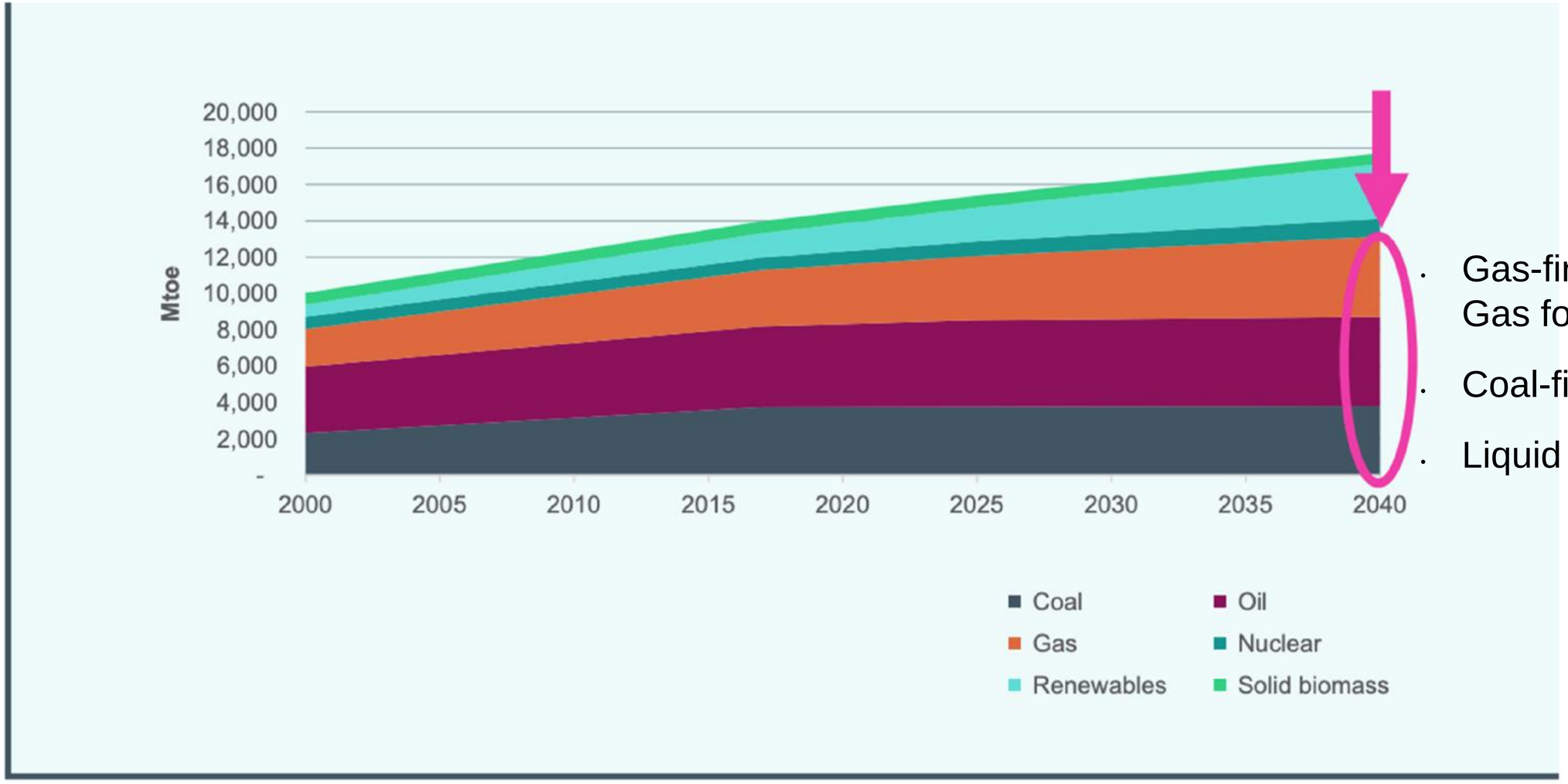
INNOVATION FOR CLIMATE

February 2021

TERRA PRAXIS

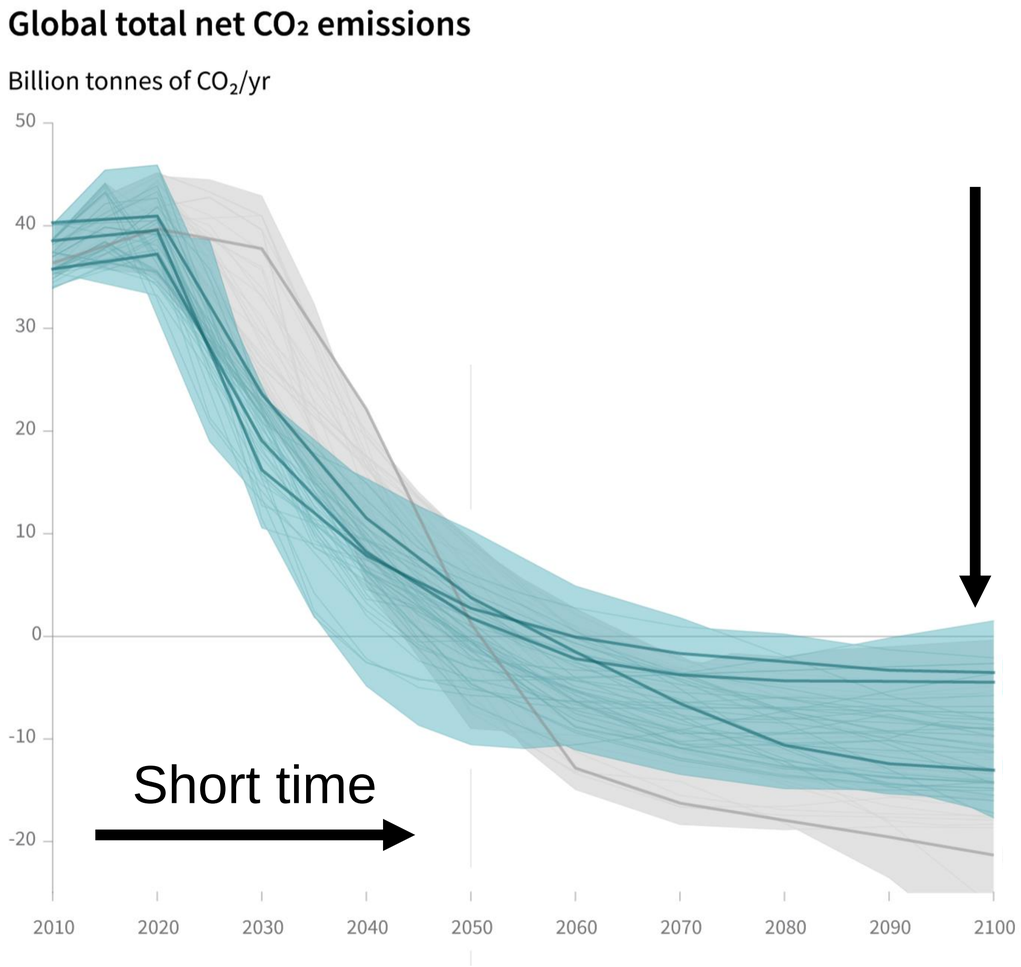
THE ROLE OF ADVANCED HEAT SOURCES IN THE DECARBONISATION CHALLENGE

Stated Policies Scenario: World Energy by Source (IEA 2018)



