

The State of the World in Energy in Twenty Charts

**ILS 6th Annual Conference on Energy Arbitration and
Dispute Resolution in the Middle East and Africa**

**Herbert Smith Freehills, London
27 June 2023**

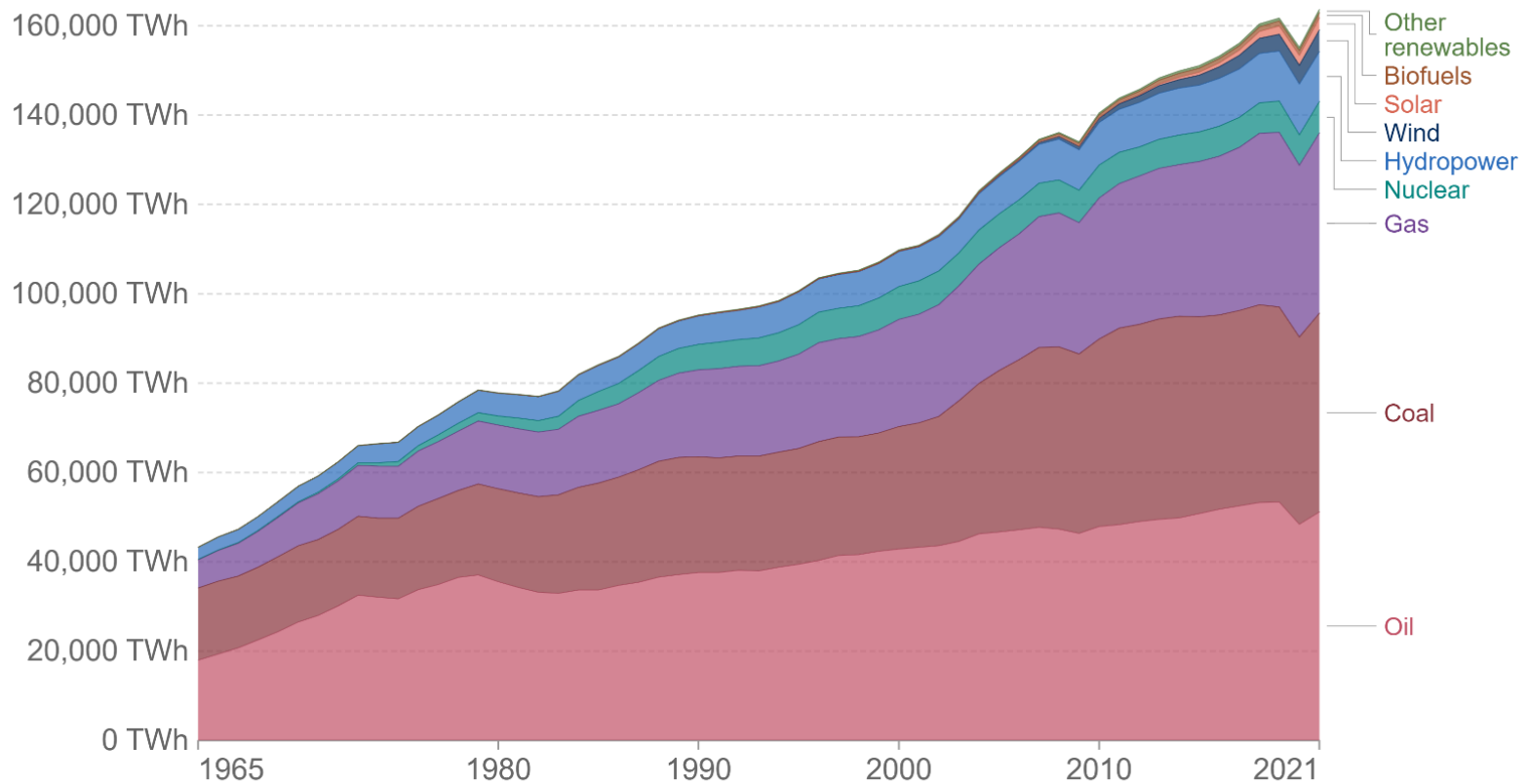
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Partner, Bates White Economic Consulting**

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1. The global primary energy mix remains heavily dependent on fossil fuels...

Energy consumption by source, World

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.

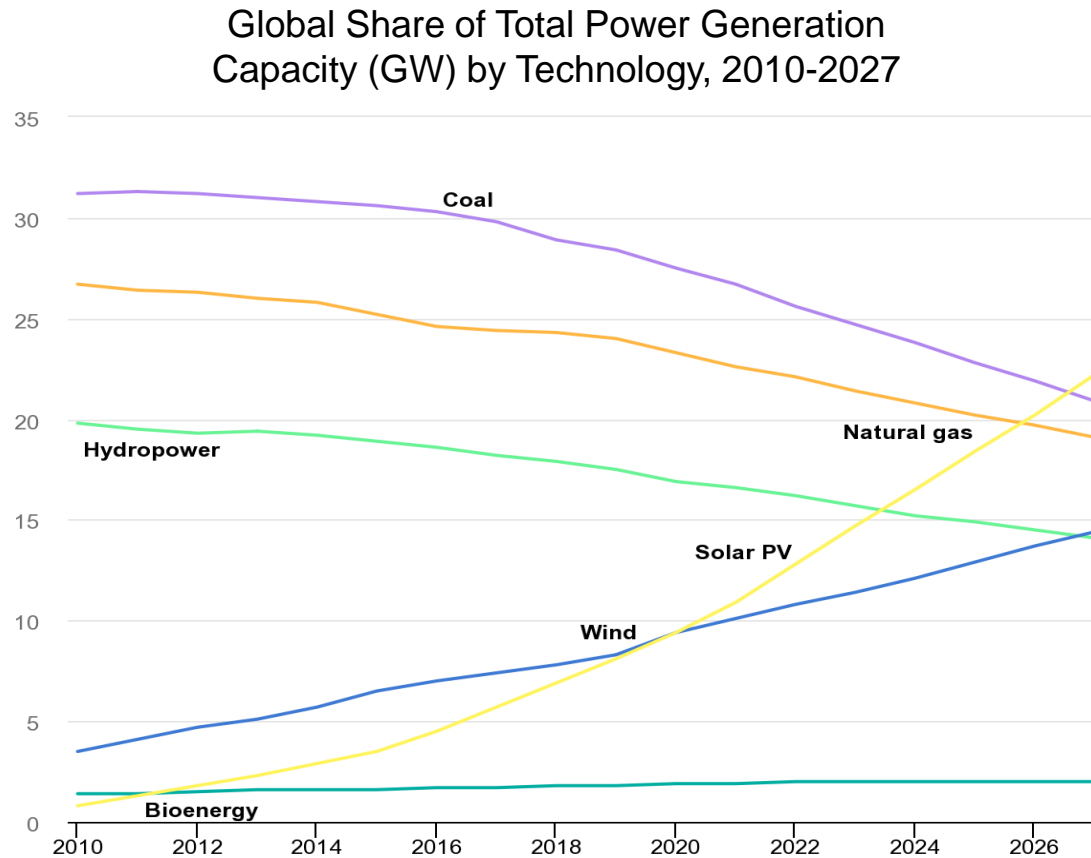


Source: BP Statistical Review of World Energy

Note: 'Other renewables' includes geothermal, biomass and waste energy.

