Carbon Capture & Storage: why / where?

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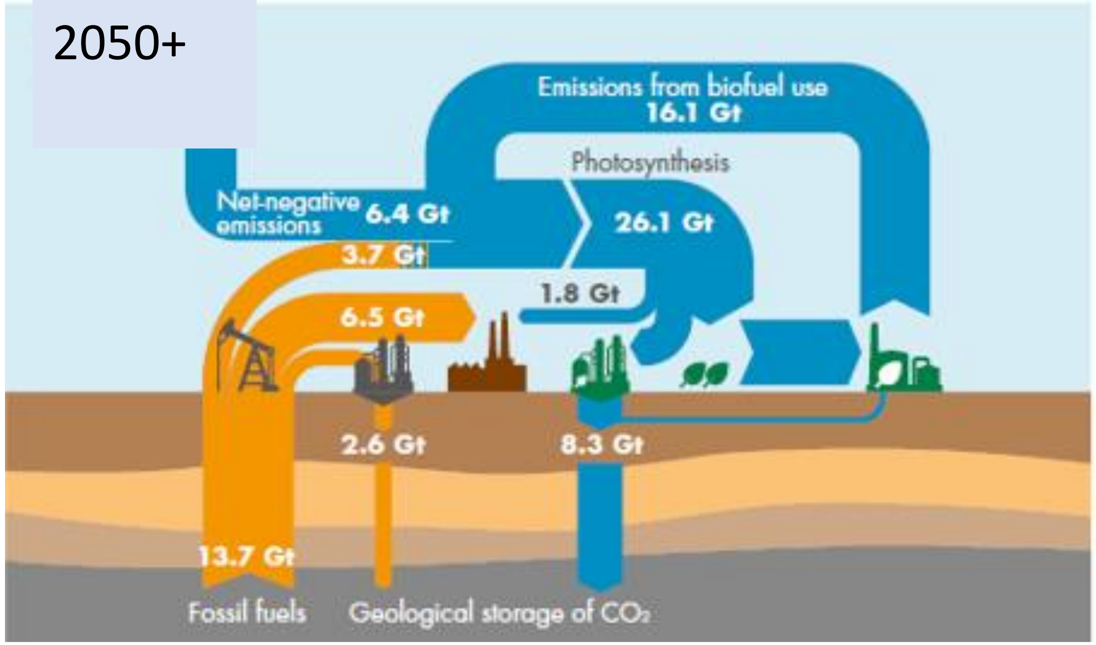
NAE-GRP Colloquium: Opportunities and Challenges – Carbon Capture, Utilization and Sequestration

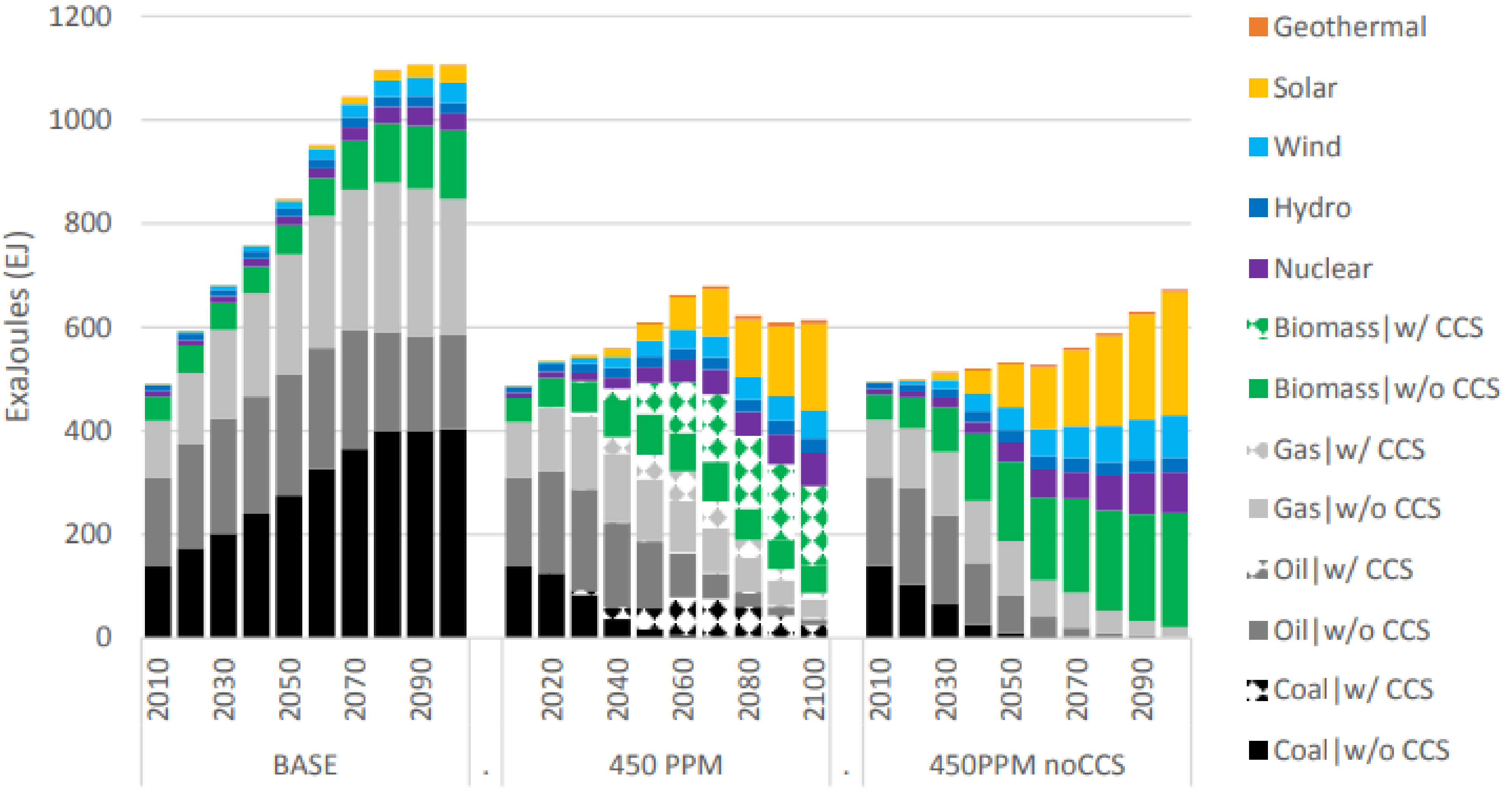


Sky scenario: www.Shell.com

Disclaimer:

Any cost information is approximate and derived from open literature and data.   Do not take any observations as investment advice.