- Gas-fired power plants
  Gas for industry
- Coal-fired power plants
- Liquid fossil fuels

This is What We Need to Do



- Repower all coal plants
- Replace flexible gas plants
- Replace gas for industrial heat
- Replace liquid fossil fuels
- While growing the energy system to supply the developing world

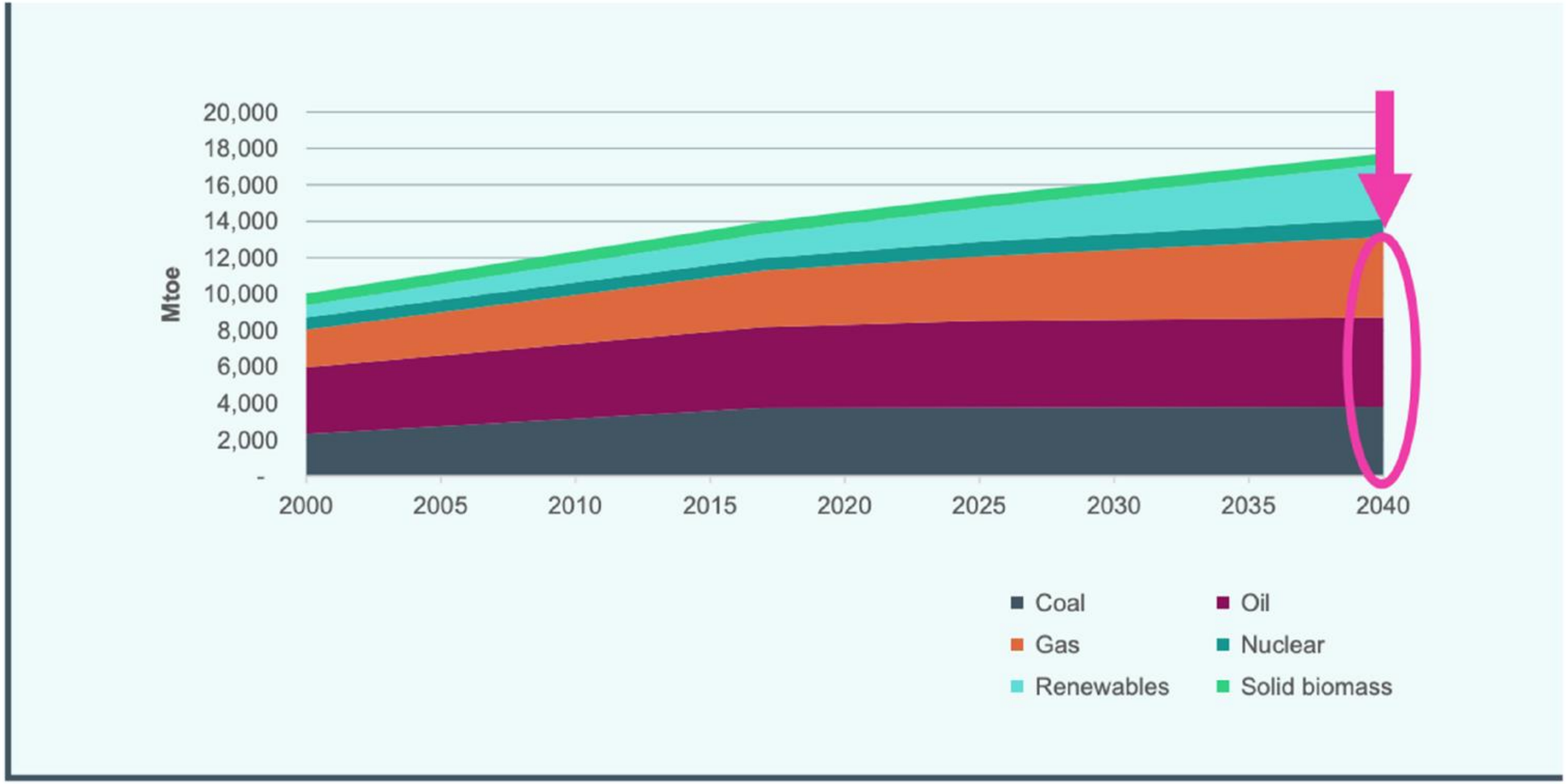
Really, really fast

Our Climate Solutions need to be Impossible Burgers

- Drop-in substitute: cost & performance
- Leverages existing infrastructure
- Cost-competitive
- Not dependent on behaviour change
- Scale applicable to market size
- Rapidly deployable

IMPOSSIBLE BURGERS FOR CLIMATE

Scale: Oil use alone is 100 million barrels per day



Advanced Heat Sources For Transformative Innovations

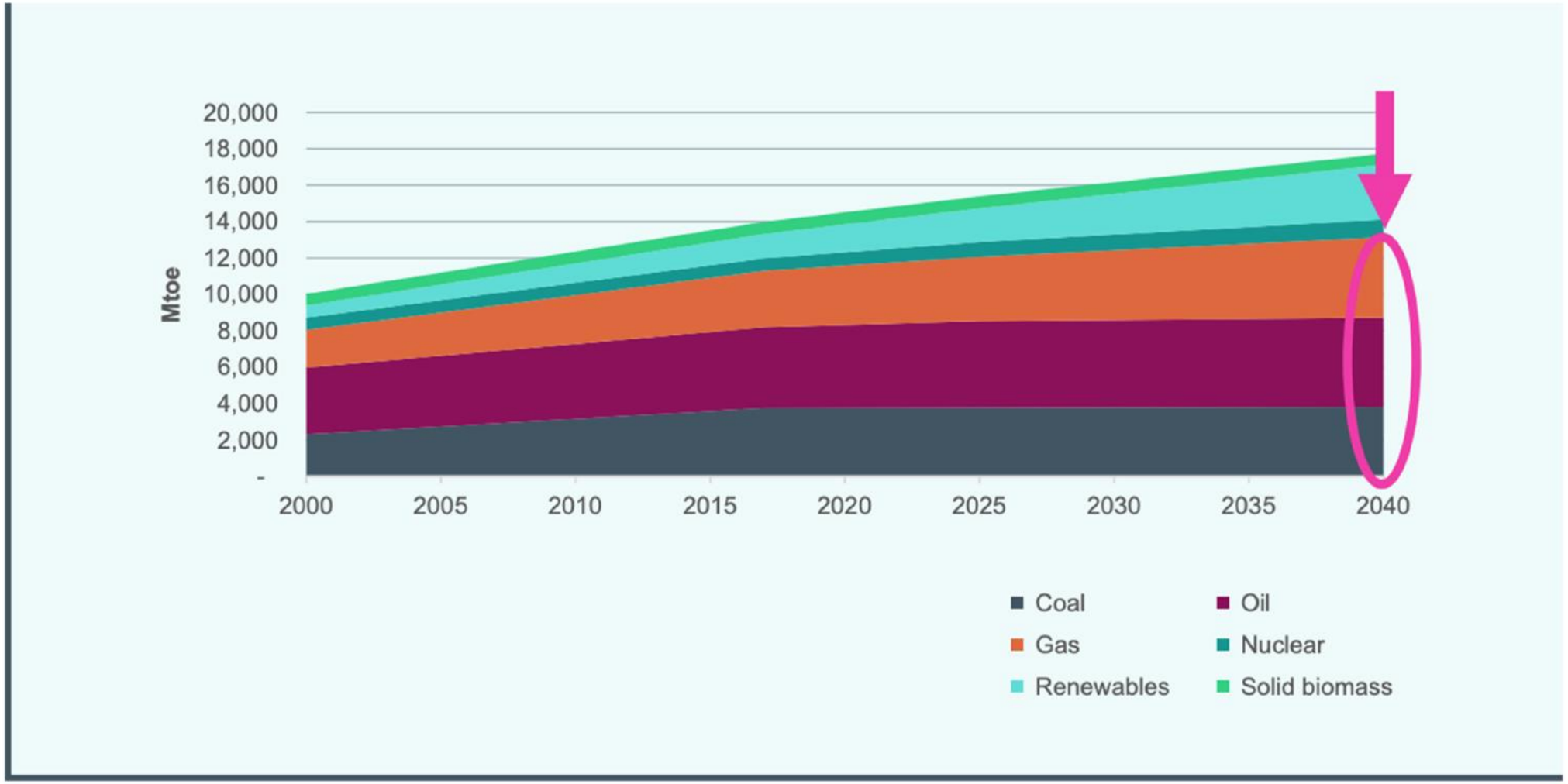
Coal Plant Heat Source – Electricity Market