OurWorldInData.org/energy • CC BY

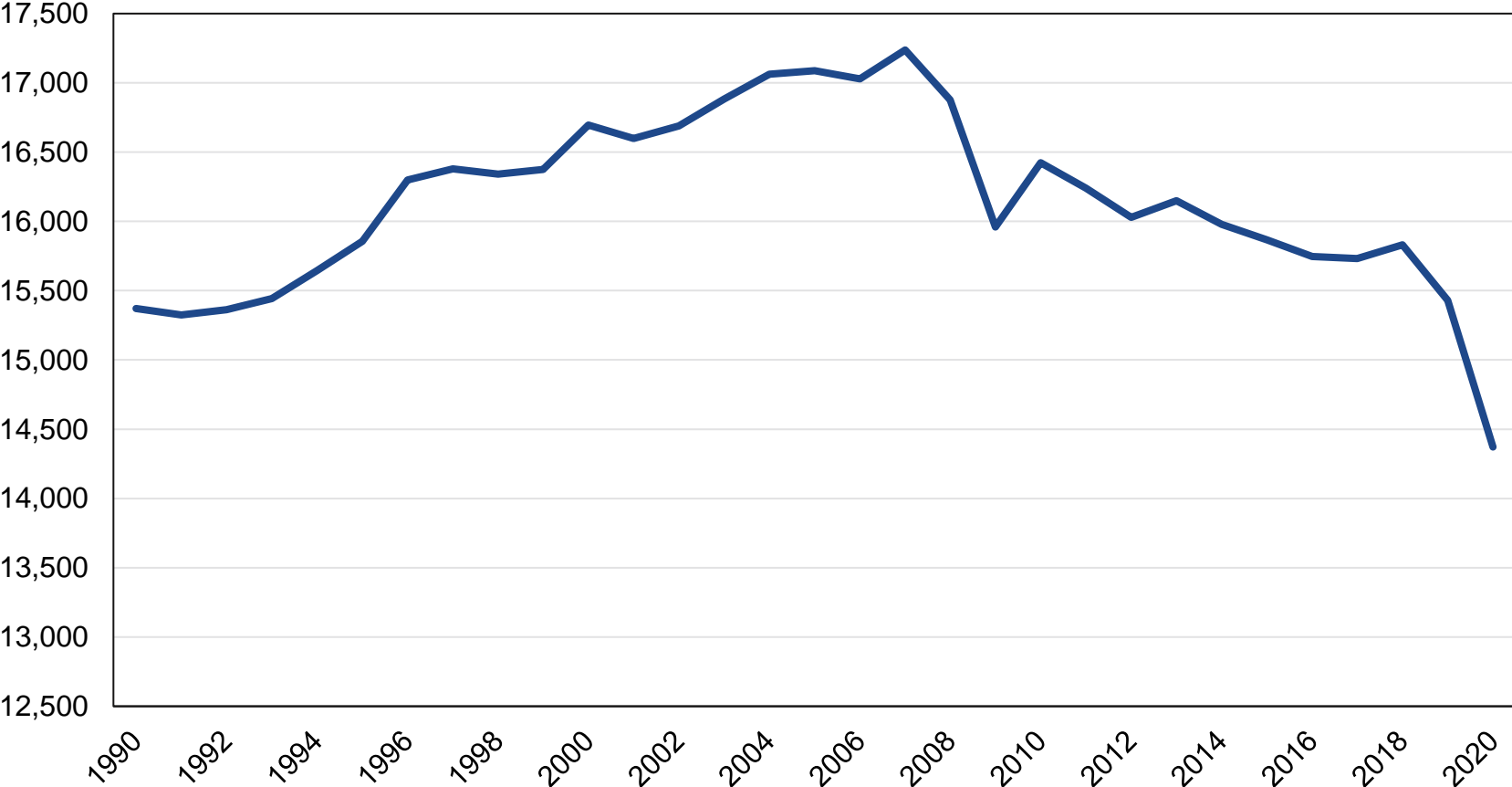
2. ...yet renewables have made rapid progress in recent years



By 2027, there will be more solar generation capacity in the world than coal- or natural gas-fired capacity

3. Carbon emissions are decreasing rapidly in OECD countries...

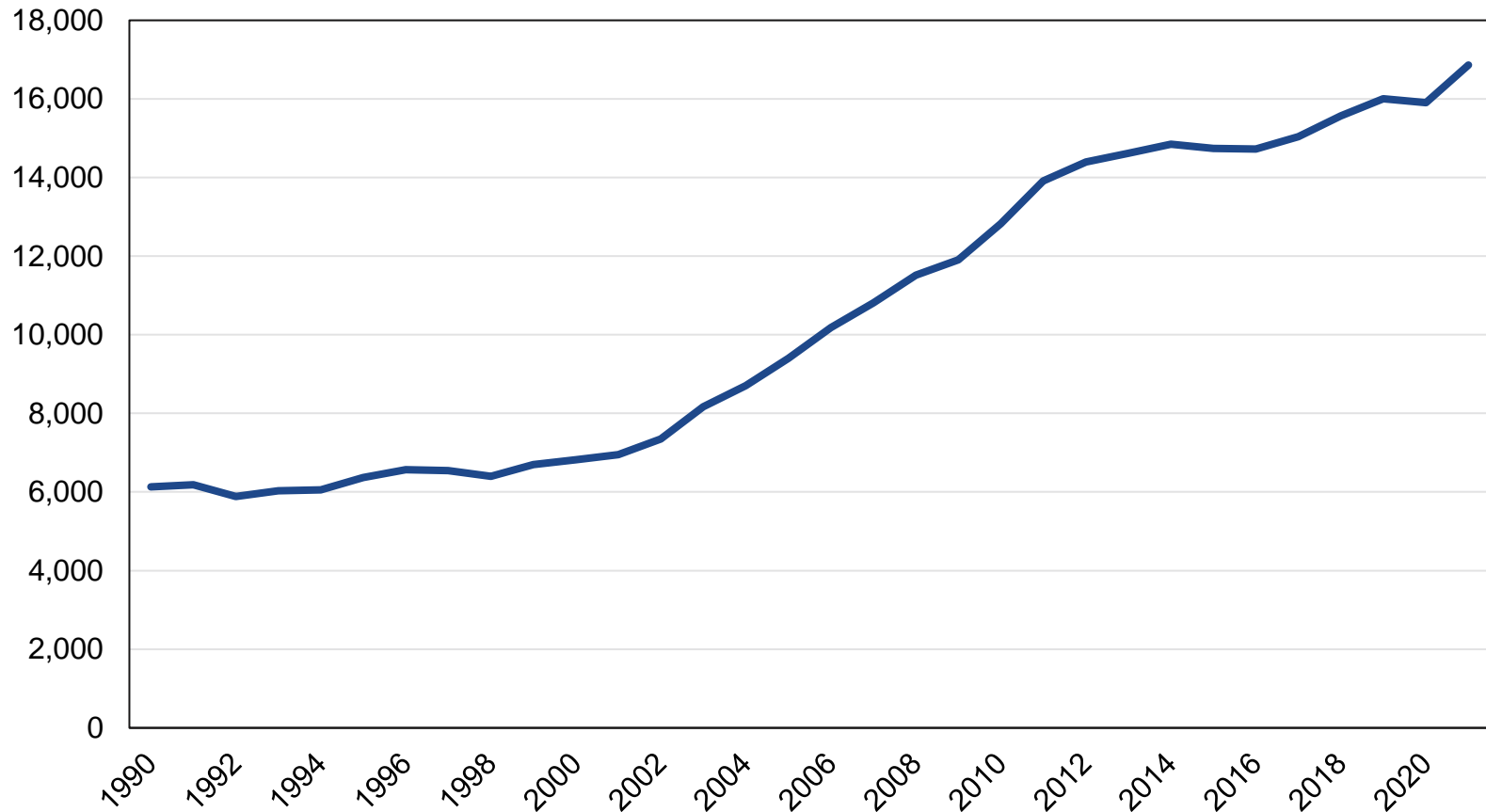
OECD Countries, tonnes CO₂ equivalent (millions)



Source: OECD

4. ...but continue to rise steadily in the developing world

BRICS countries, metric tonnes CO₂ equivalent (millions)



Without adequate “buy-in” from BRICS countries, global carbon emissions will likely continue to increase

