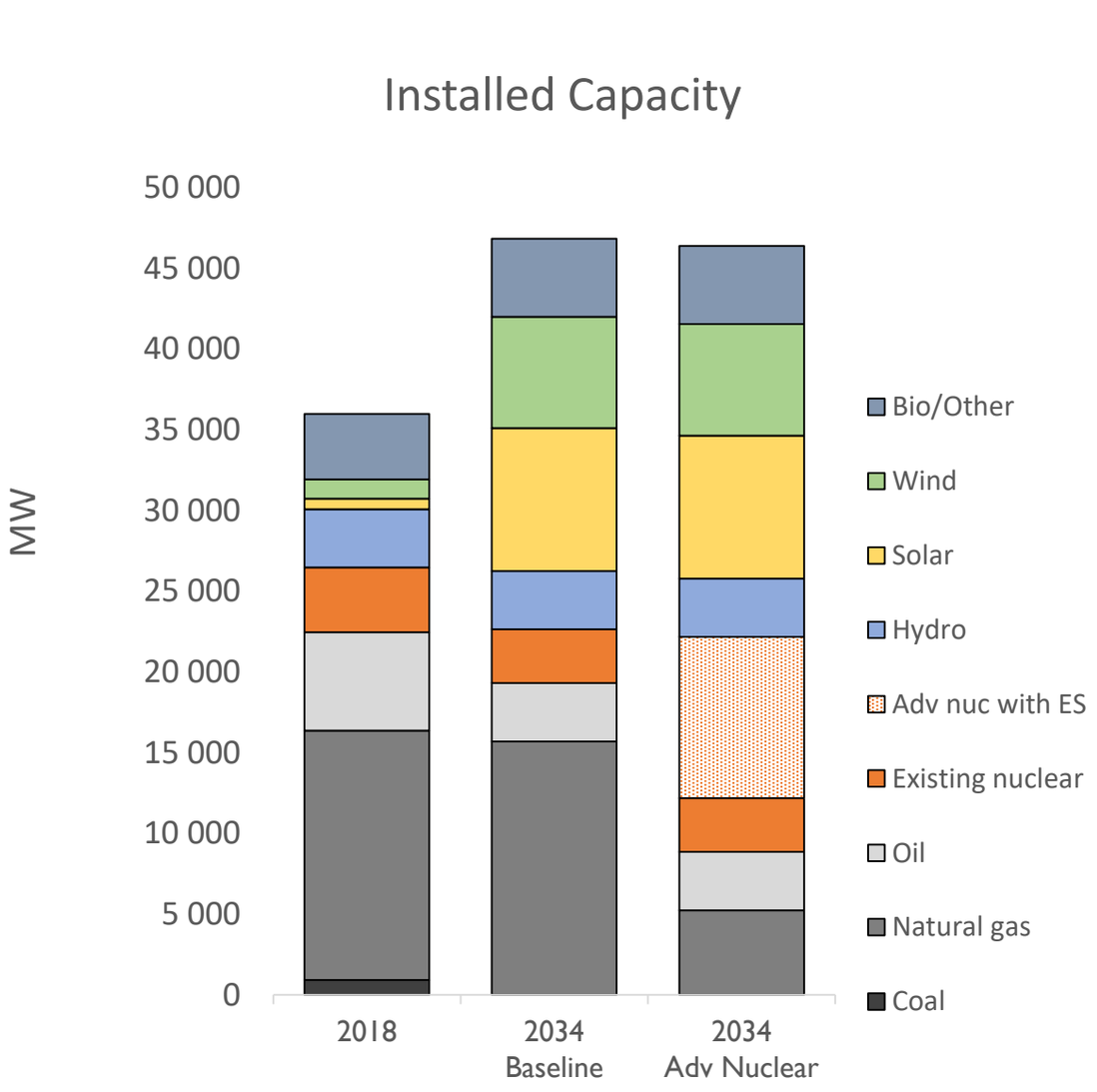
# 75% SUPPORT BALANCED ENERGY MIX INCLUDING NUCLEAR AND RENEWABLES

