



ENERGY TRANSITIONS

EXPLORING GLOBAL ENERGY SCENARIOS

Session 4

Is there a realistic Best Global Energy Mix for 2030?

IEEJ 50th and APERC 20th Anniversary Symposium

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WARNING: UNCERTAINTIES AHEAD

The Scenarios are part of an ongoing process used in Shell for 40 years to challenge executives' perspectives on the future business environment. We base them on plausible assumptions and quantification, and they are designed to stretch management to consider even events that may be only remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes and investors should not rely on them when making an investment decision with regard to Royal Dutch Shell plc securities.

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THE ENERGY CHALLENGE

RISING ENERGY DEMAND, SUPPLY PRESSURE, CLIMATE CHANGE



9.5 billion people, **75%** living in cities in 50 years time

(2.5 billion more than today)



Hundreds of **millions** of people will rise out of poverty; with higher living standards energy use rises



Energy demand could **be 60% more** over the next 50 years while CO₂ emissions must be a **quarter of** today's to avoid serious climate change



Emissions need to **peak** next decade to meet COP21 aspirations

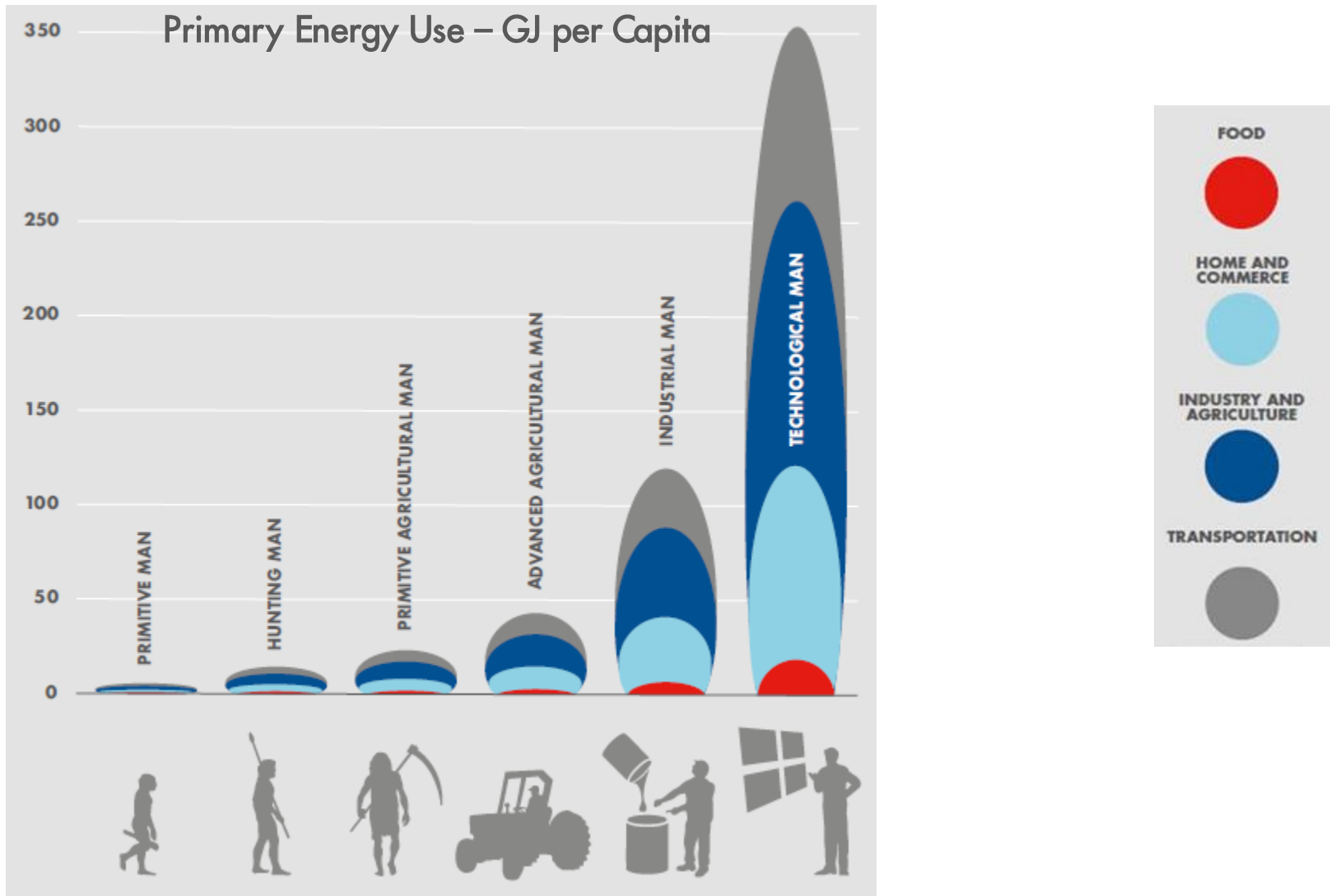


Twice as efficient, using **half** the energy to produce each dollar of wealth



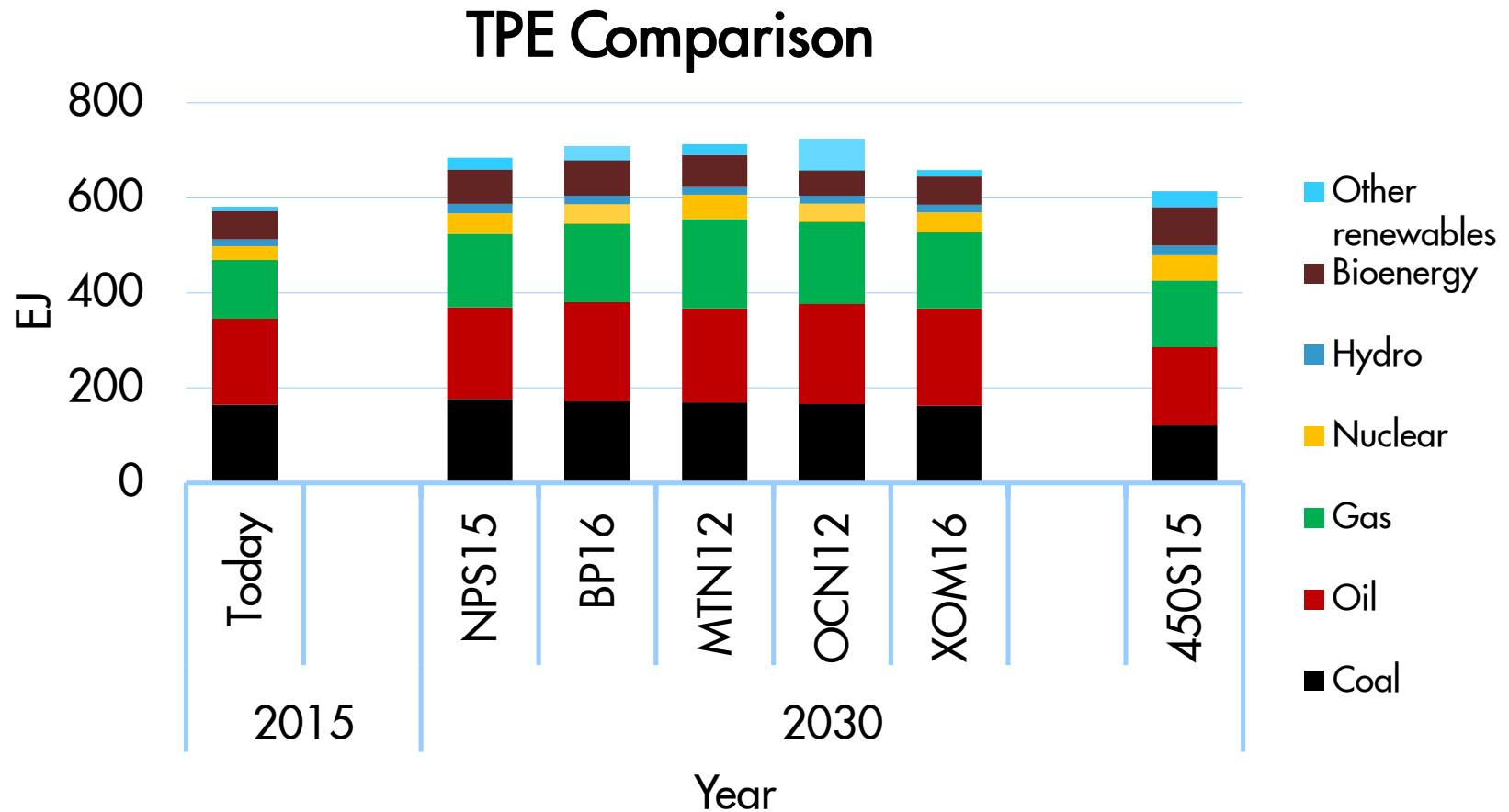
Up to **4** times more energy from renewable sources by 2060