Hydrogen Cogeneration – Electricity & Fuels

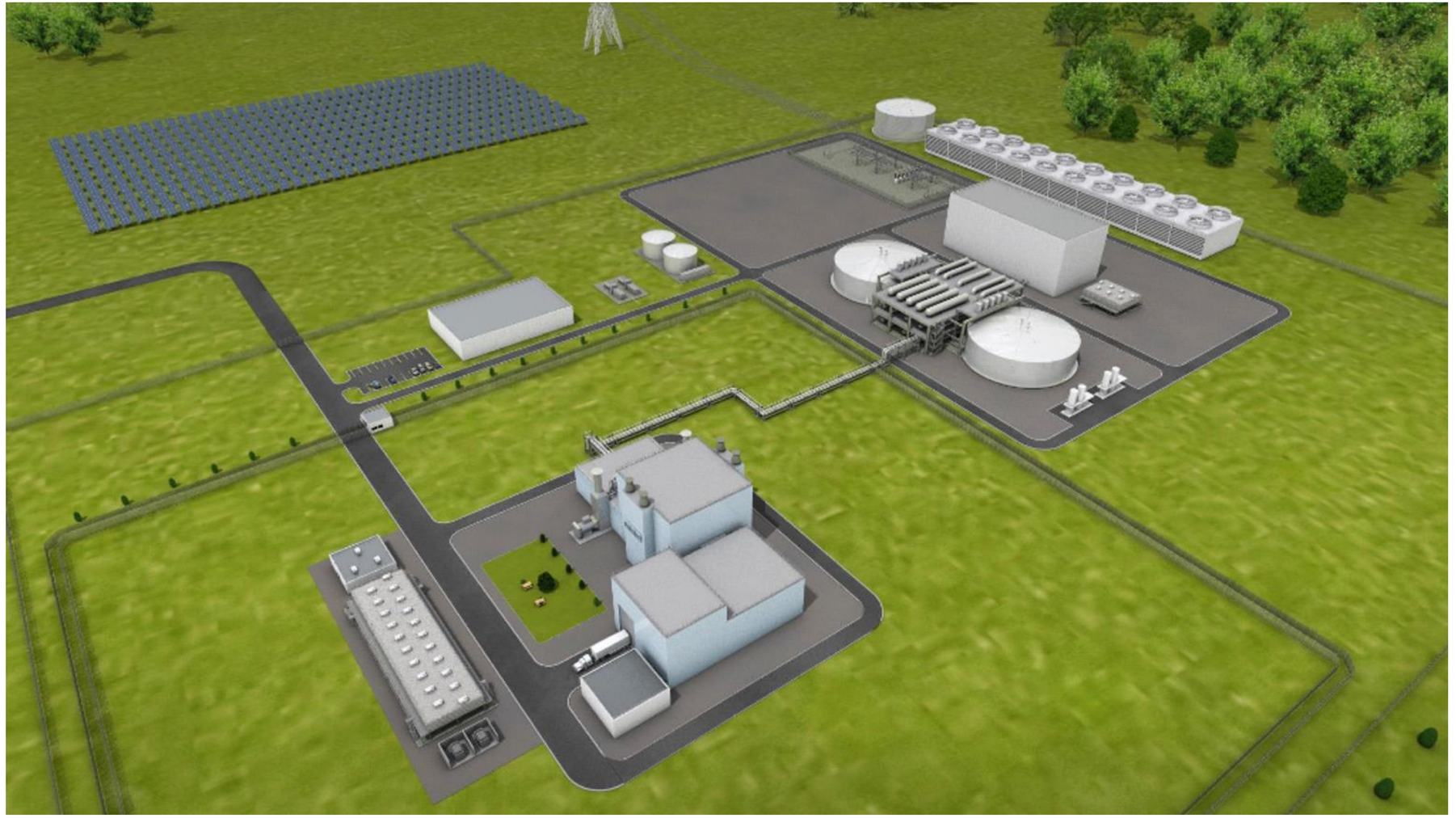
Flexible Generator – Electricity Market

Hydrogen/Synfuel Gigafactory – Fuels Market

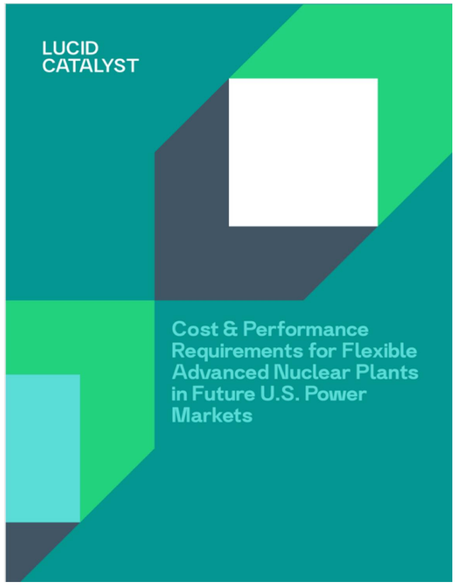
Addressing Remaining Carbon Based Fuels



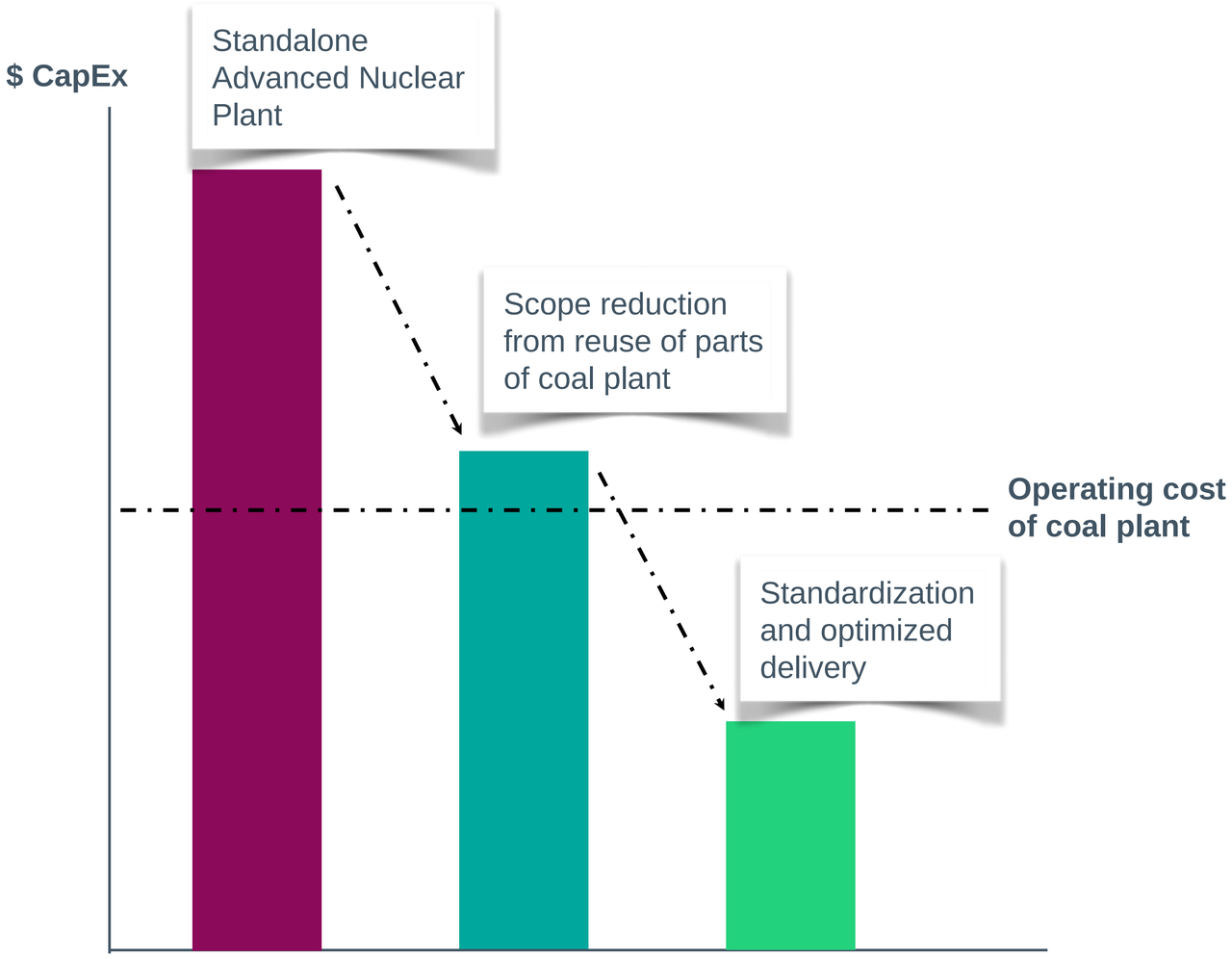
Flexible Generation (Inspired By Arpa-e Report)

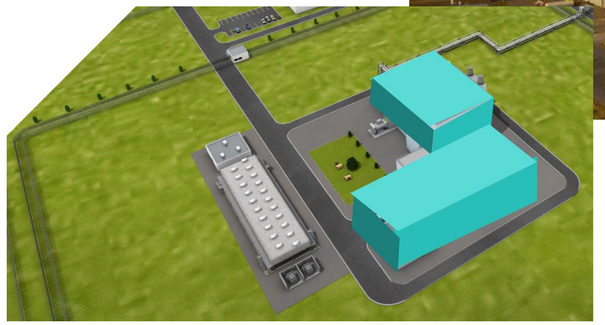


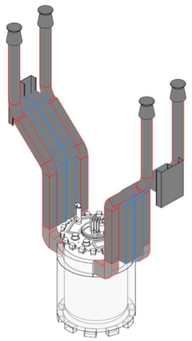
Nuclear island is separated from the power island via thermal energy storage system.