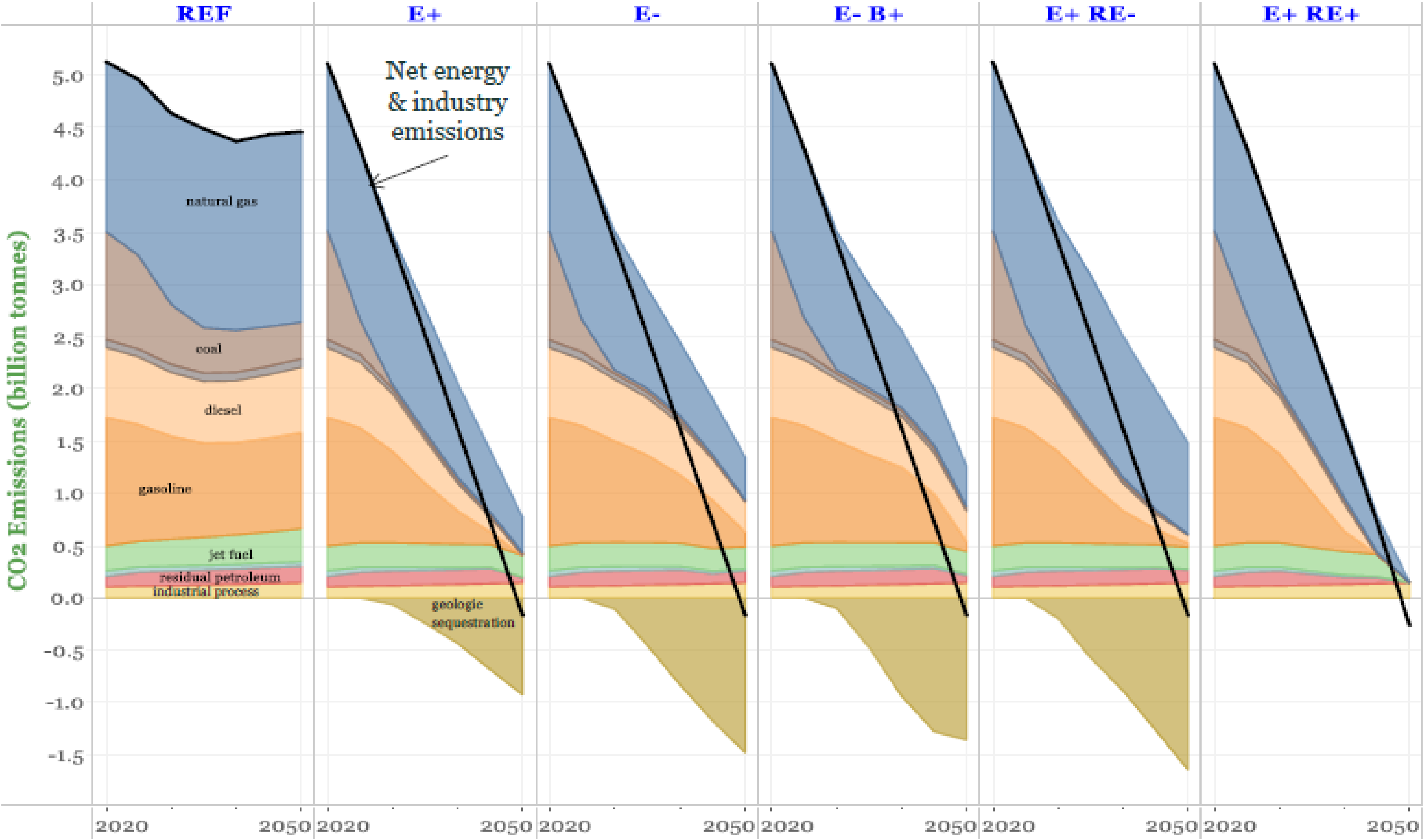
IEA: The case for CCS / cost of energy transition



2019-05 IEA: CCS IN ENERGY AND CLIMATE SCENARIOS https://ieaghg.org/files/2019-05_CCS_in_Energy_and_Climate_Scenarios.pdf

Net Zero America (2021): CCS in all scenarios

Energy and industrial CO_2 emissions are net negative by 2050 to deliver net-zero emissions for the full economy



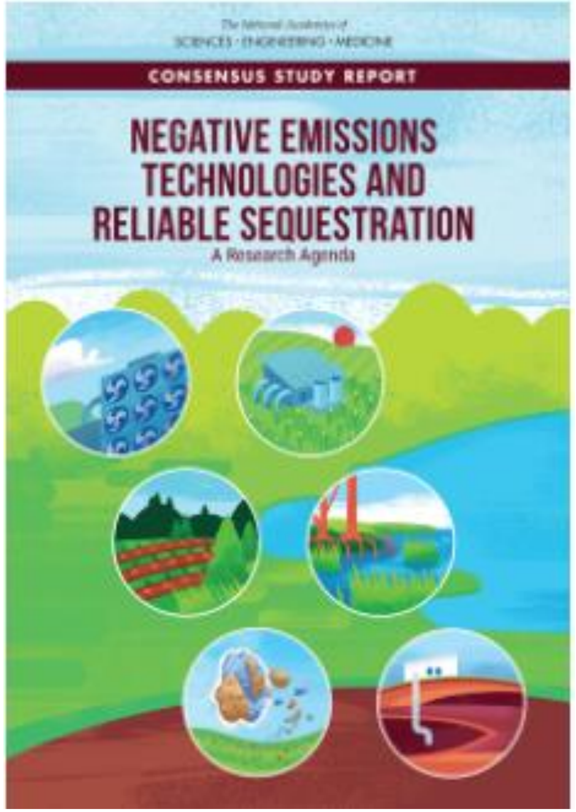
Fossil fuel use declines significantly in all net-zero pathways; coal use all but disappearing by 2030.