EVOLUTION OF PRIMARY ENERGY CONSUMPTION BY MAN



Source: The flow of Energy in an Industrial Society, Earl Cook, Scientific American, 1971
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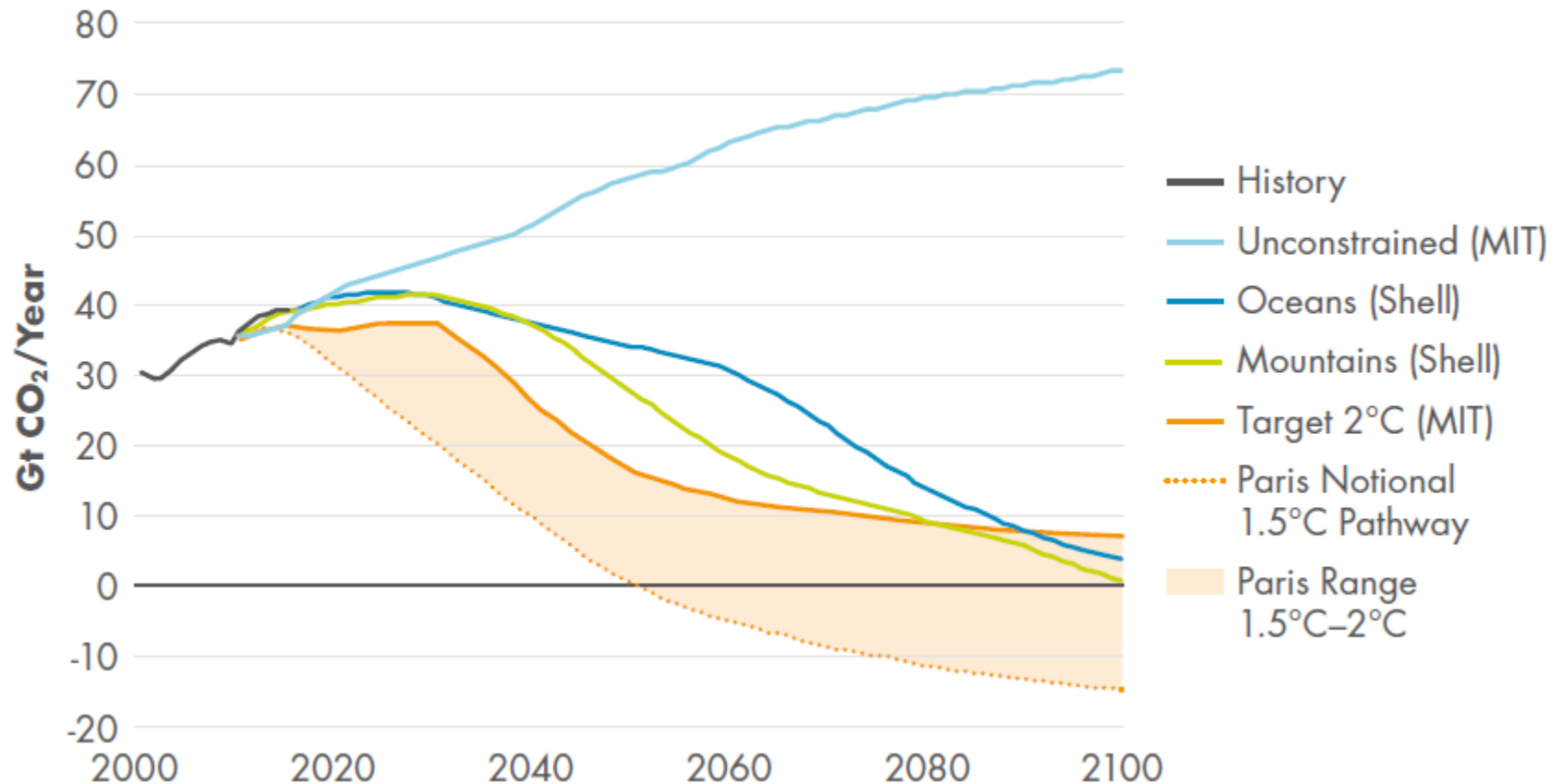
IS THERE A REALISTIC BEST GLOBAL ENERGY MIX FOR 2030?



- Not much differentiation for the 2030 Energy Mix according Industry
- Only the normative 450 pathway shows the first steps towards a 2° world