5. Natural gas has recovered quickly from the shock associated with Russia's invasion of Ukraine...

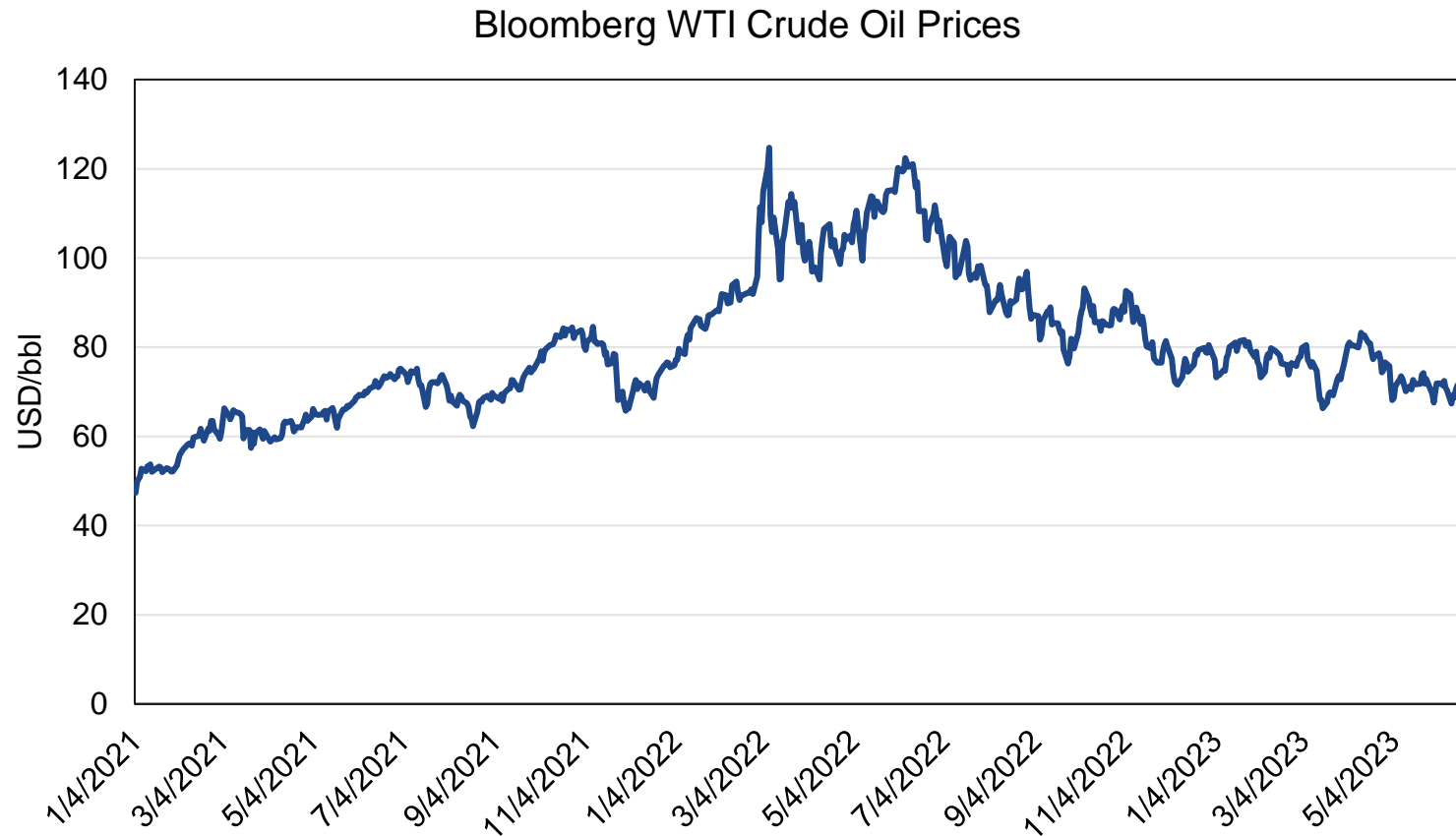
European benchmark natural gas prices

Per megawatt hour; Daily, Jan. 3, 2022, to Jan. 3, 2023



Data: FactSet; Chart: Axios Visuals

6. ...while oil prices remain elevated and subject to the whims of OPEC



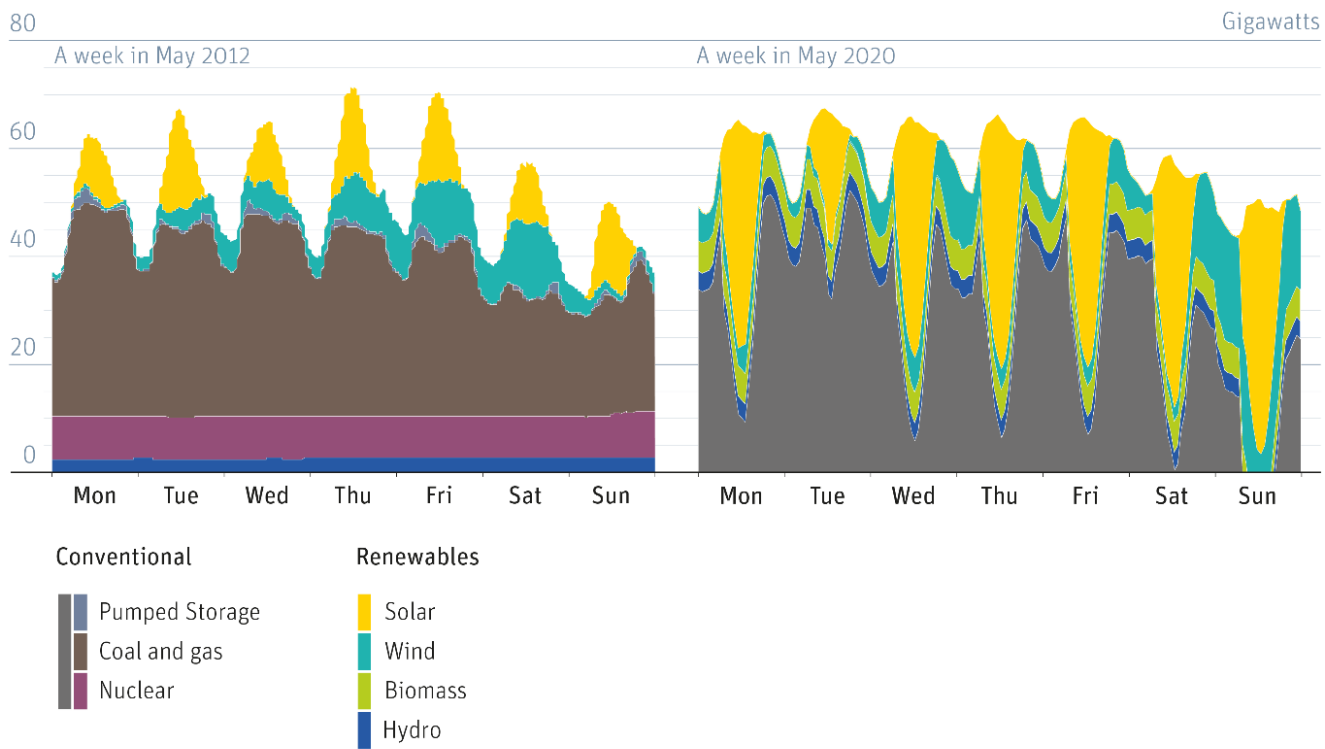
While oil prices are declining, they have yet to come down to pre-war levels and may remain elevated for a prolonged period