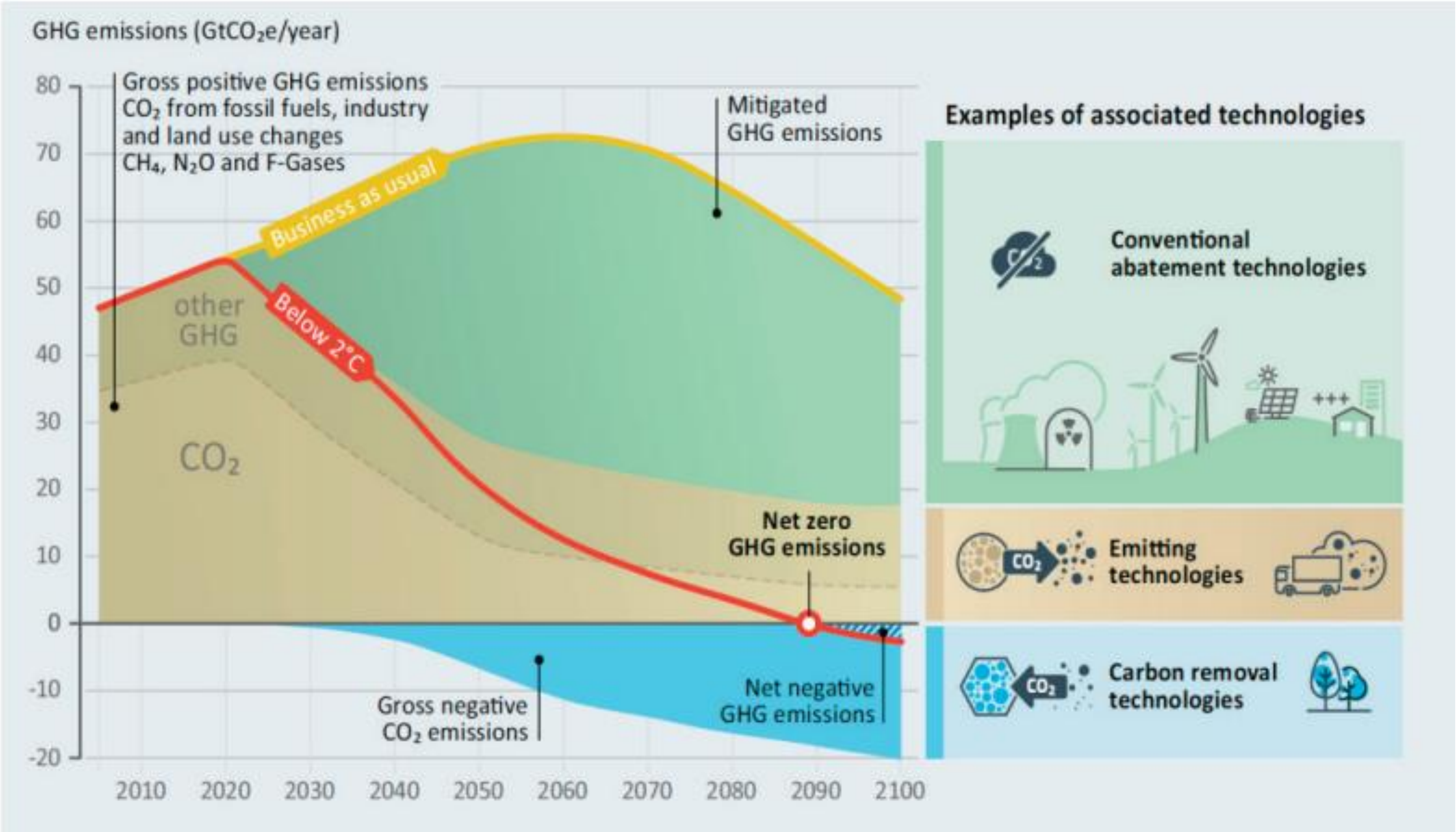
- natural gas
- coal
- coke
- diesel
- gasoline
- jet fuel
- LPG
- residual petroleum
- industrial co2
- geologic sequestration

Carbon storage in long-lived products is included in the modeling, but is not shown explicitly here.

E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020. https://netzeroamerica.princeton.edu