Sources: IEA, BP, XOM, Shell analysis

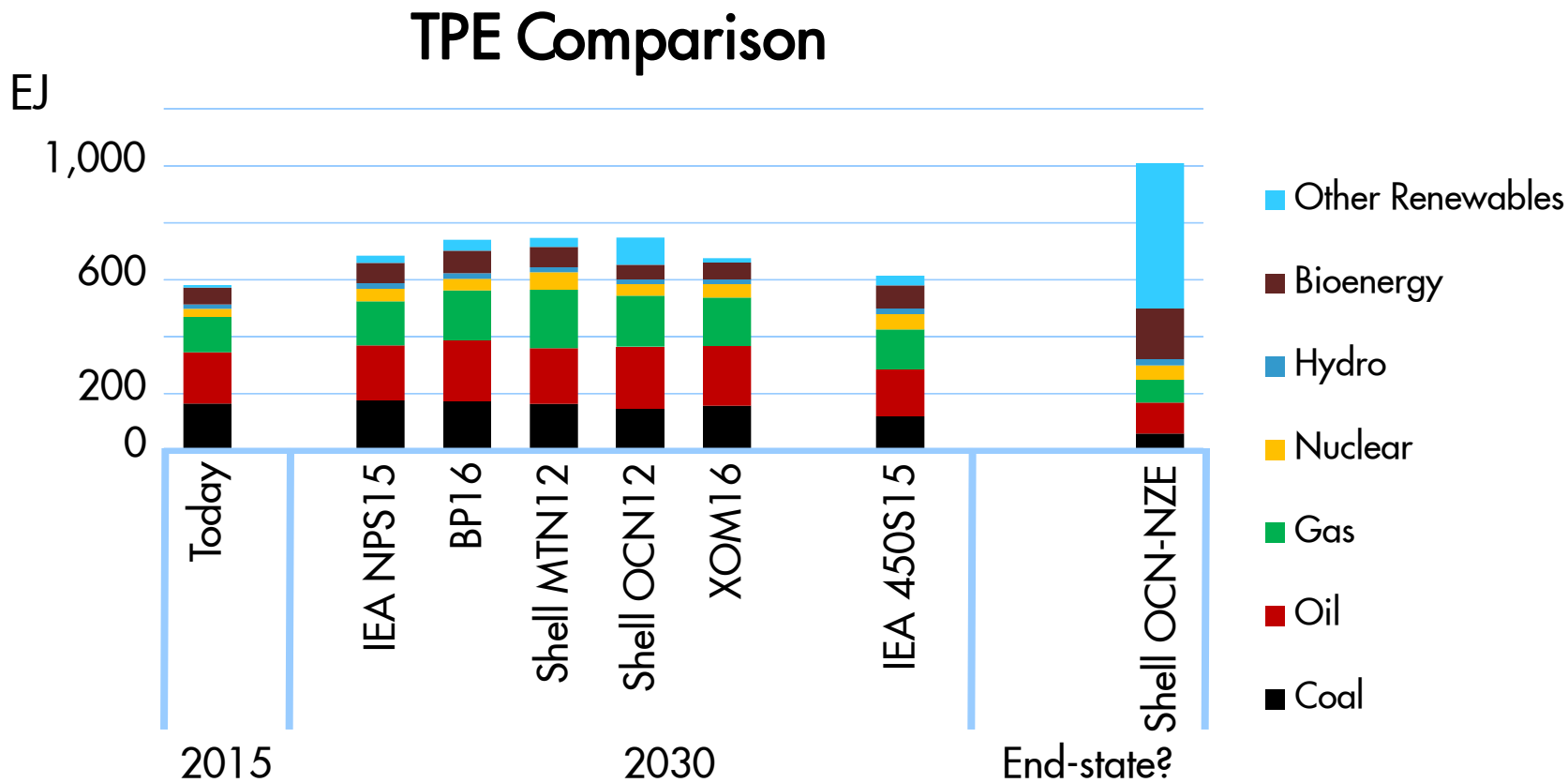
PATHWAYS FOR TOTAL CO₂ – HOW TO TURN FASTER?