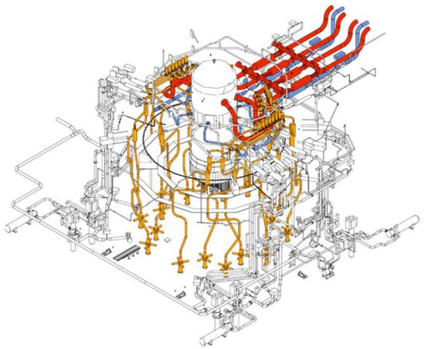


Cost-competitive Coal Plant Repowering



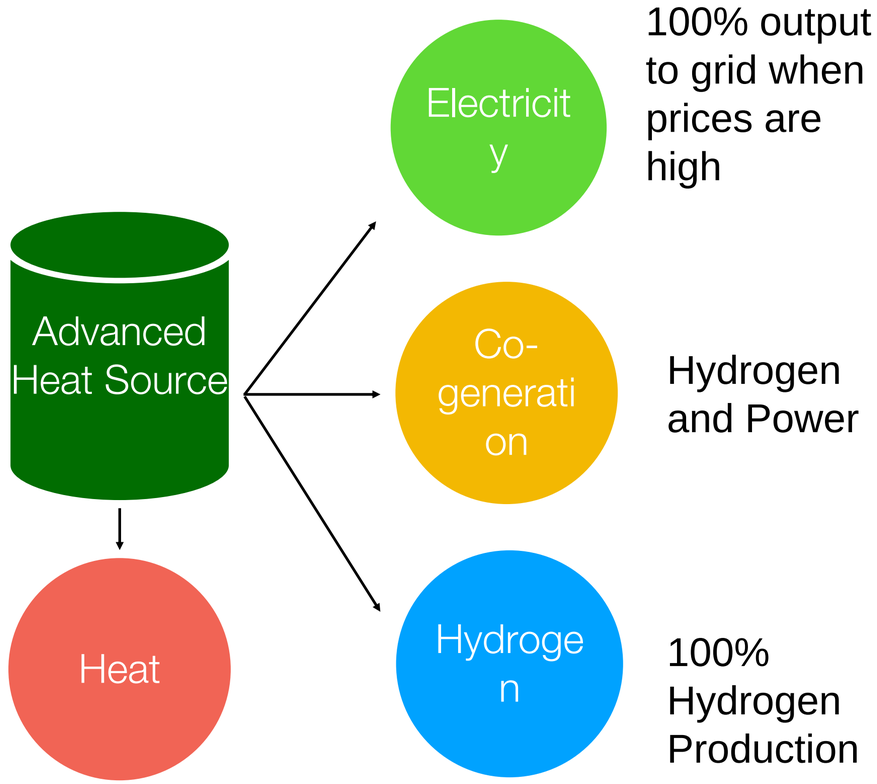






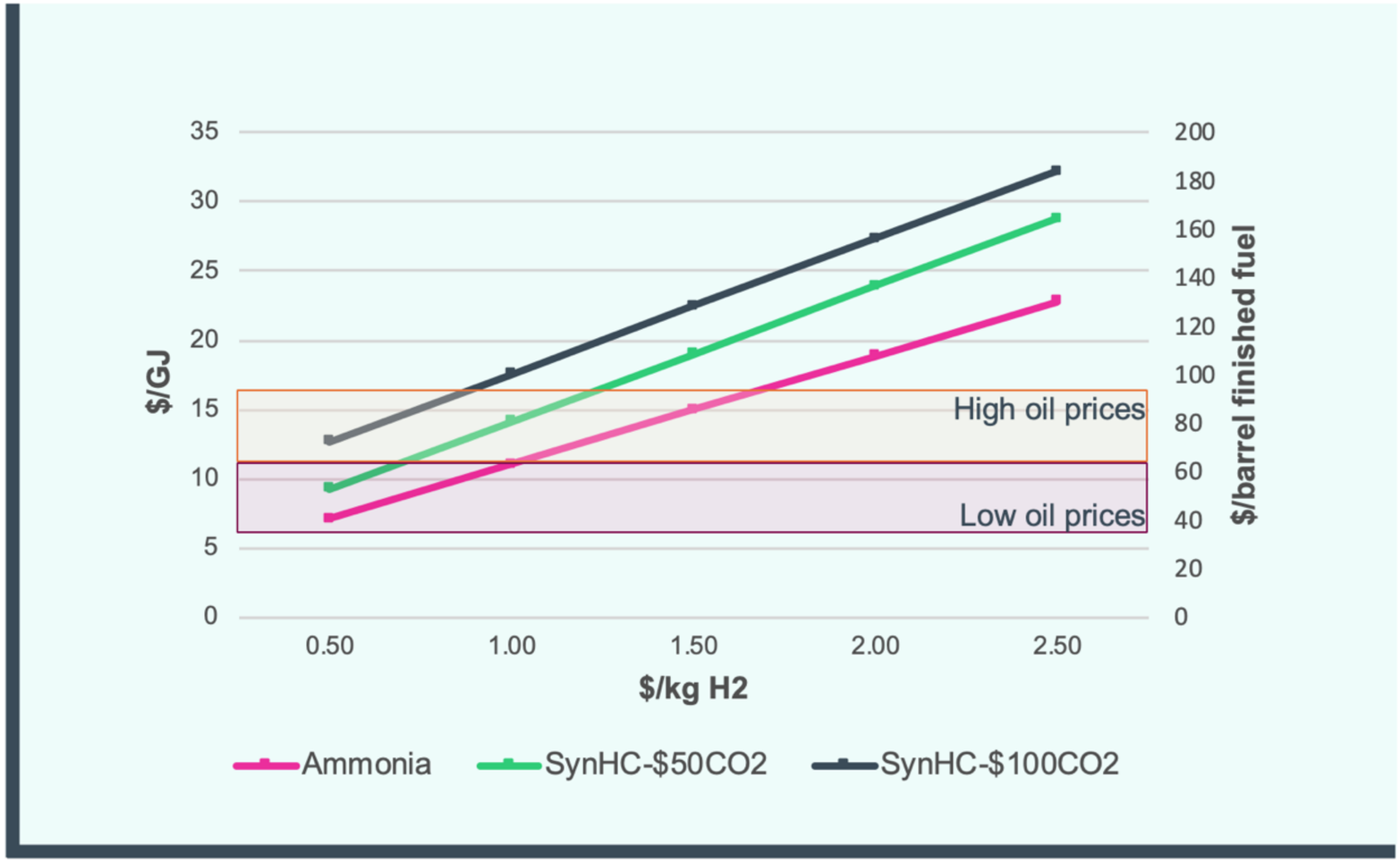
Flexible Cogeneration Of Hydrogen And Power

Three modes of operation

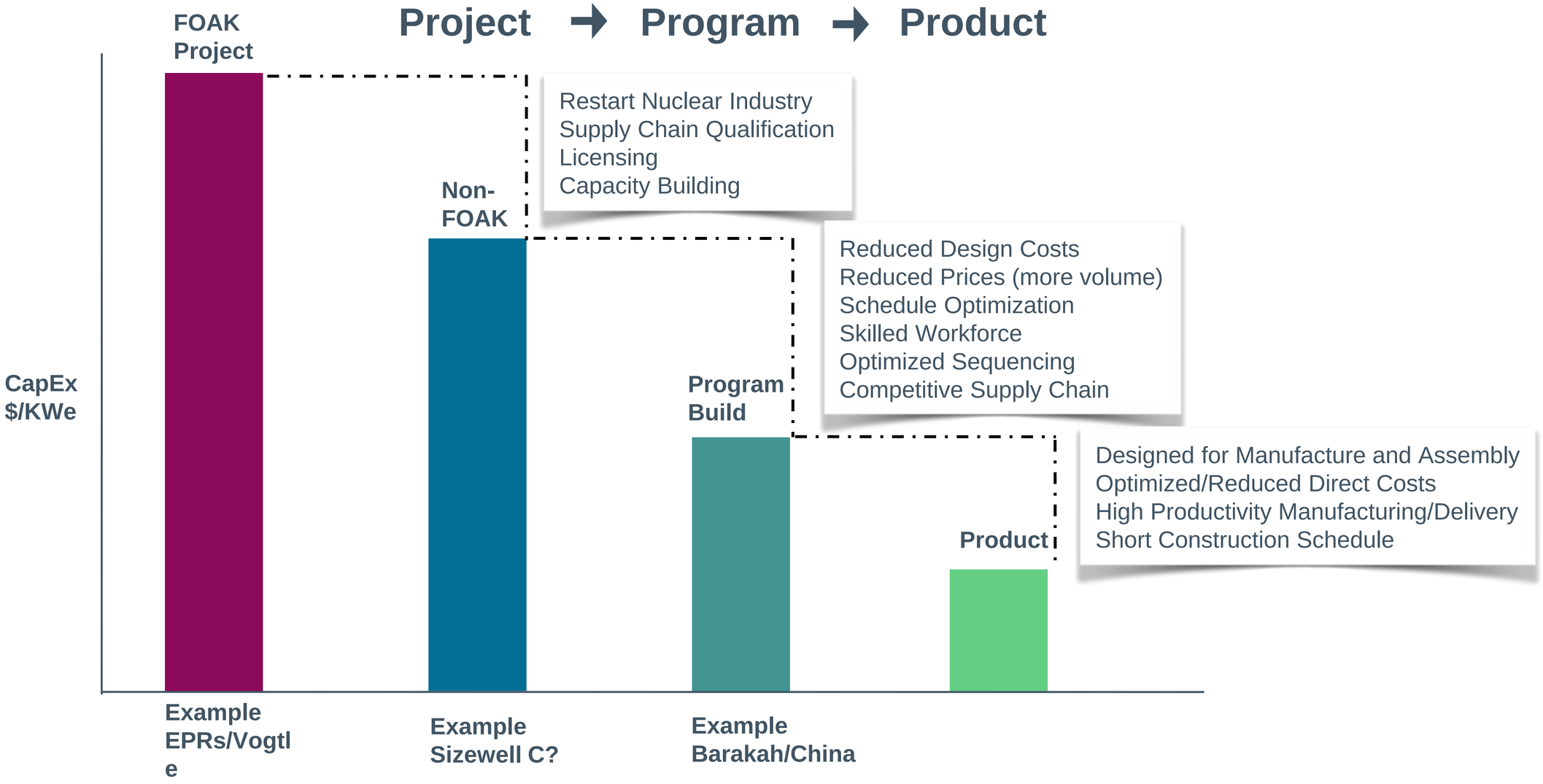


DE-DEPLOYING OIL AND GAS CAPABILITY FOR CLEAN HYDROGEN/SYNFUELS PRODUCTION

Cost: Oil Price ‘Guardrails’ of the Hydrogen Economy



Pathway To Low Cost



Refinery-scale Hydrogen / Synfuel Gigafactory /

Source: *Missing Link to a Livable Climate: How Hydrogen-Enabled Synthetic Fuels Can Help Deliver the Paris Goals*