CCS – negative emissions

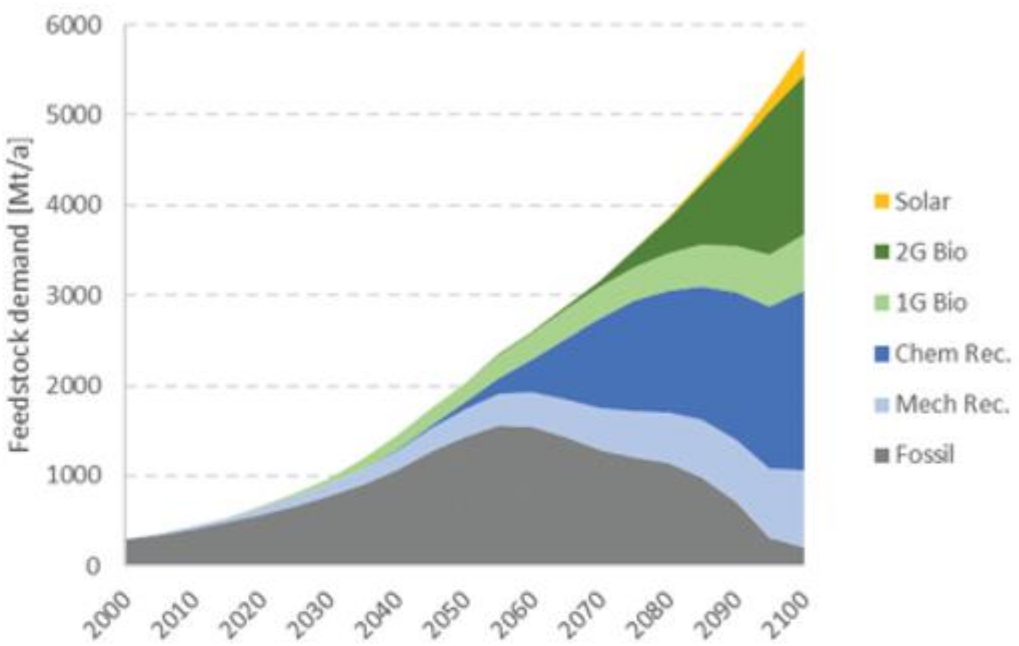


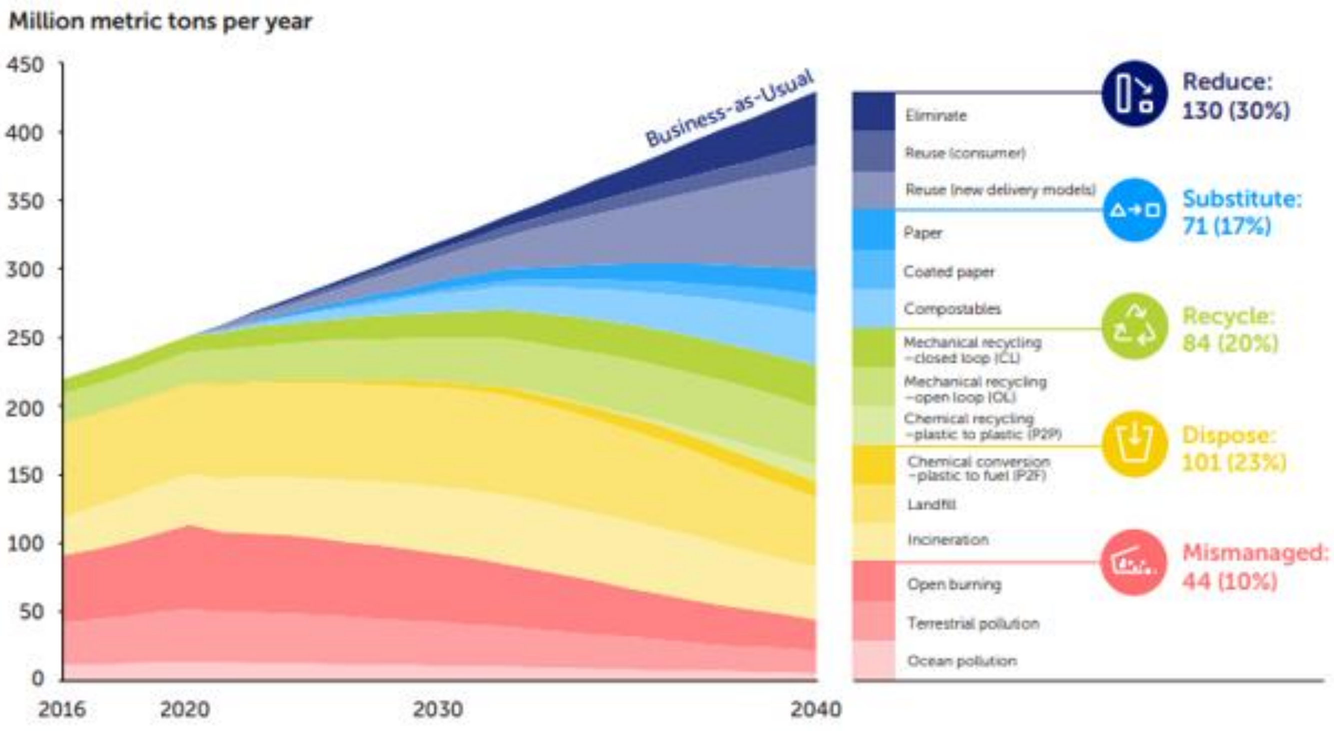


National Academies of Sciences, Engineering, and Medicine. 2019. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda*. Washington, DC: The National Academies Press.https://doi.org/10.17226/25259.

Circularity scenarios: future CCS from waste recycle

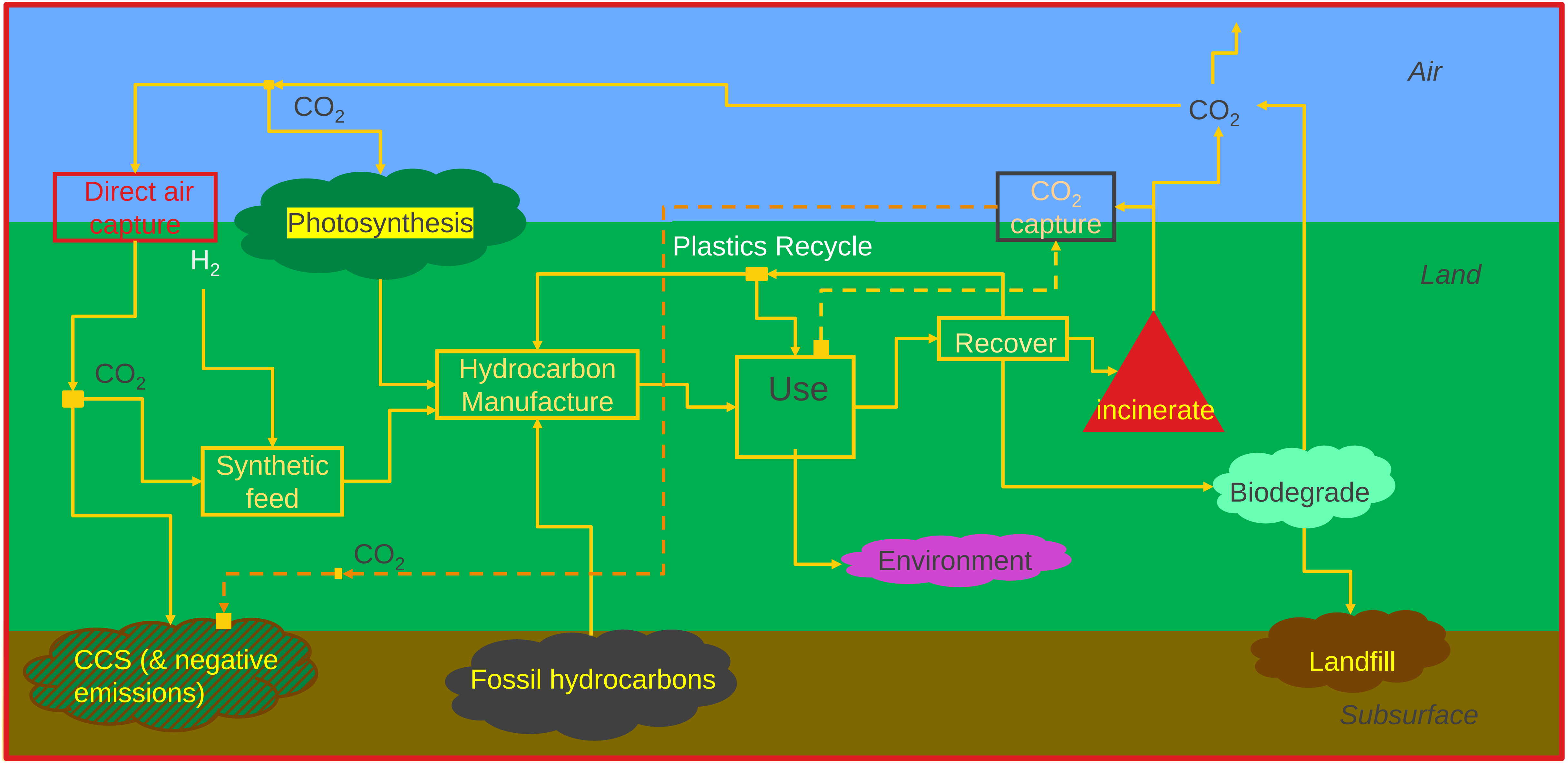
J.-P. Lange, Towards circular carbo-chemicals – the metamorphosis of petrochemicals, *Energy Environ. Sci.*, 2021, **14**, 4358–4376