- Much more needs to be done for a 2° world, and even more for a 1.5° world

Source: Shell analysis – World Energy Model and MIT's Outlook

A NET-ZERO EMISSION WORLD LOOKS VERY DIFFERENT

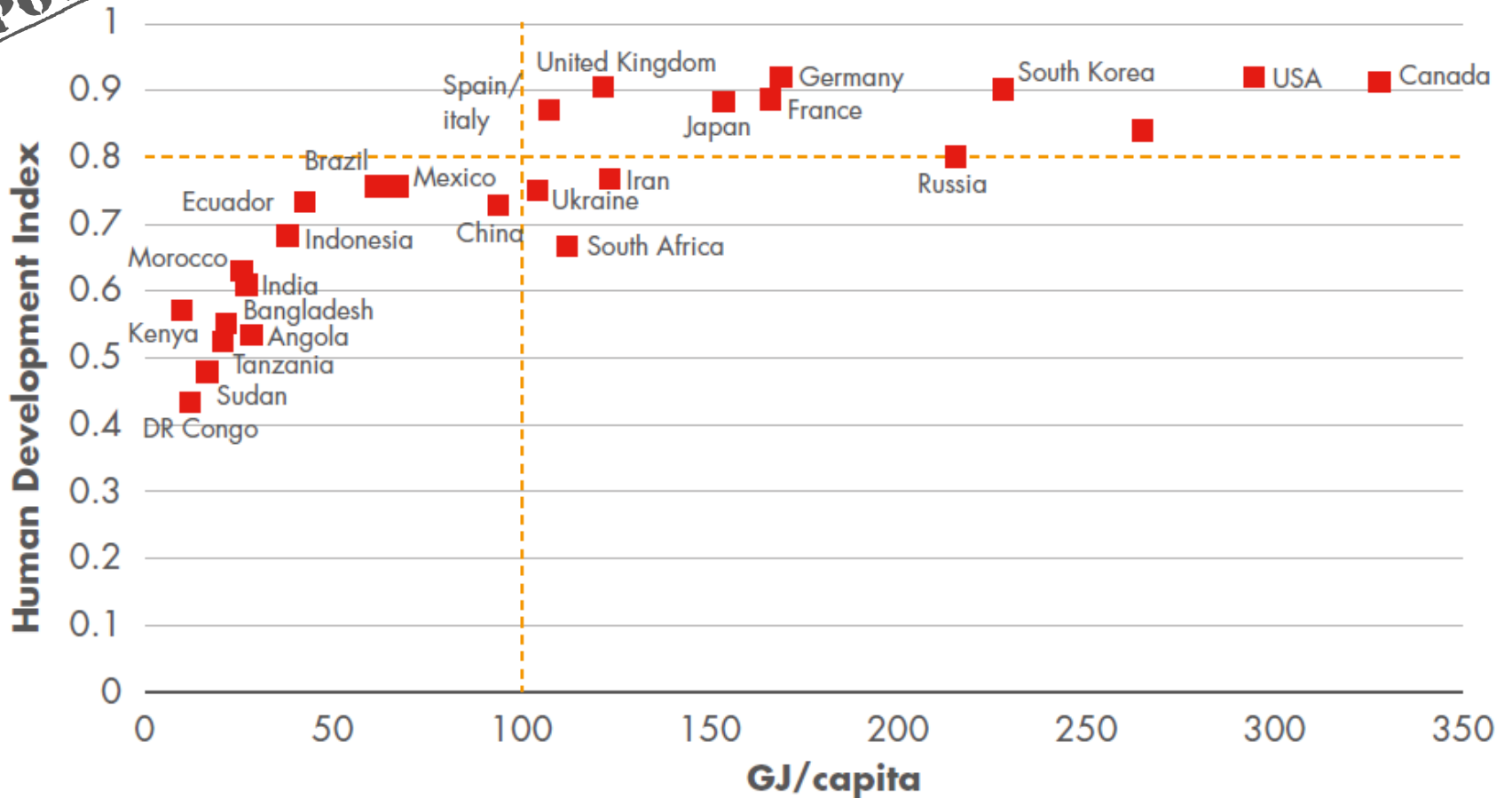


- More energy could be used in the “end-state” as long as it is from renewable electrons, or Hydrogen via electrolysis from renewable electrons

Sources: IEA, BP, XOM, Shell analysis

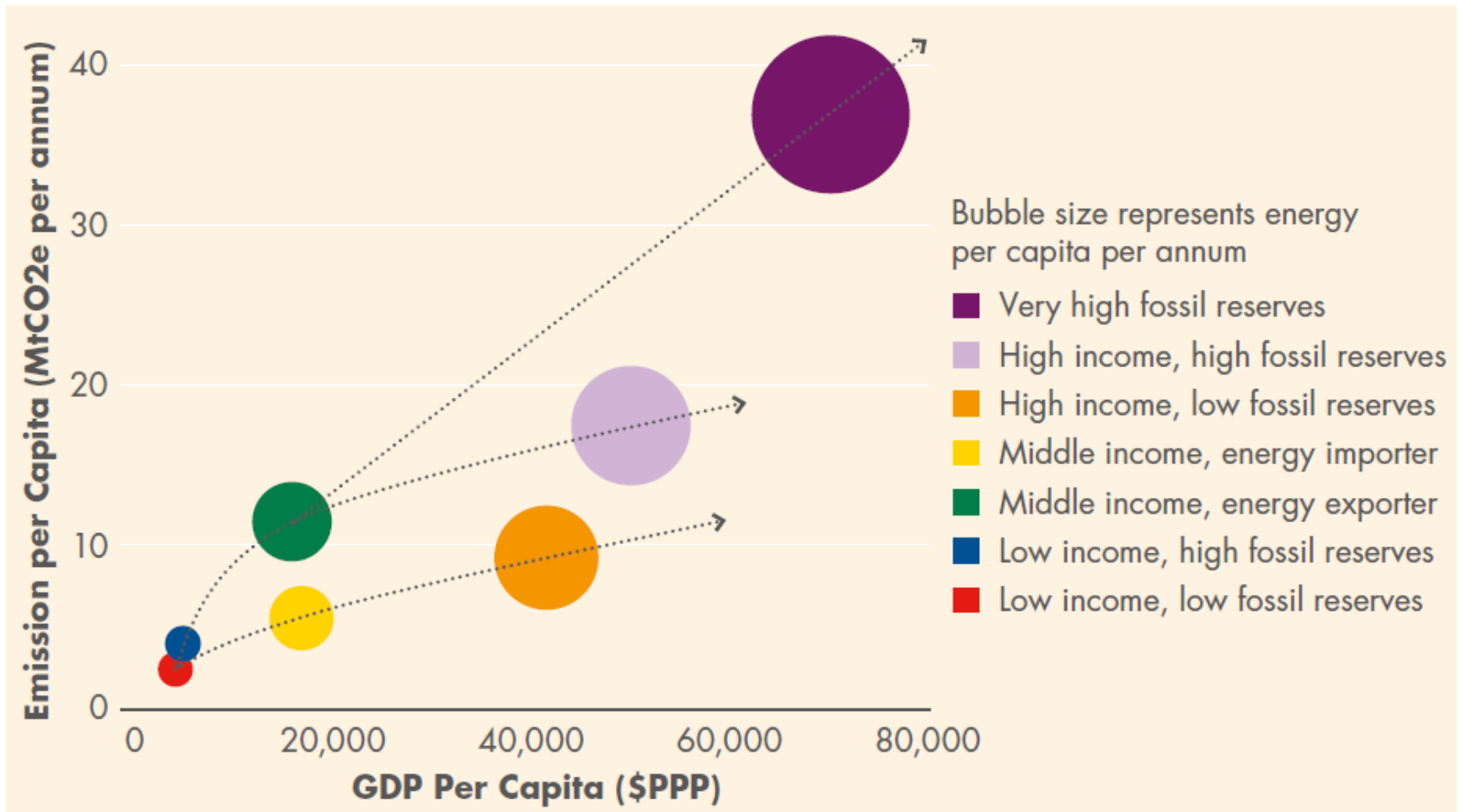
100 GJ/CAPITA PER YEAR IS SUFFICIENT FOR A DECENT LIFE