Shipyard Construction of Floating Off-shore Platform (FPSO)

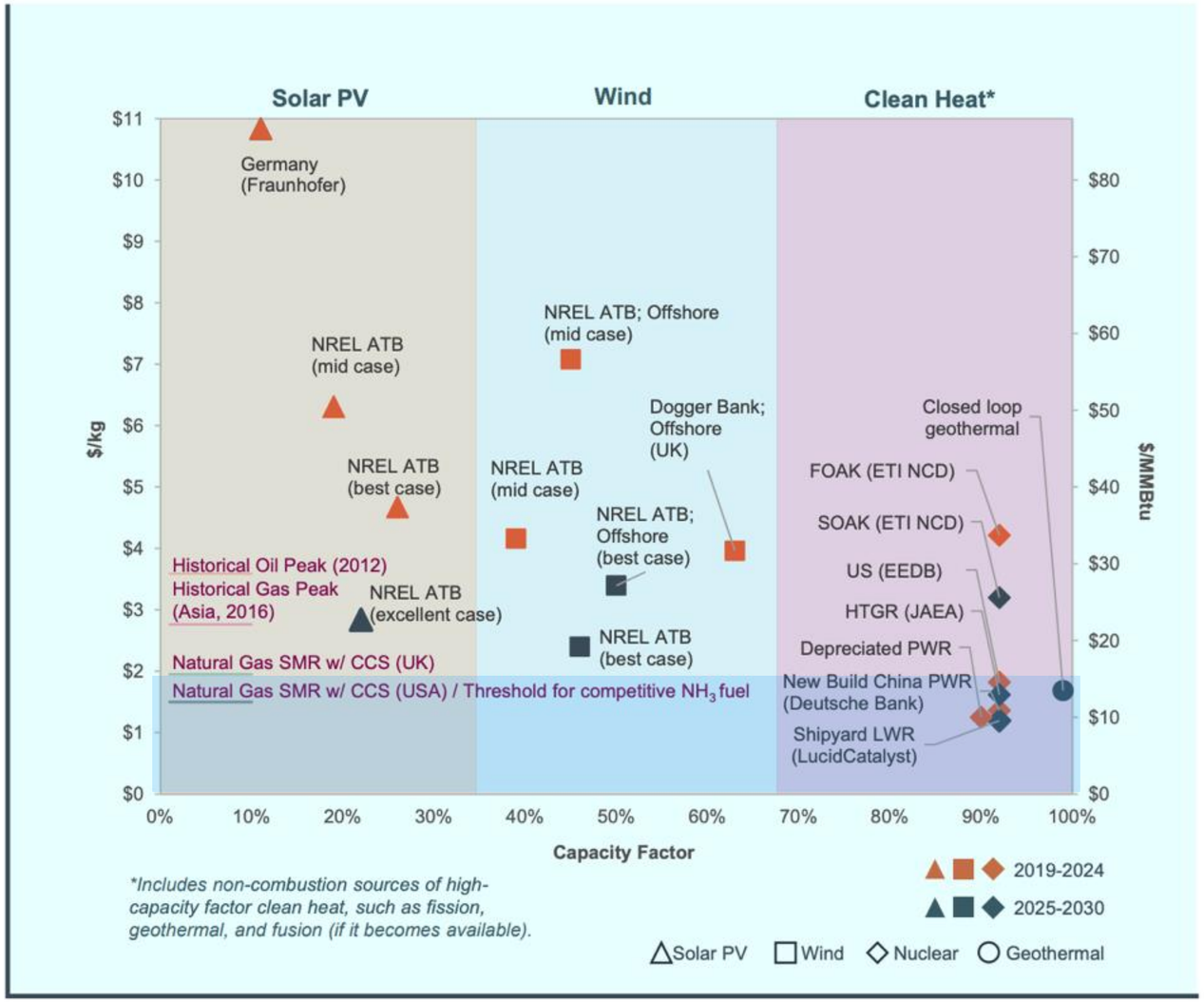
Modular blocks are added to an FPSO under construction in a dry dock.

Shipyard Manufactured Off-shore Production Platform

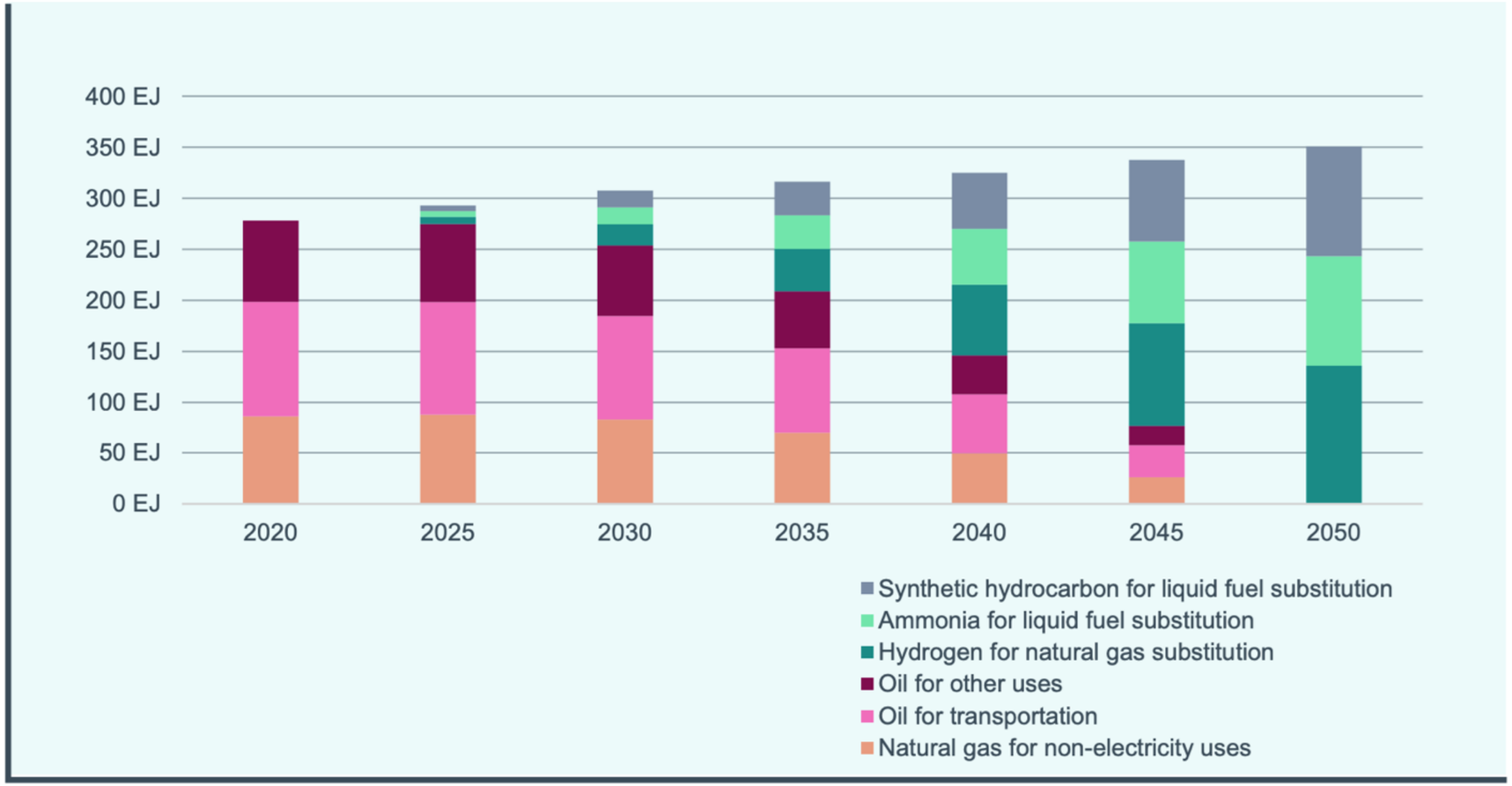
Source: Forthcoming Electric Power Research Institute (EPRI) report*:*