7. The challenge with renewables is that they do not produce power when and where it is needed...

Renewables need flexible backup, not baseload

Estimated power demand over a week in 2012 and 2020, Germany

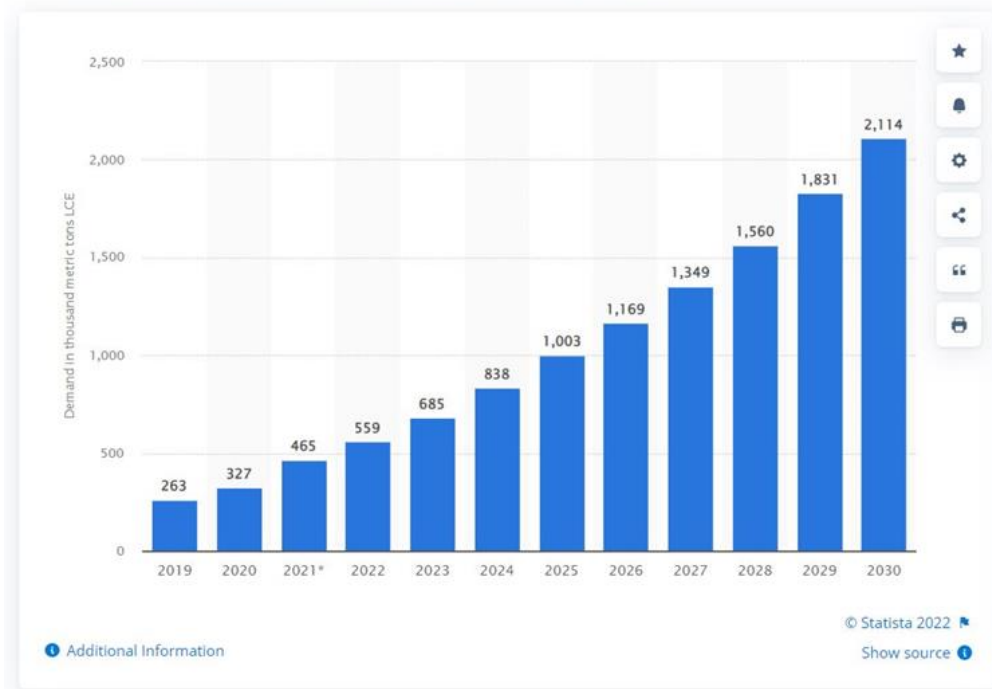
Source: Volker Quaschnig, HTW Berlin



8. ...and require colossal amounts of rare-earth elements from unstable or unfriendly parts of the world

Projection of worldwide lithium demand from 2019 to 2030

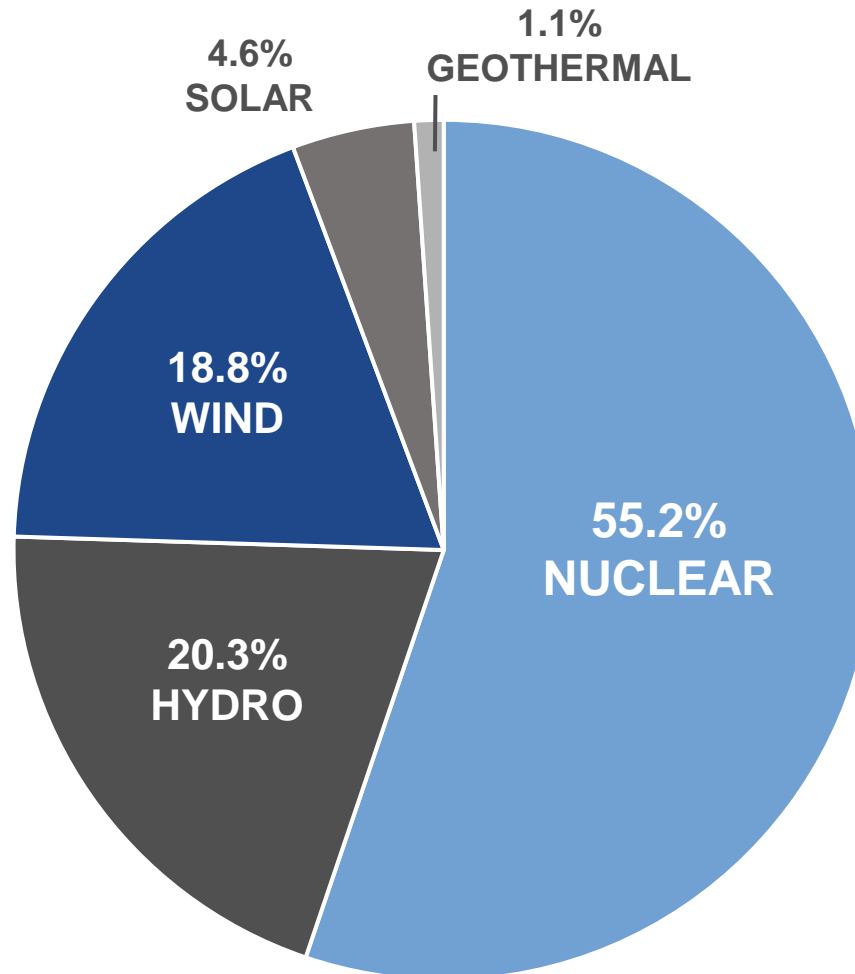
(in 1,000 metric tons of lithium carbonate equivalent)



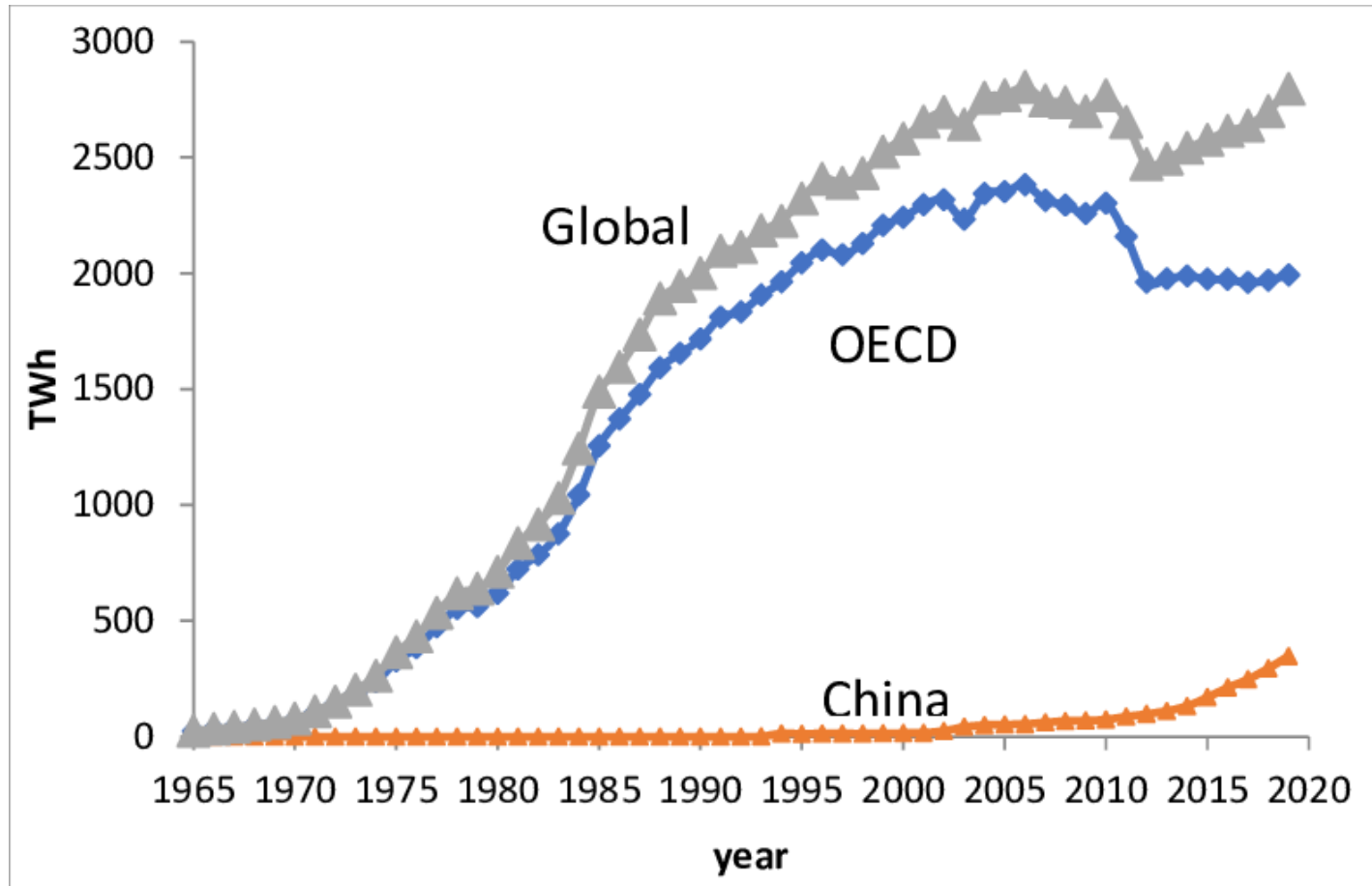
Political instability and human rights abuses in mining rare-earth elements may limit growth in renewable technologies