HYPOTHESIS



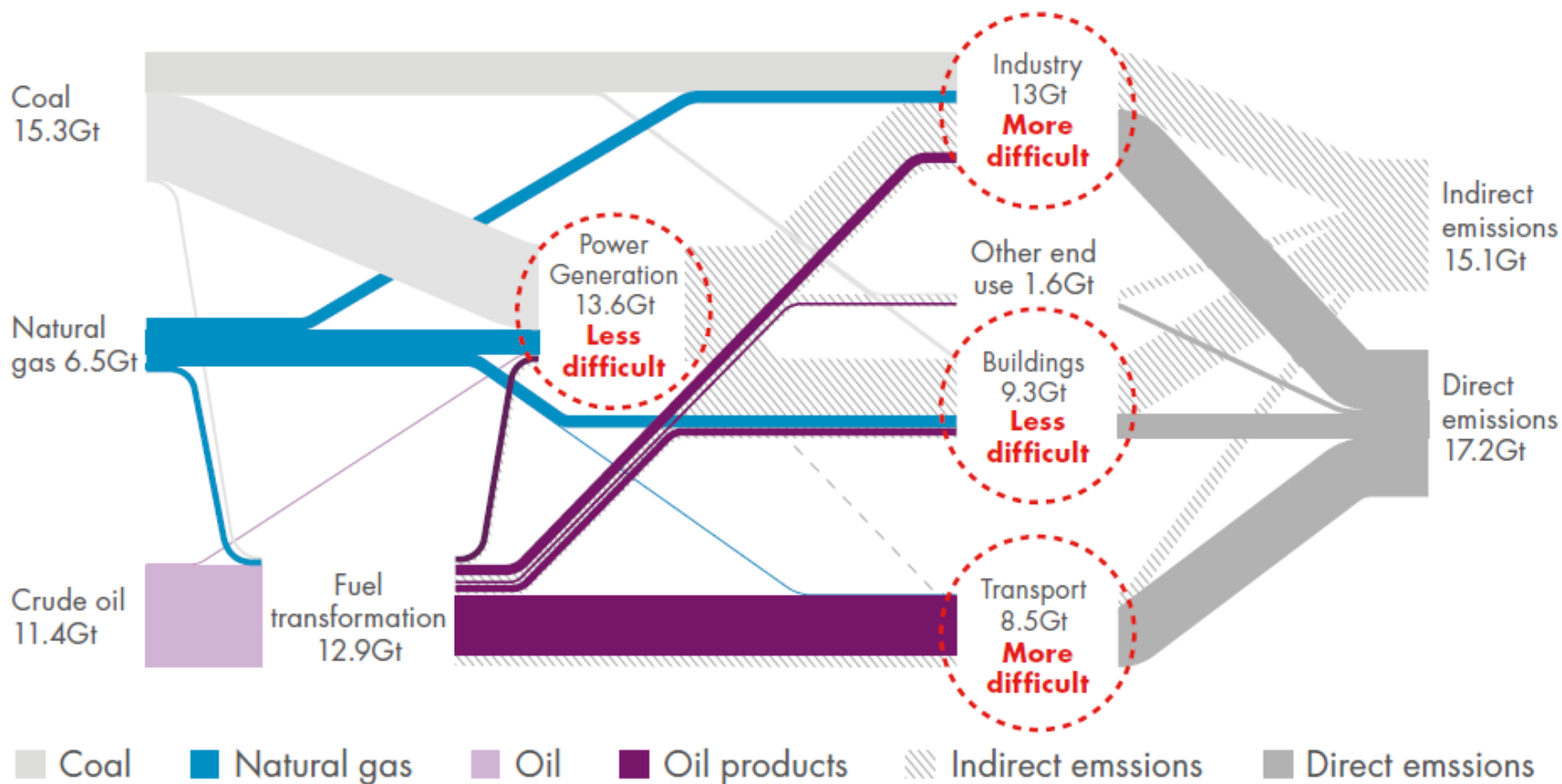
Source: Shell analysis - UN Human Development Index

HISTORIC RELATIONSHIP BETWEEN INCOME AND EMISSIONS



Source: Shell analysis

SOURCES OF ENERGY-RELATED CO₂ EMISSIONS



■ **Less difficult** or **more difficult** is both a technical and political assessment