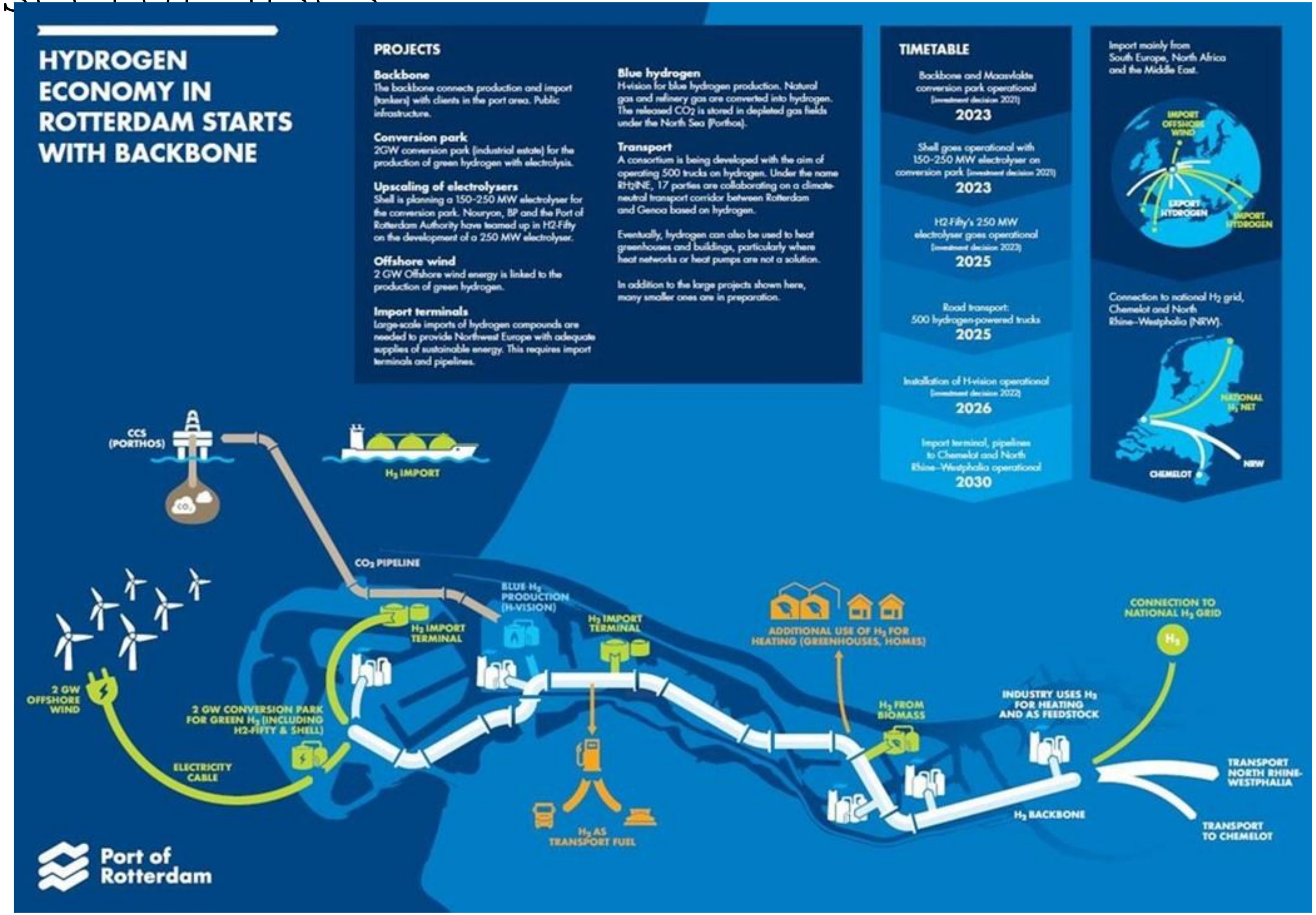


Pew 2020: https://www.pewtrusts.org/-/media/assets/2020/07/breakingtheplasticwave_report.pdf