9. Nuclear and hydroelectric are the mainstays of carbon-free electric power...

US Emissions-Free Fuel Shares (2018)



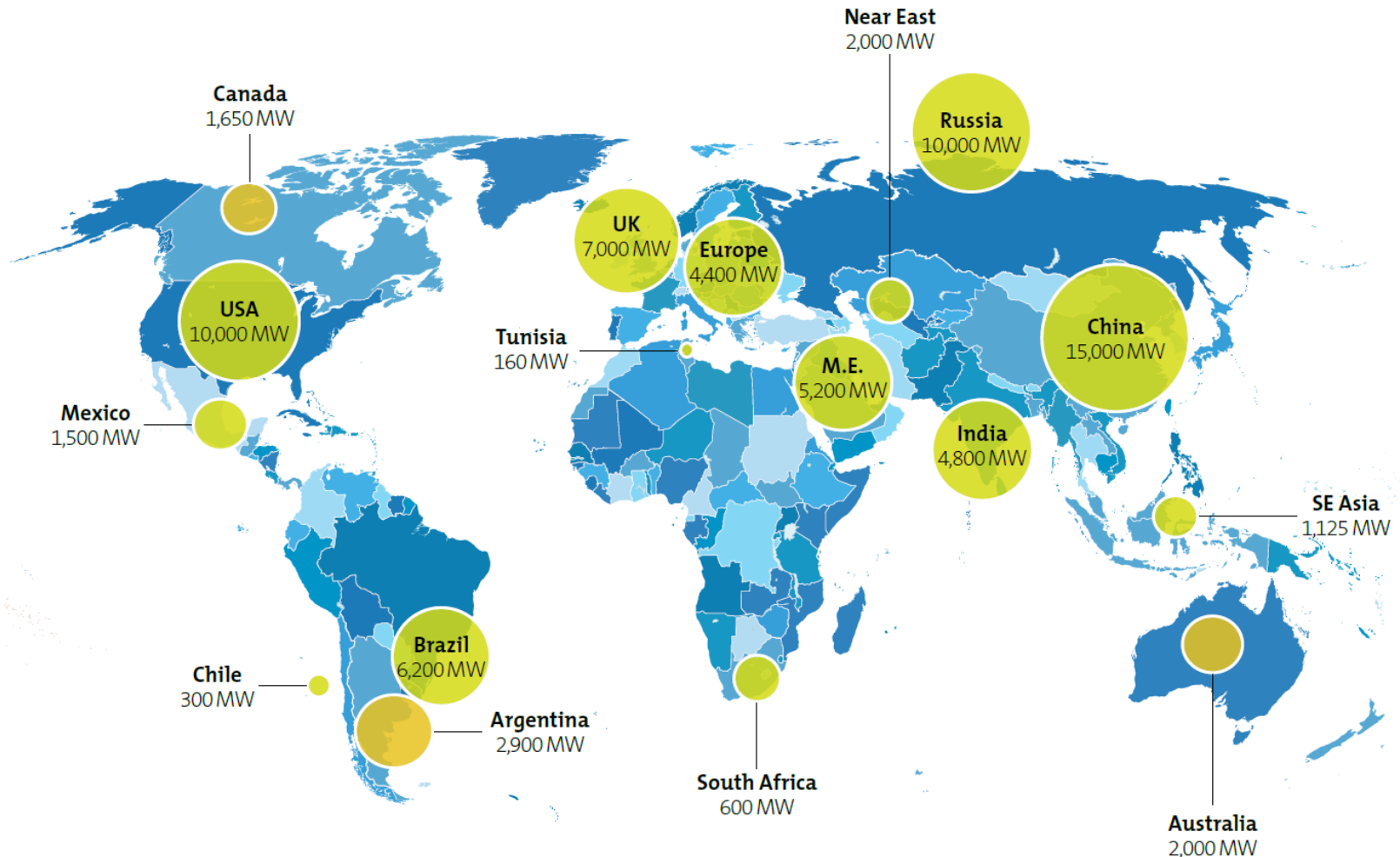
10. ...though growth in nuclear power has been stalled in OECD countries in recent decades



Nuclear generation has been stagnant since 2010 in OECD countries

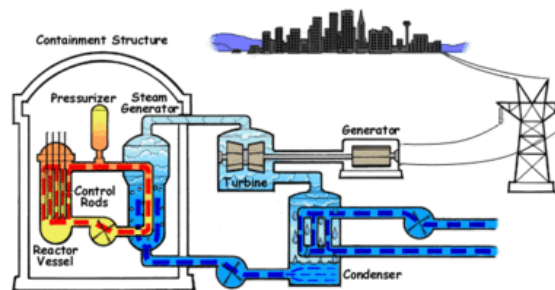
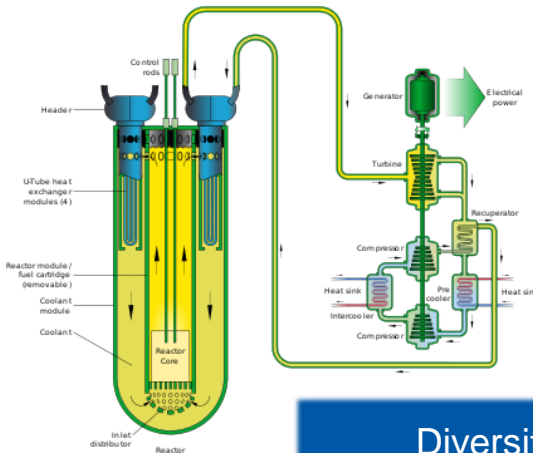
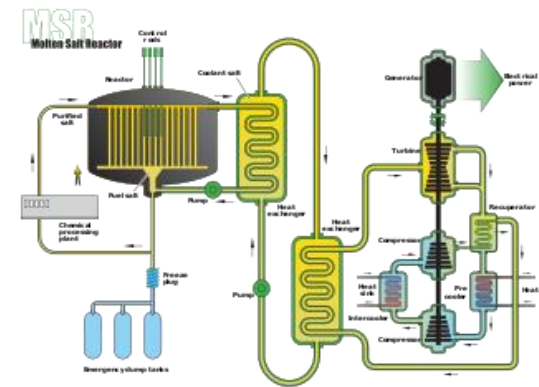
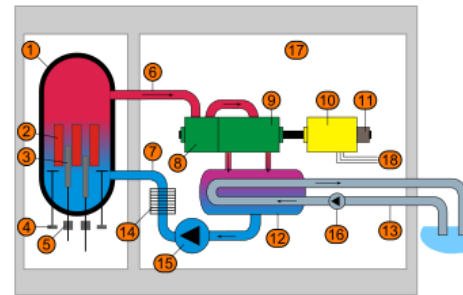
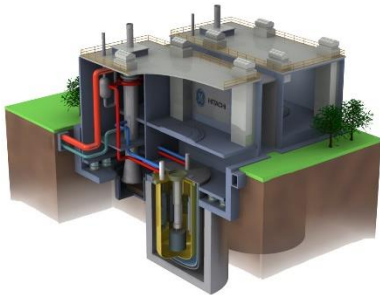
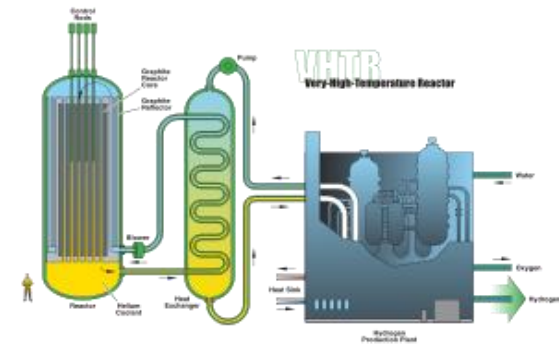
11. Small Modular Reactors (SMRs) have the potential to jump-start the nuclear sector...