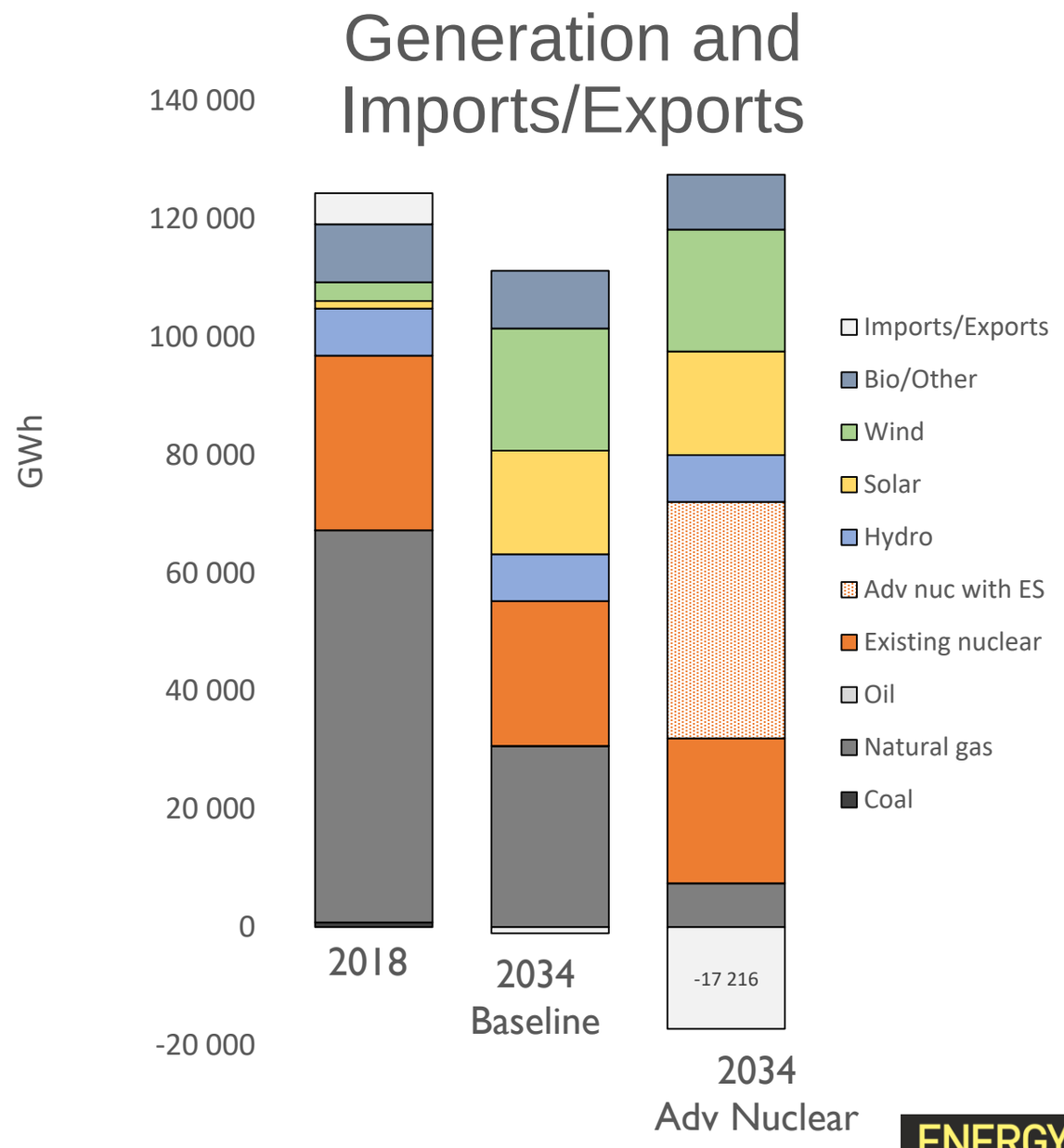



**Who wants a 2030 decarbonisation target?**

ENERGY FOR HUMANITY

# LUCIDCATALYST FLEXIBLE NUCLEAR STUDY FOR ARPA-E: ISO-NE NREL



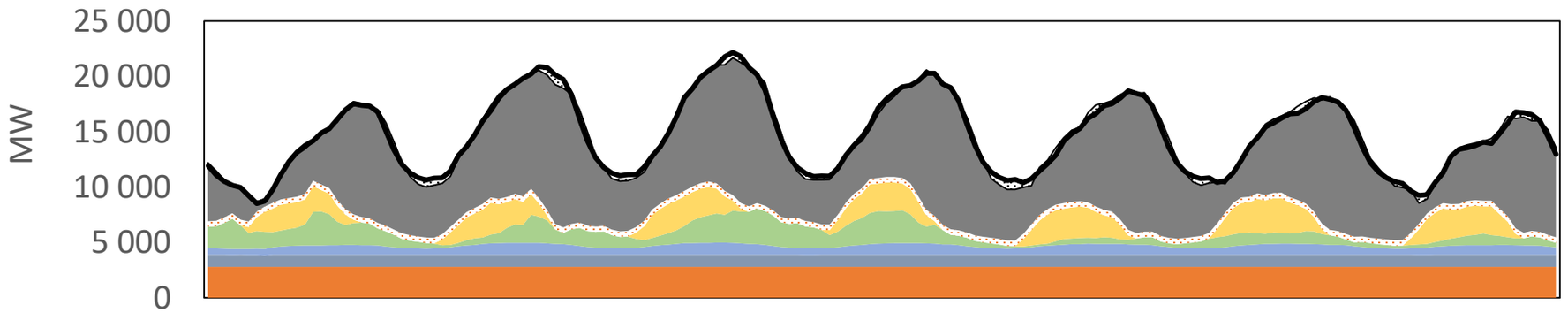

- *Overall generation increases in the Advanced Nuclear scenario enabling clean energy exports.*