Circular Economy

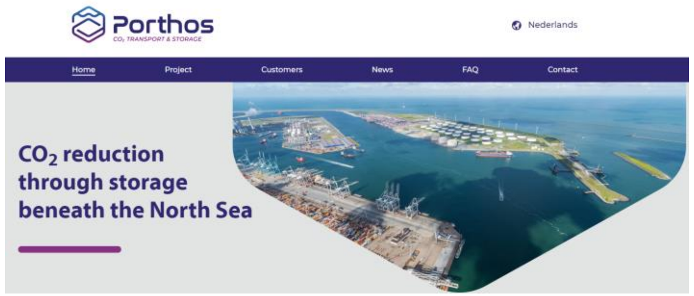


Infrastructure Utilization: Ports and stacked sector uses



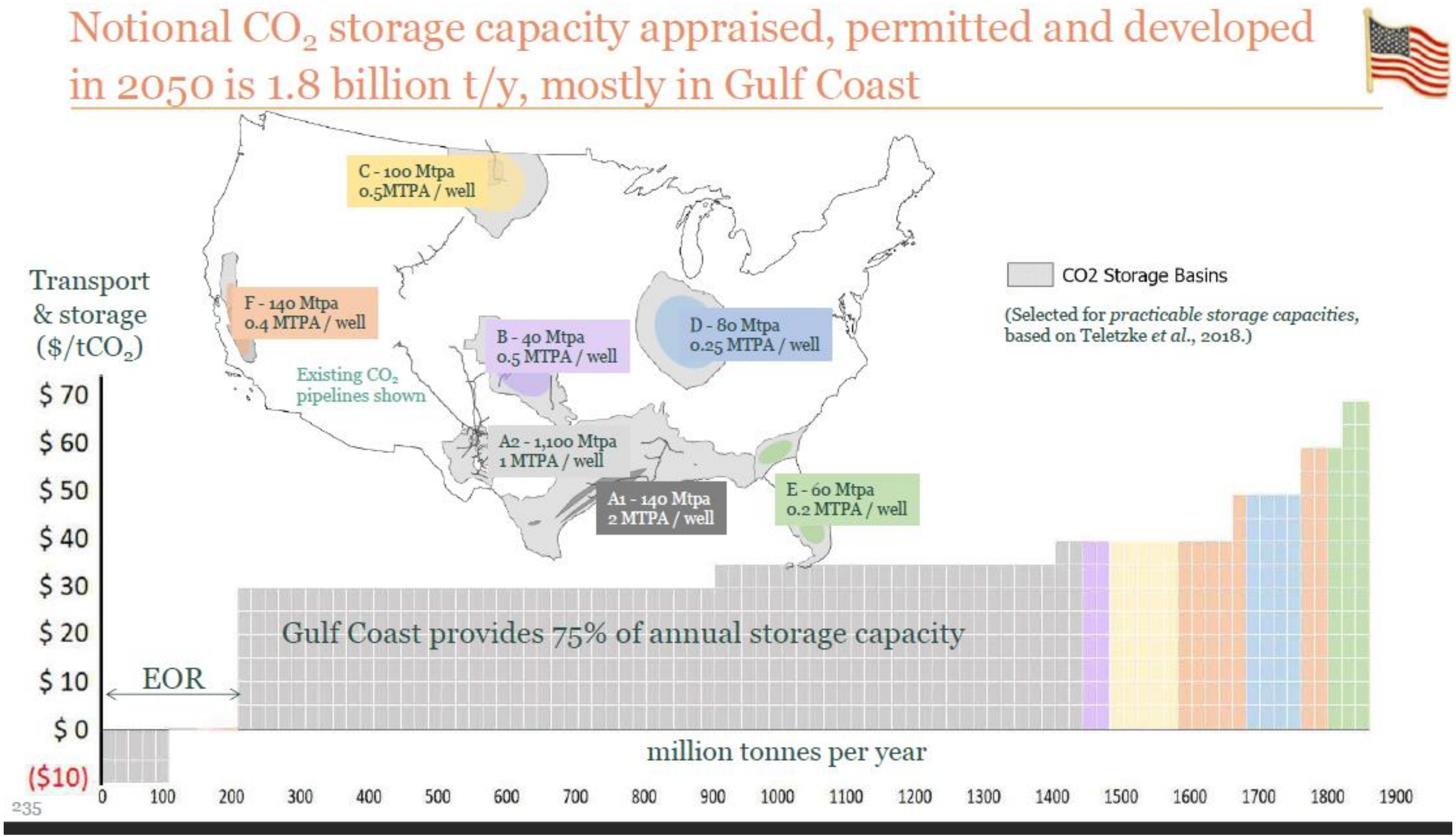
- **Rotterdam Harbor**:
- www.portofrotterdam.com/en/doing-business/port-of-the-future/energy-transition/hydrogen-in-rotterdam

Gasunie & EBN



https://www.porthosco2.nl/en/

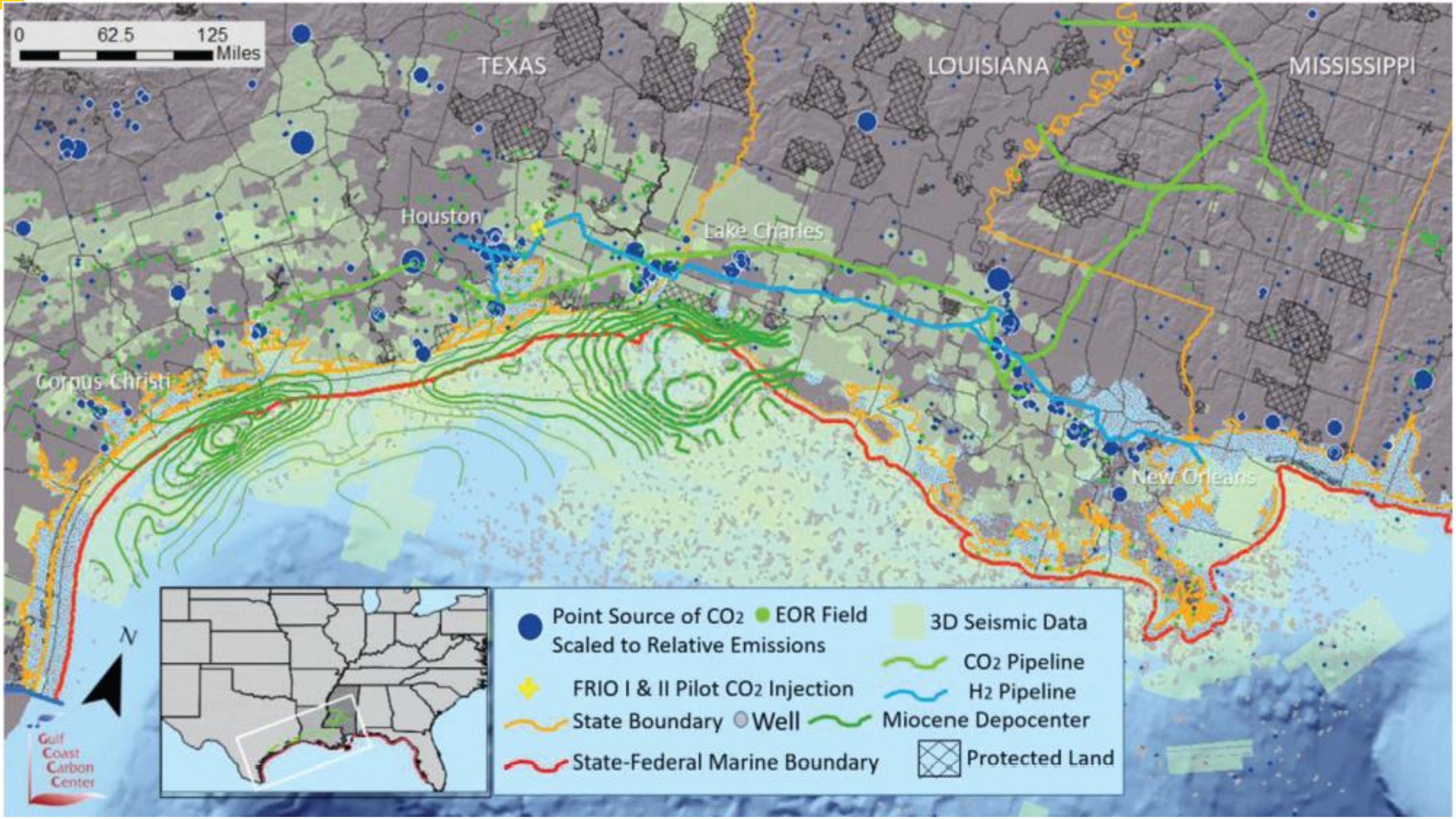
Net Zero America (2021): CCS in all scenarios