Global demand for SMRs may reach 65-85 GWe by 2035, valued at £250-400 billion



12. ...though they present some challenges of their own

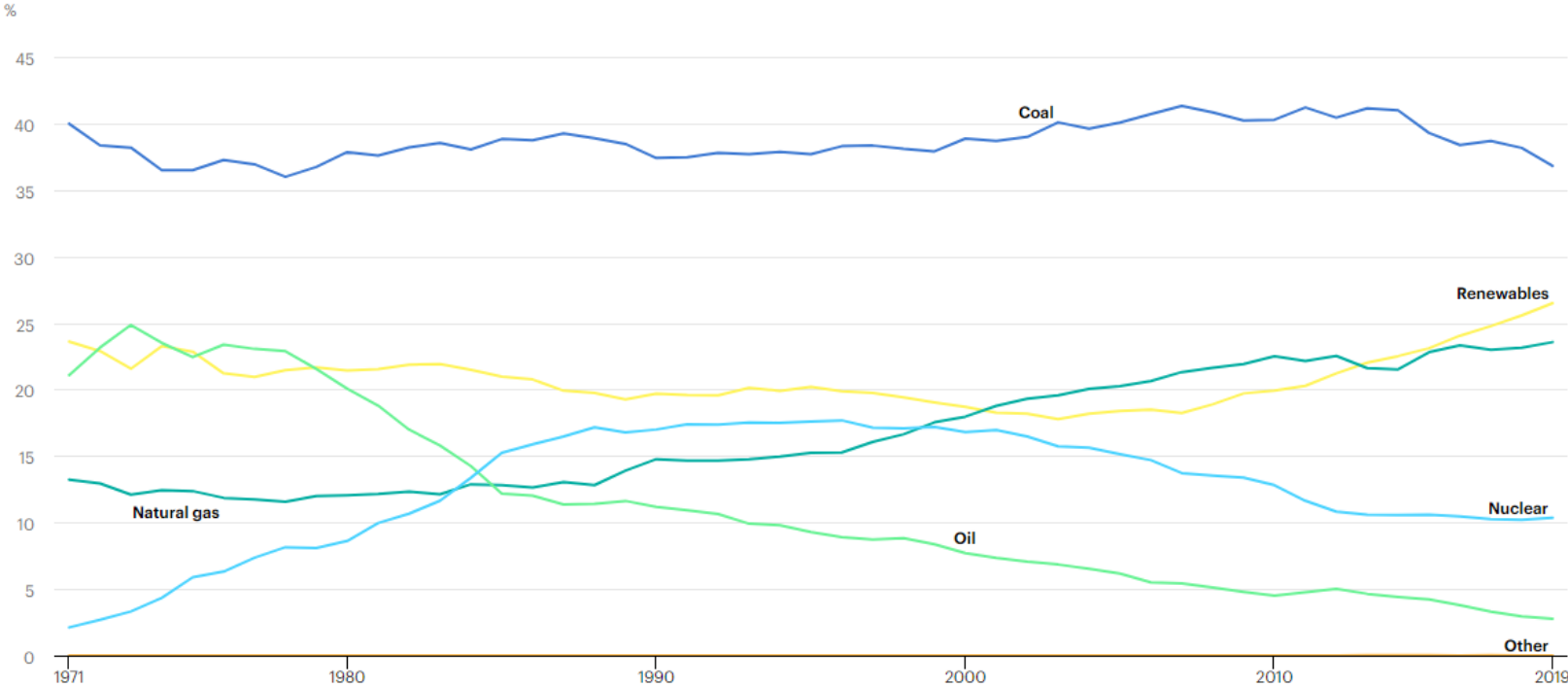
- FBR (fast breeder reactor)
- HTGR (high-temperature gas-cooled reactor)
- LFR (lead-cooled fast reactor)
- LWR (light-water reactor): PWR, BWR
- MSR (molten salt reactor)
- SFR (sodium-cooled fast reactor)
- TWR (traveling-wave reactor)



Diversity of SMR designs being deployed may limit the likelihood any of them will achieve economies of scale—the basis for their appeal

13. The future of decarbonization lies not only in the electric power sector...

Global Electricity Generation (GWh) Mix by Fuel (1971-2019)



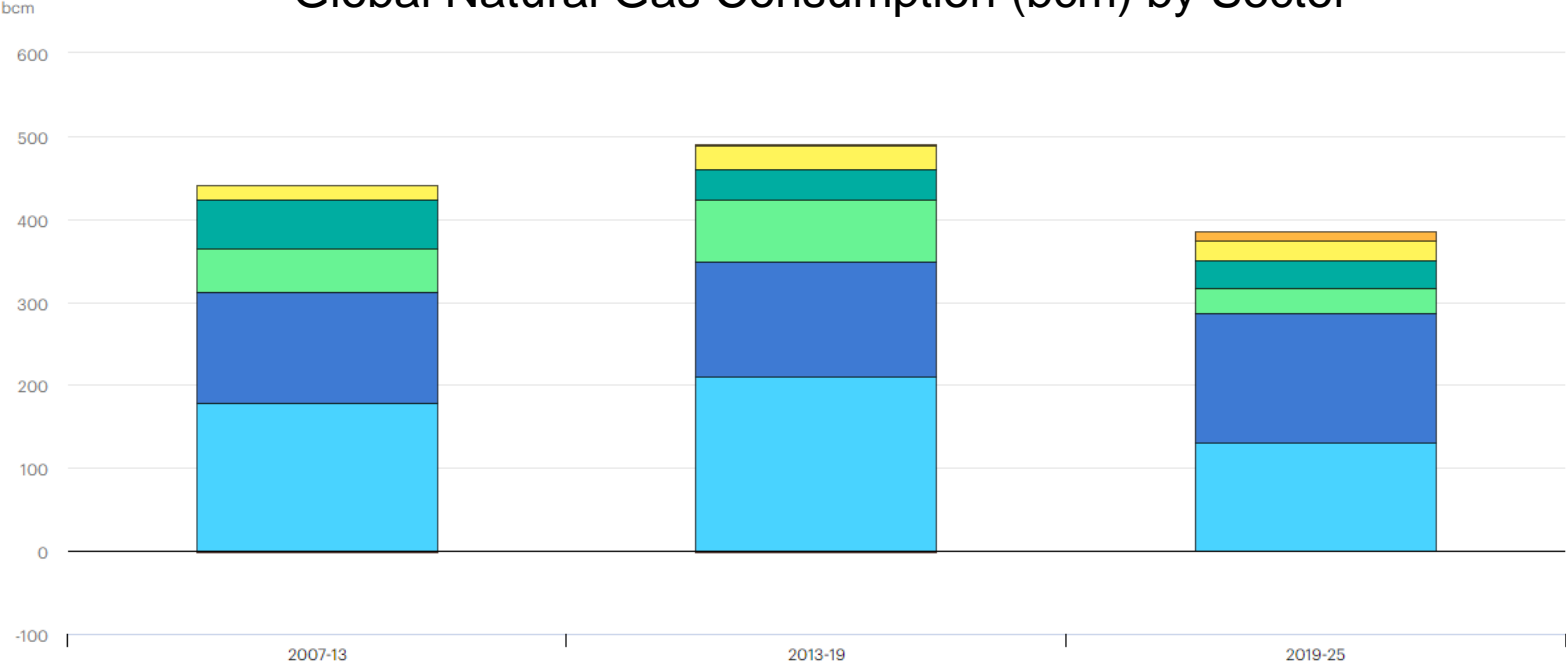
IEA. Licence: CC BY 4.0

● Nuclear ● Coal ● Oil ● Natural gas ● Renewables ● Other

Source: IEA

14. ...but in industrial uses of natural gas and the use of oil in transport, and heating/cooking