ENERGY FOR HUMANITY

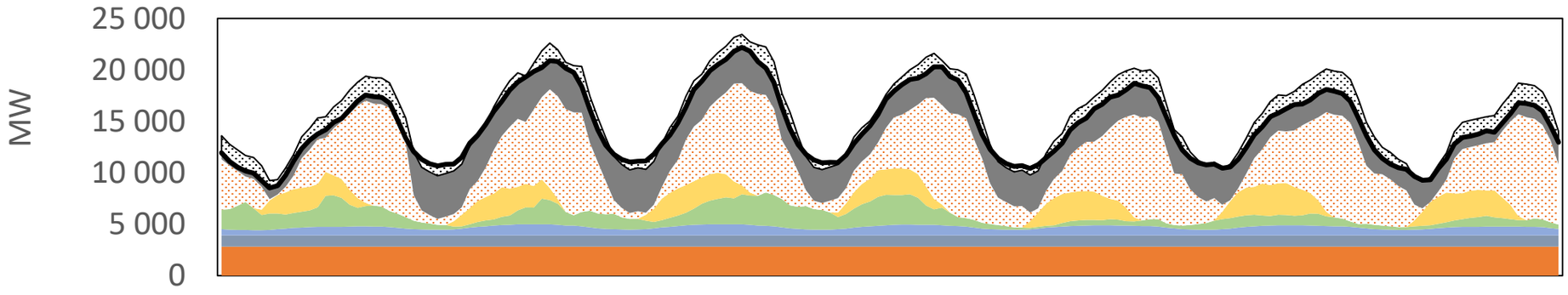
# CLOSE UP ON 2034 SCENARIO: DISPATCH IN MID JULY (DURING SEASONAL SOLAR PEAK)

## Flexible advanced nuclear, when coupled with storage, can provide the same grid flexibility as CCGTs

1 Plant (500 MW average 1GW peak)




10 Plants (5,000 MW average 10GW Peak)




ENERGY FOR HUMANITY

## CONTACT INFO:

**info@nice-future.org**

NICE Future
Nuclear Innovation: Clean Energy Future
An Initiative of the Clean Energy Ministerial

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

ENERGY FOR HUMANITY_

ENERGY OPTIONS NETWORK

CLEARPATH

FNC

# FLEXIBLE NUCLEAR CAMPAIGN
FOR NUCLEAR-RENEWABLES INTEGRATION

A CAMPAIGN OF THE CLEAN ENERGY MINISTERIAL

ENERGY FOR HUMANITY_

How to move towards a whole system mindset

Frame the whole discussion from the start in terms of whole system thinking - how can we design the highest possible performing system (clean, reliable, affordable, flexible) with a diverse portfolio of technologies?

- Imagine if the energy transition was designed to achieve outcomes – clean air; resource efficient; climate friendly; protecting nature; abundant; scalable; low cost – in a genuinely technology-neutral way?
  - What would change?
- Imagine committing as much resource and effort to increasing deployment rates, and driving down costs for all low carbon technologies identified as necessary by the IPCC as we have done for wind and solar.
  - What would the effect be?
- Technology tribalism in climate and energy discourse prohibits a whole energy system perspective.
  - Hinders efforts to determine the fastest, most cost effective, most feasible pathways to rapid, deep and affordable decarbonisation.
- Whose interests does it serve to differentiate between technologies, rather than focus on overall performance of the whole system.
  - Establish cost and performance requirements including emissions, and other sustainability factors and then design systems to deliver against those metrics.
- Apply the whole systems perspective beyond the power sector to decarbonise the whole economy affordably and at scale.
  - Through the production of hydrogen and clean synthetic fuels.
    - Repurpose existing infrastructure and distribution networks where most appropriate and efficient to achieve identified goals and outcomes.
- Apply learning from successful wind and solar cost reduction and rate of deployment to all low carbon technologies.
  - Consistent determination to enable cost reduction and high deployment across all technologies identified by IPCC within defined system parameters.

ENERGY FOR HUMANITY_

- IRENA merging with IAEA
- Weird uncomfortable feeling you get when you think about that shows how differently we think about those technologies
  - Inconsistency in access to finance, regulatory burden, policy support, advocacy
    - *Standardised & consistent approach to best practice across all technologies*
      - *Access to finance*
      - Siting
      - *Consistent independent regulation*
      - *Investment in supply chain development and capability*
      - Project management
  - Matthew Nisbett study showing extent of climate funding for RES compared to nuclear
  - Thought experiment shows how wide the gap really is

ENERGY FOR HUMANITY

# All our climate solutions need to be impossible burgers

ENERGY FOR HUMANITY_

# Thank You


Kirsty Gogan
Energy for Humanity
@kirstygogan
www.energyforhumanity.org


ENERGY FOR HUMANITY_