E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020. https://netzeroamerica.princeton.edu

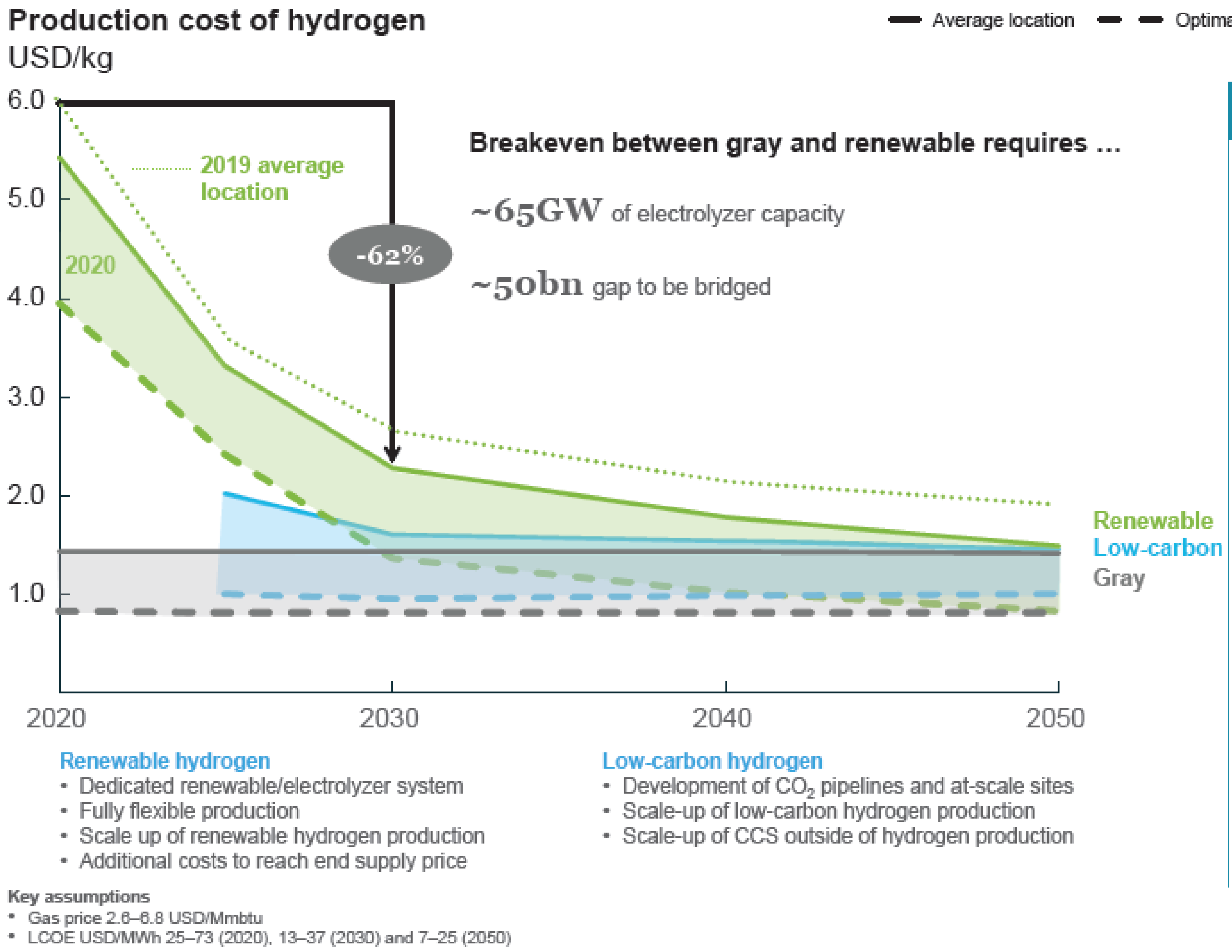
US Gulf Coast: CO_2 sources, pipelines, sinks