Global Natural Gas Consumption (bcm) by Sector



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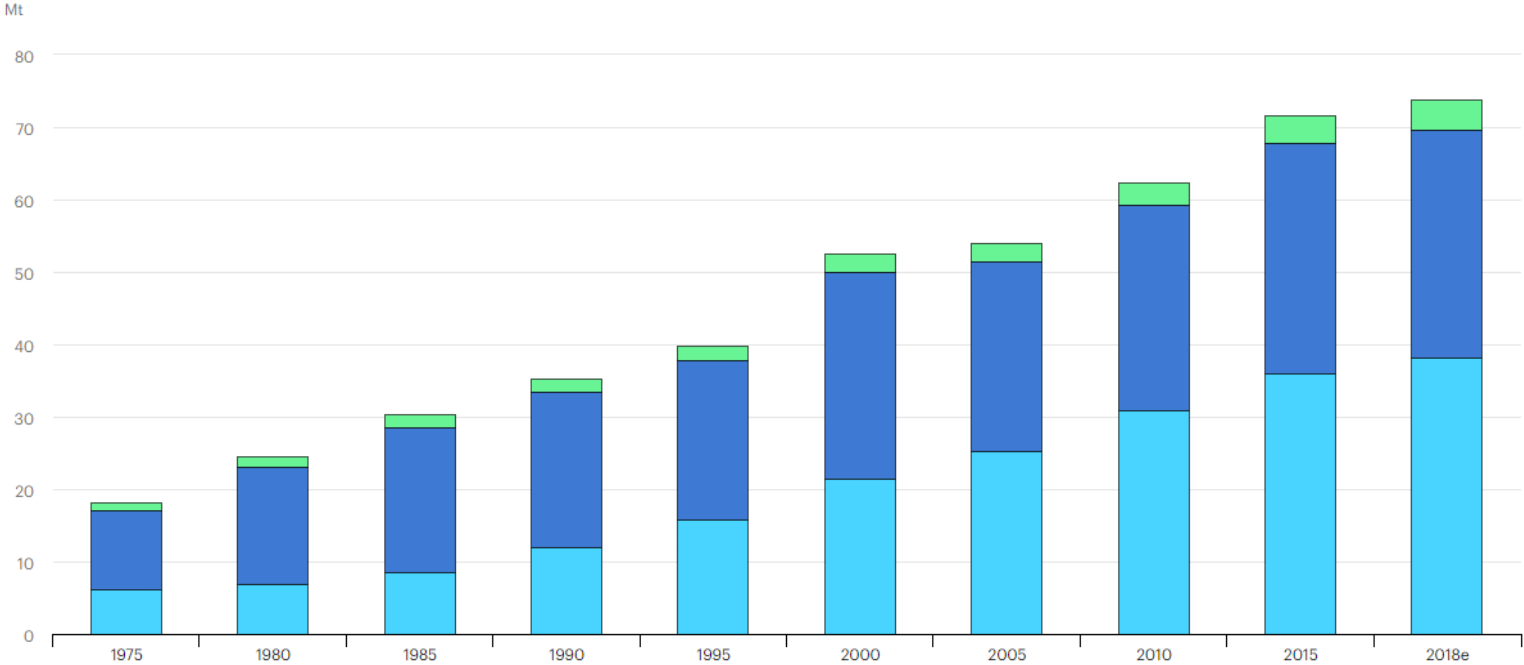
● Power generation ● Industry ● Residential and commercial ● Energy industry own use ● Transport (including pipeline) ● International marine bunkers ● Losses

In 2022, 62% of natural gas consumption in the USA was in the industrial, residential, commercial, and transportation sectors

Source: IEA

15. Natural gas for industrial use could potentially be replaced by hydrogen...

Global Demand for Elemental Hydrogen (1975-2018)

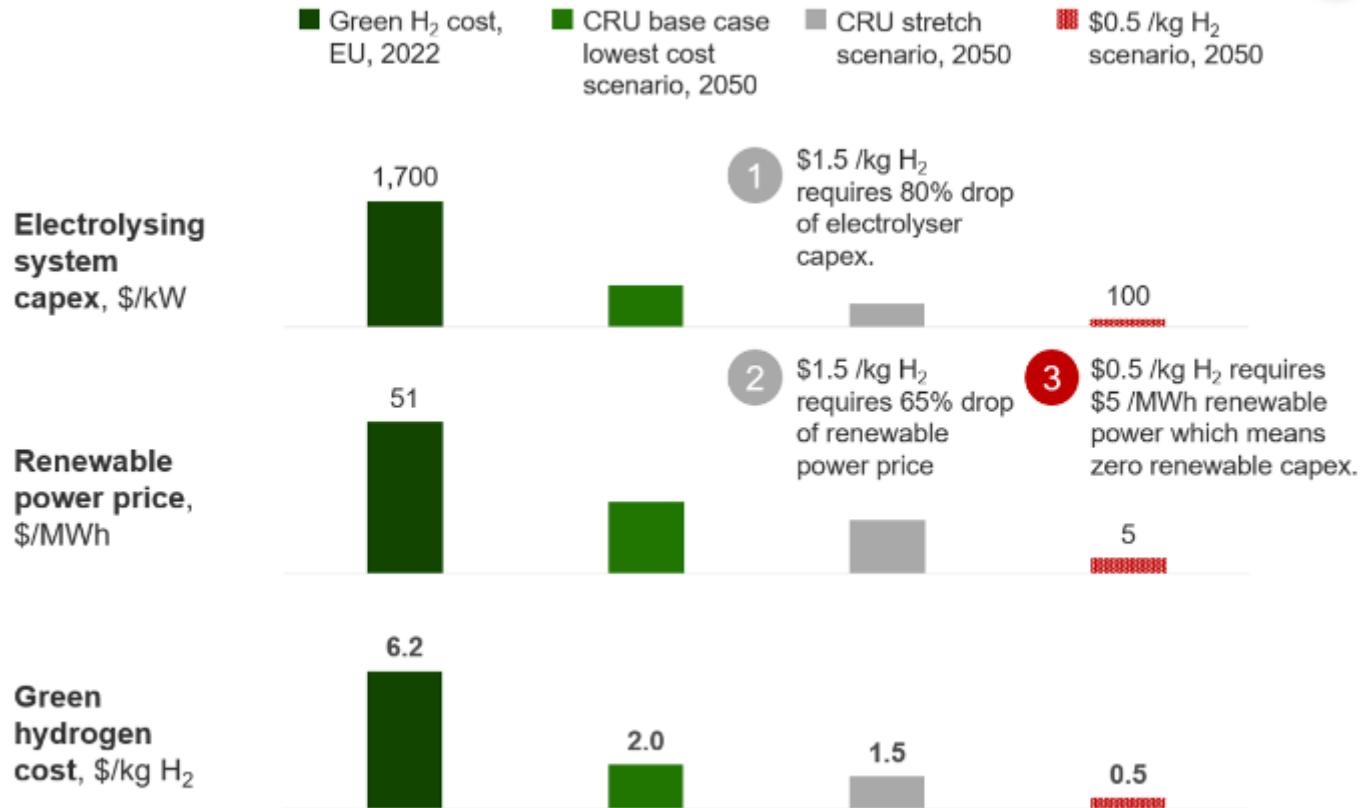


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● Refining ● Ammonia ● Other

16. ...but hydrogen production is fraught with challenges, not least of which is cost