Rethinking Deployment Scenarios to Enable Large-Scale, Demand-Driven Non-Electricity Markets for Advanced Reactors

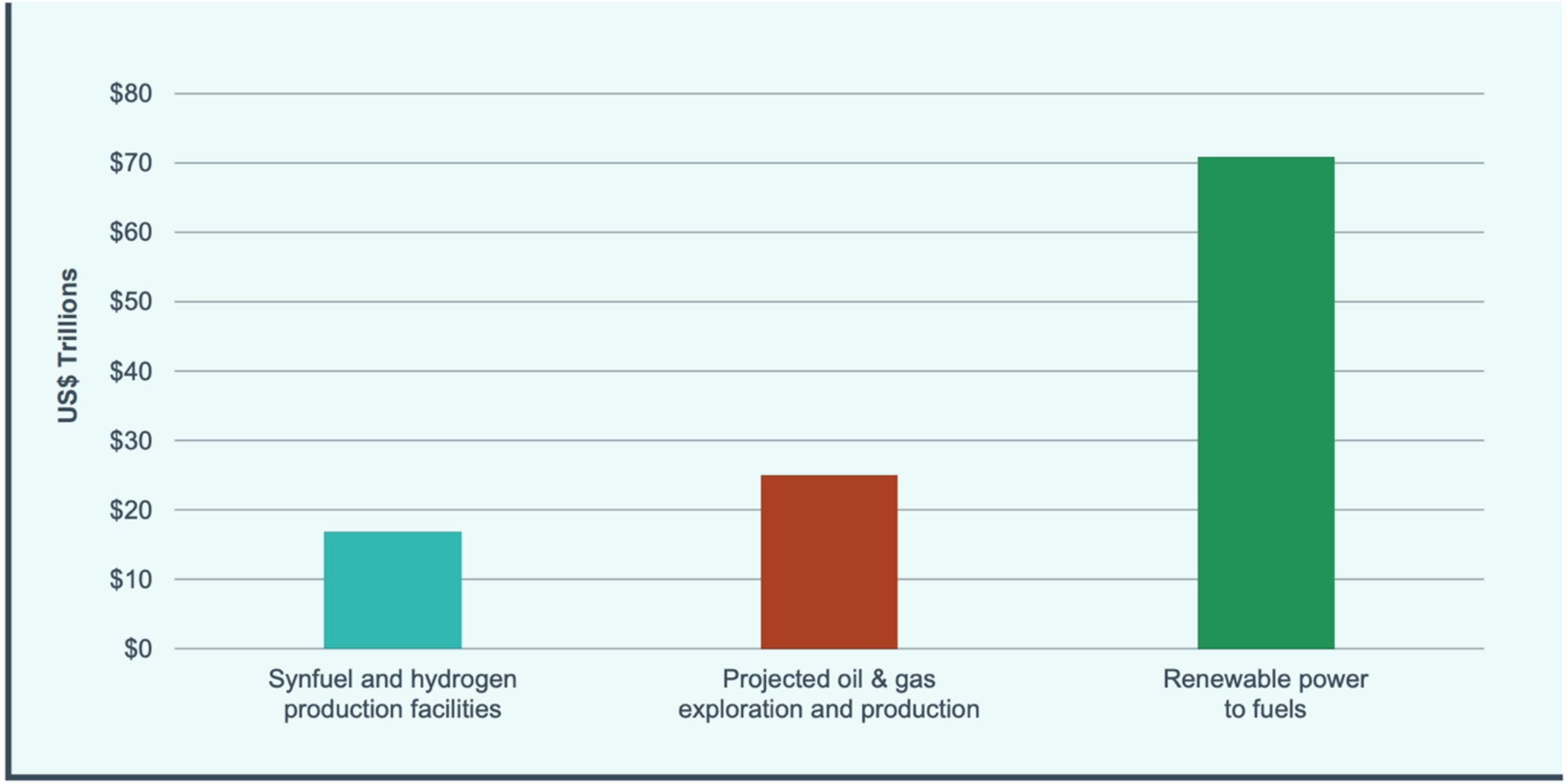
2018-2030 Hydrogen Production Costs



Fuel substitution in difficult-to-decarbonise sectors from ultra-cheap hydrogen generated by advanced heat sources from 202-2050