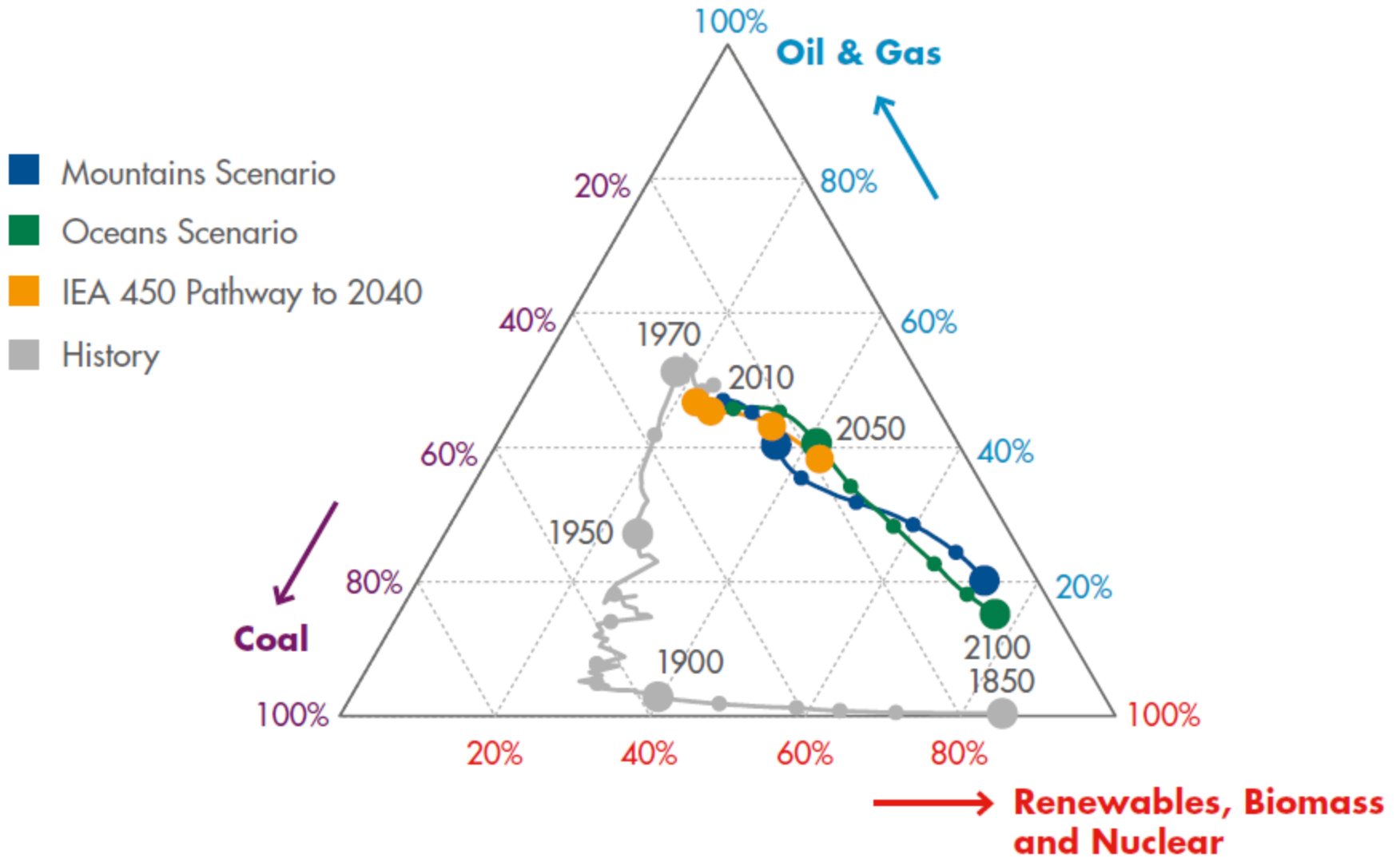
Source: Shell analysis

IT WILL TAKE DECENNIA TO REPLACE OUR INFRASTRUCTURE

Average Infrastructure turnover in years

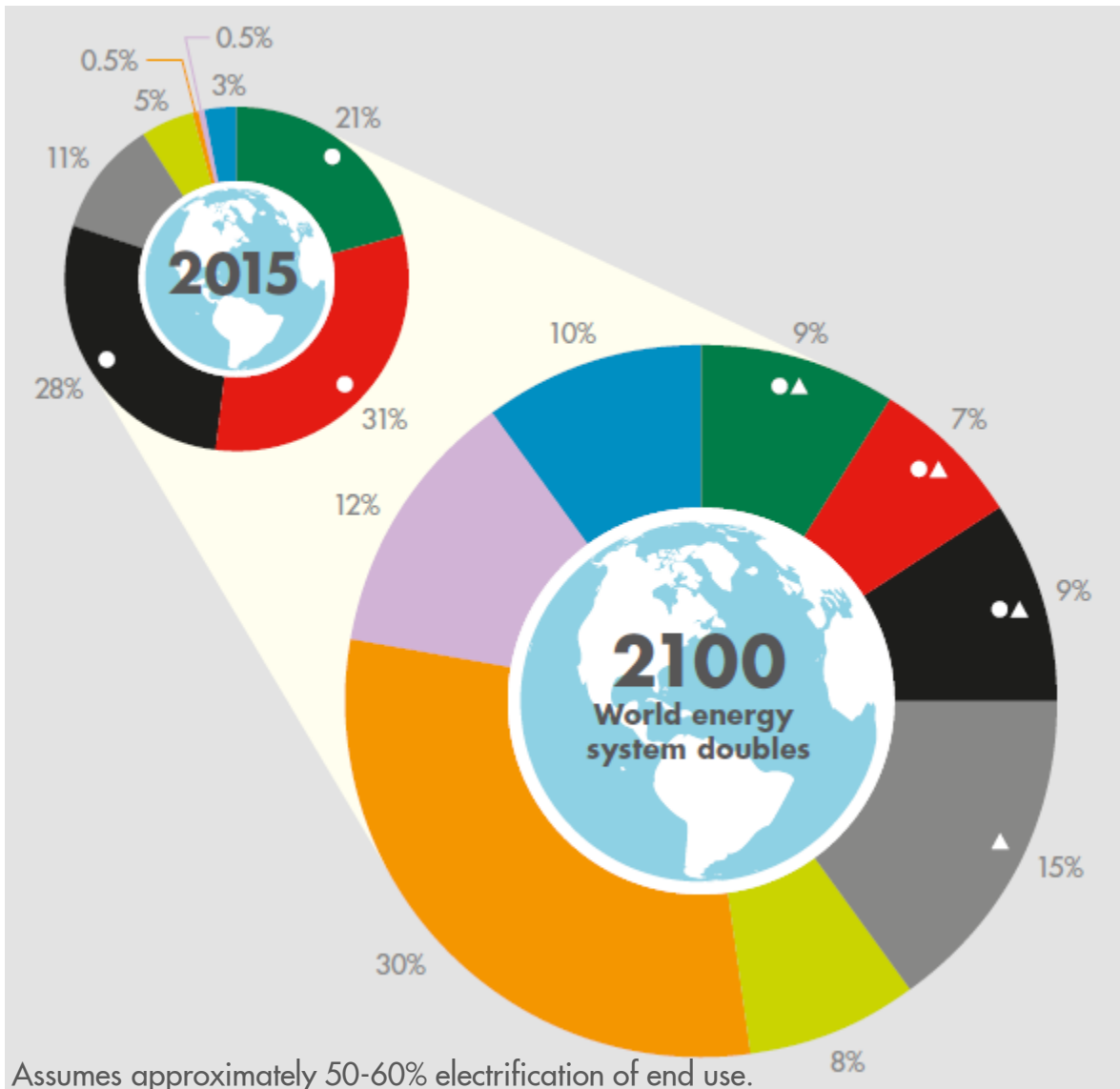


THE ENERGY TRANSITION – GOING FULL CYCLE



Source: Graph based on L. Barreto, *et al.*, *Int. J. H2 Energy* 28 (2003) 267. Data prior to 1960 was taken from the IIASA PFU database (Version 0.0.2) <https://intcat.iiasa.ac.at/PFUDB>; data 1960-2014: IEA and Shell; data 2015-2100: Shell NLS scenarios.

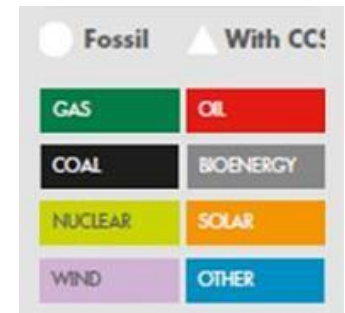
ENERGY MIX IN A NET-ZERO EMISSIONS WORLD



Assumes approximately 50-60% electrification of end use.

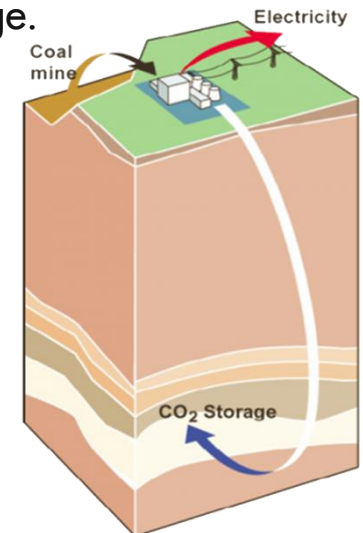
Source: Shell analysis

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Limiting the accumulation of CO₂ is only possible by;

- Ending fossil carbon extraction or;
- Utilizing carbon capture & storage.



CONCLUDING REMARKS



STEPS TOWARDS A PROSPEROUS NET-ZERO EMISSIONS WORLD...

Encourage responsible development of all energy sources and trade

Recognise that some Sectors and some Countries will transition more slowly

Policy support for:

- Government-led Carbon Pricing mechanisms
- Carbon dioxide capture & storage (CCS)
- Sustainable agriculture including biomass

Addressing Consumption Sectors

- End-use efficiency
- Effective urban development
- Sector-targeted Research and Development