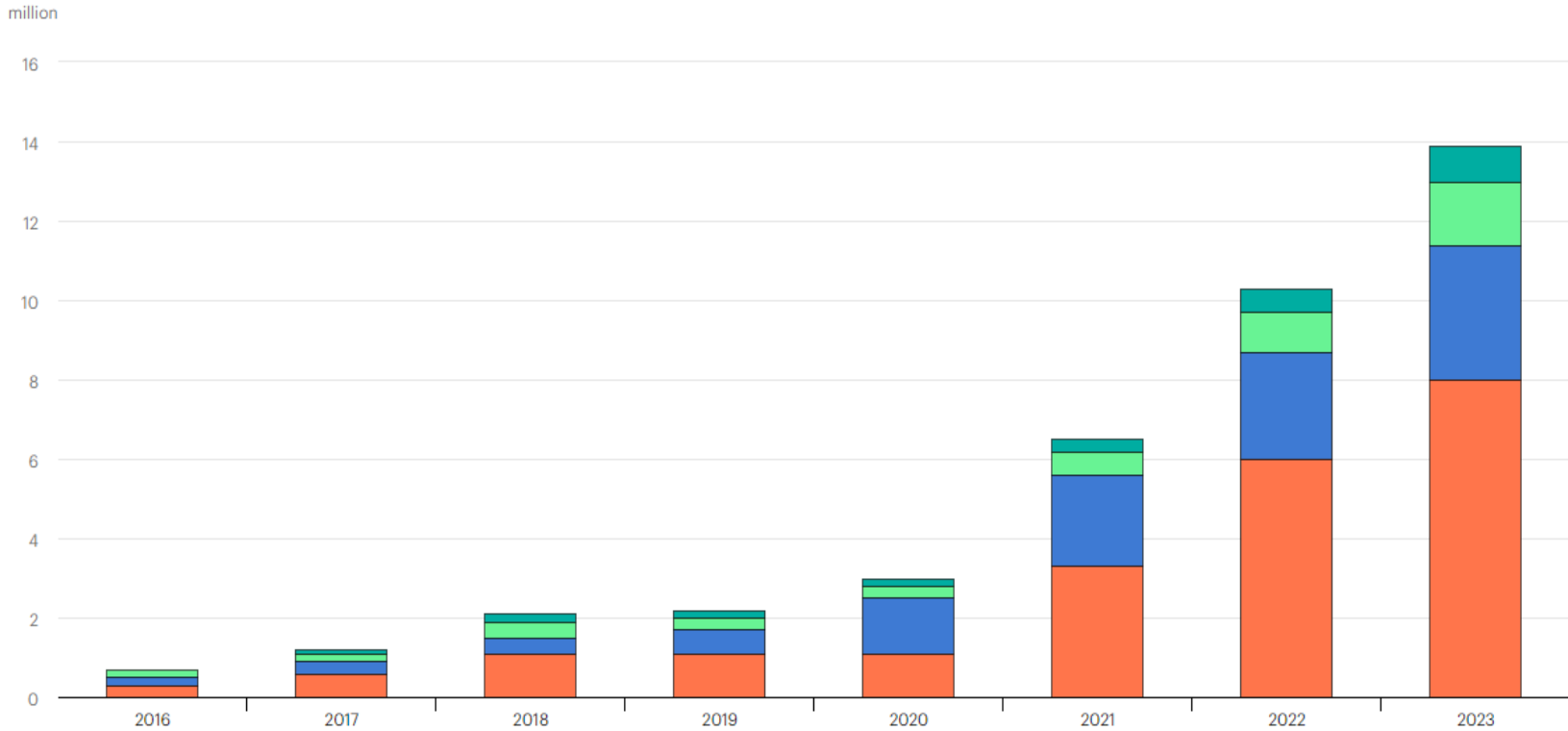
Figure 4: Green hydrogen at \$0.5 /kg effectively requires zero renewables capex.



Current technology for “green hydrogen” production is expensive and inefficient and cannot in the foreseeable future achieve the much-touted goal of \$0.50/kg

17. Electric Vehicles (EVs) are making good progress...

Global Electric Passenger Vehicle Sales (2016-2023)

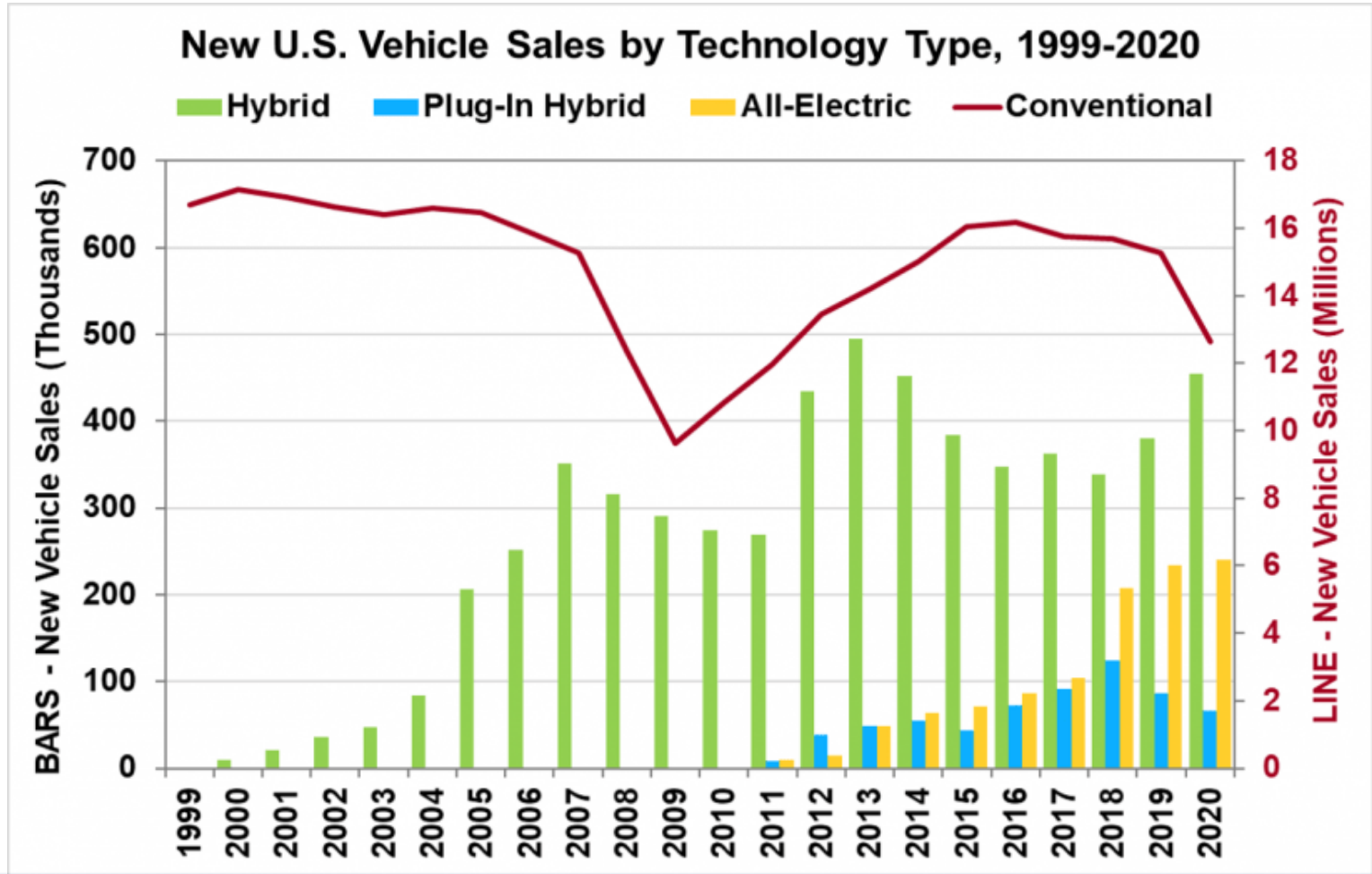


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● China ● Europe ● United States ● Other

Source: IEA

18. ...but still represent just a tiny fraction of total vehicle sales



EV sales are still counted in the thousands compared with the *tens of millions* of conventional vehicles sold globally each year

19. Decarbonizing home heating/cooking is possible...

U.S. Regulators And State Lawmakers Consider Banning Gas Stoves—Here's Why

Ty Roush Forbes Staff
I cover breaking news.

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Jan 11, 2023, 02:26pm EST

New York becomes the first state to ban natural gas stoves and furnaces in most new buildings



By [Rachel Ramirez](#) and [Ella Nilsen](#), CNN

Updated 12:31 PM EDT, Wed May 3, 2023

California's 2030 Ban on Gas Heaters Opens a New Front in the War on Fossil Fuels

20. ...but may face significant customer resistance

How the humble gas stove became the latest flash point in the culture wars

Regulators have no plans to ban gas stoves, but Republicans are slamming the Consumer Product Safety Commission for announcing it will examine the health impacts of the appliances

The Country's First Gas Stove Ban Has Been Overturned

Passed in 2019, the Berkeley Calif. law was found to be in violation of the Energy Policy and Conservation Act by the 9th Circuit Court of Appeals.

GOP cooks up a new storm on gas stove rules

Republicans will use a House hearing and a markup Wednesday to fan the flames over proposed DOE efficiency standards.



Gas stoves have become a 'hot topic' as many refuse to switch to alternative technologies in their homes

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