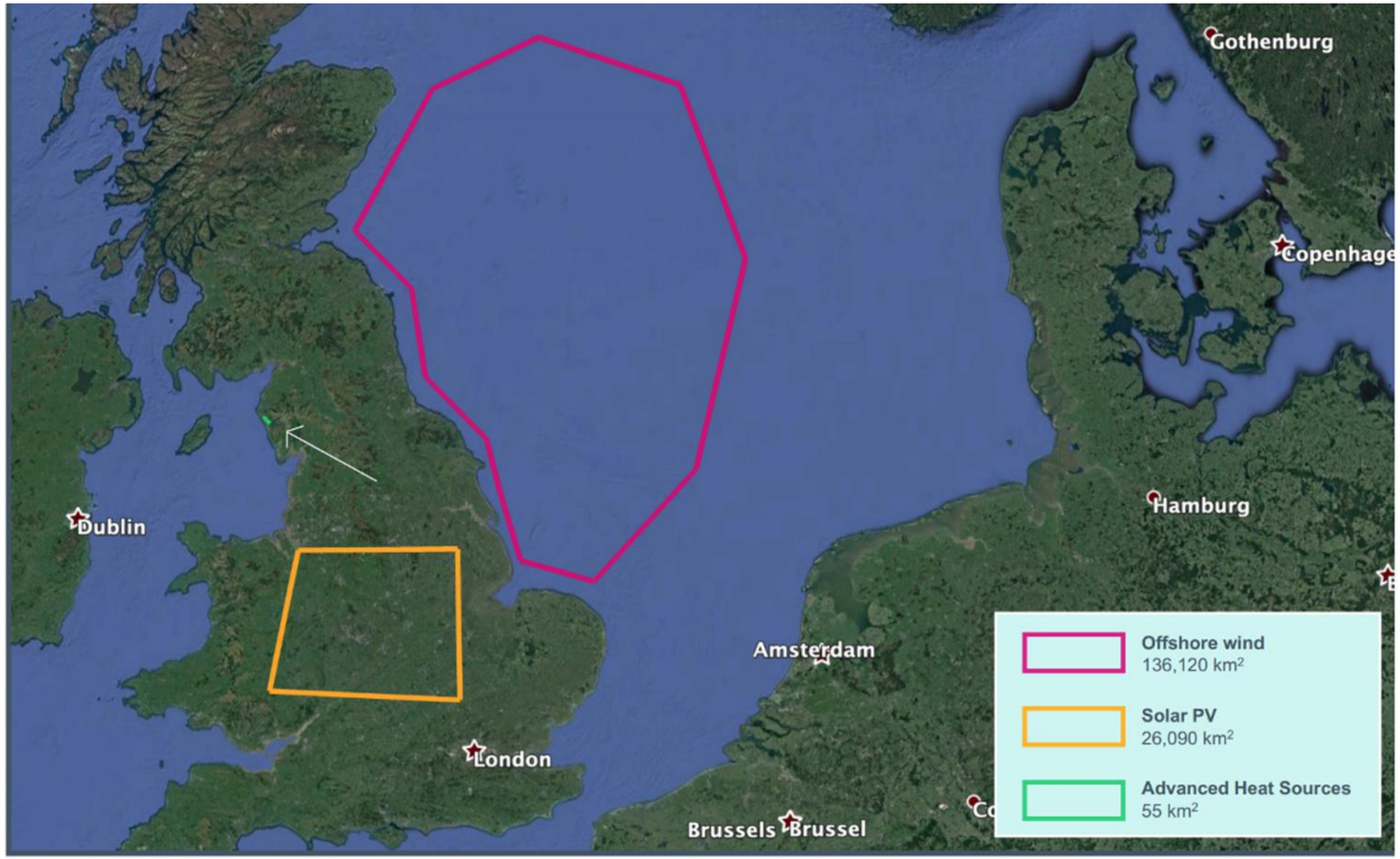


Comparative investment for fuel substitution by 2050



LAND CONSTRAINTS – A REALITY CHECK

Land Area Requirements For Meeting Current Uk Oil Consumption From Hydrogen

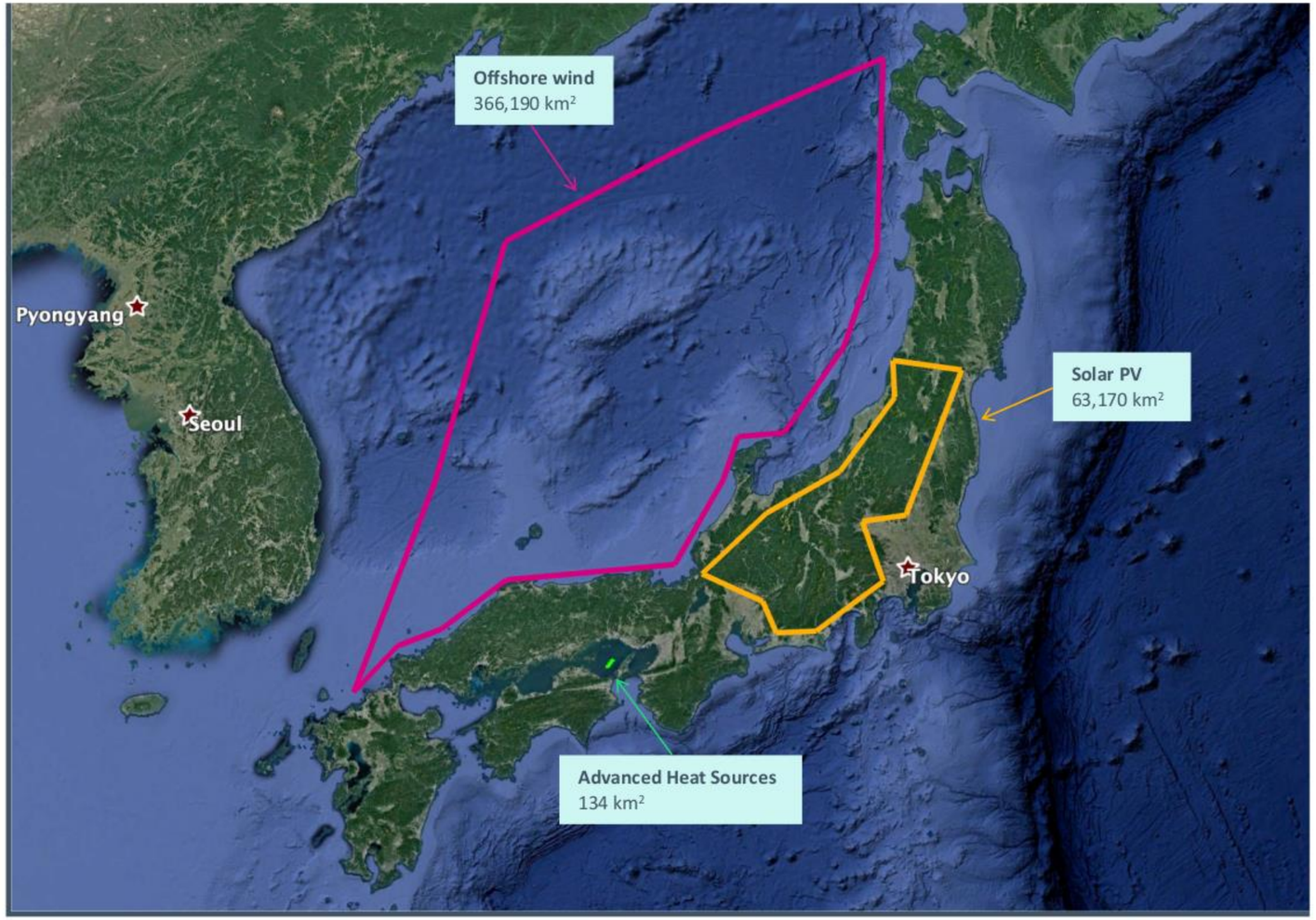


Each colored outline represents the total area that would be required for the siting of each type of resource if it were to be the only one used to generate enough hydrogen to replace current oil consumption in the UK.

Comparing area required to replace the UK's current oil consumption with hydrogen generated from either wind, solar, or advanced heat sources.

Source: *Missing Link to a Livable Climate*

Japan Hydrogen Production Geographic Area Requirements



Comparing the total area required to replace Japan's current oil consumption with hydrogen generated from either wind, solar, or advanced heat sources

Source: *Missing Link to a Livable Climate*

Conclusion

- Given the scale and urgency of the required clean transition combined with growth of the global energy system, all zero-carbon hydrogen production options should be pursued.
- The potential of advanced heat sources to power the production of large-scale, very low-cost hydrogen and hydrogen-based fuels could transform global prospects for near-term decarbonization and prosperity.
- Our report: *Missing Link to a Livable Climate* sets out a pathway to decarbonize a substantial portion of the global energy system, for which there is currently no viable alternative.

ENERGY INNOVATION FOR A PROSPEROUS PLANET

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