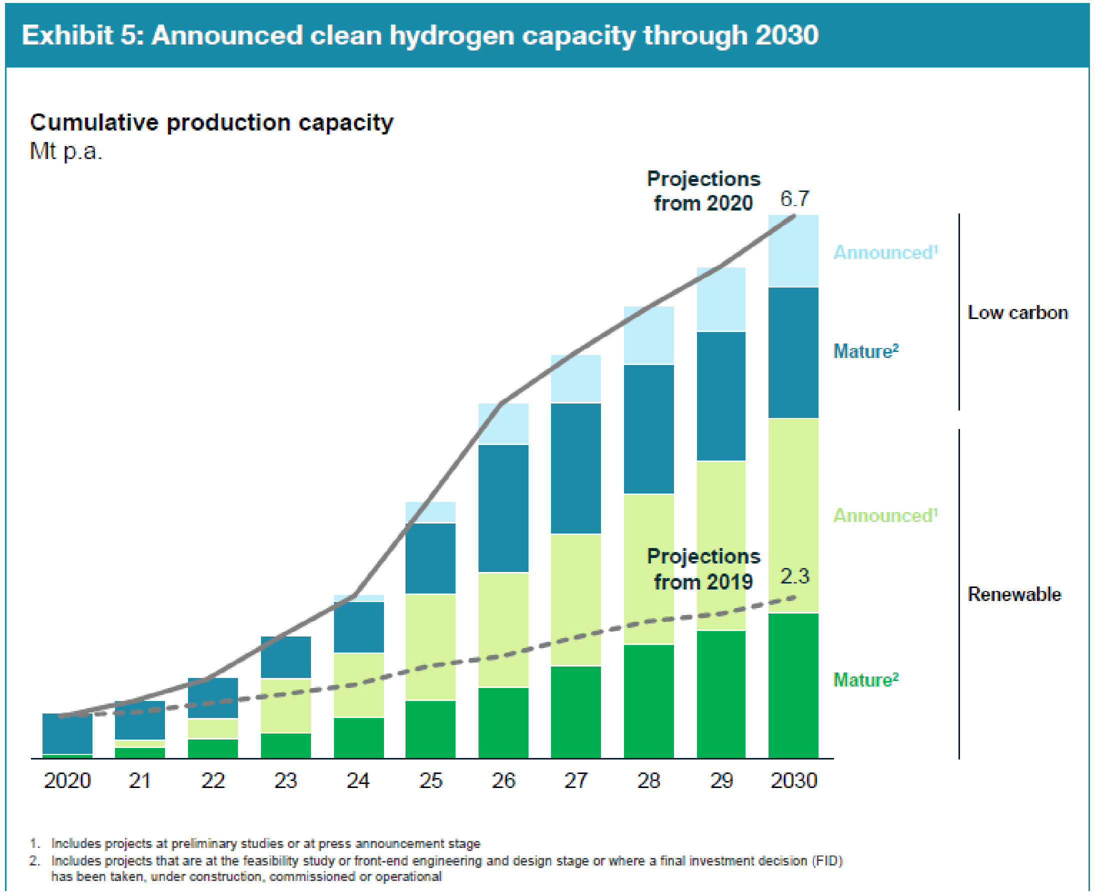
Fed = 3.45 miles offshore (10.45 RX)



T. A. Meckel, A. P. Bump, S. D. Hovorka and R. H. Trevino (UT-BEG), Carbon capture, utilization, and storage hub development on the Gulf Coast, Greenhouse Gas Sci Technol, 2021, 11, 619–632.

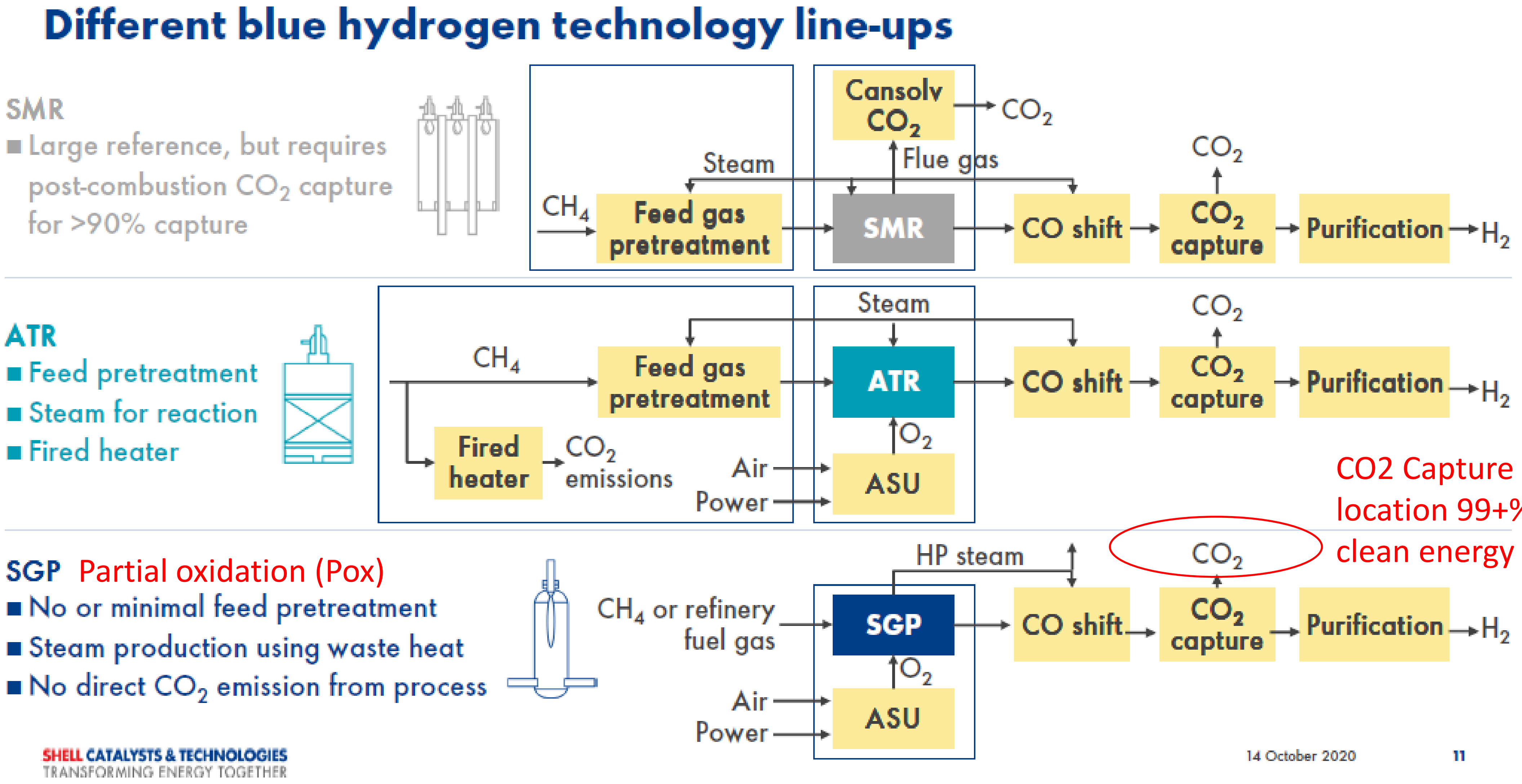
McKinsey / Hydrogen Council





Hydrogen Council / McKinsey: **Hydrogen Insights A perspective on hydrogen investment, market development and cost competitiveness February 2021** https://hydrogencouncil.com/wp-content/uploads/2021/02/Hydrogen-Insights-2021.pdf

Blue Hydrogen Manufacture: SMR → ATR → POx

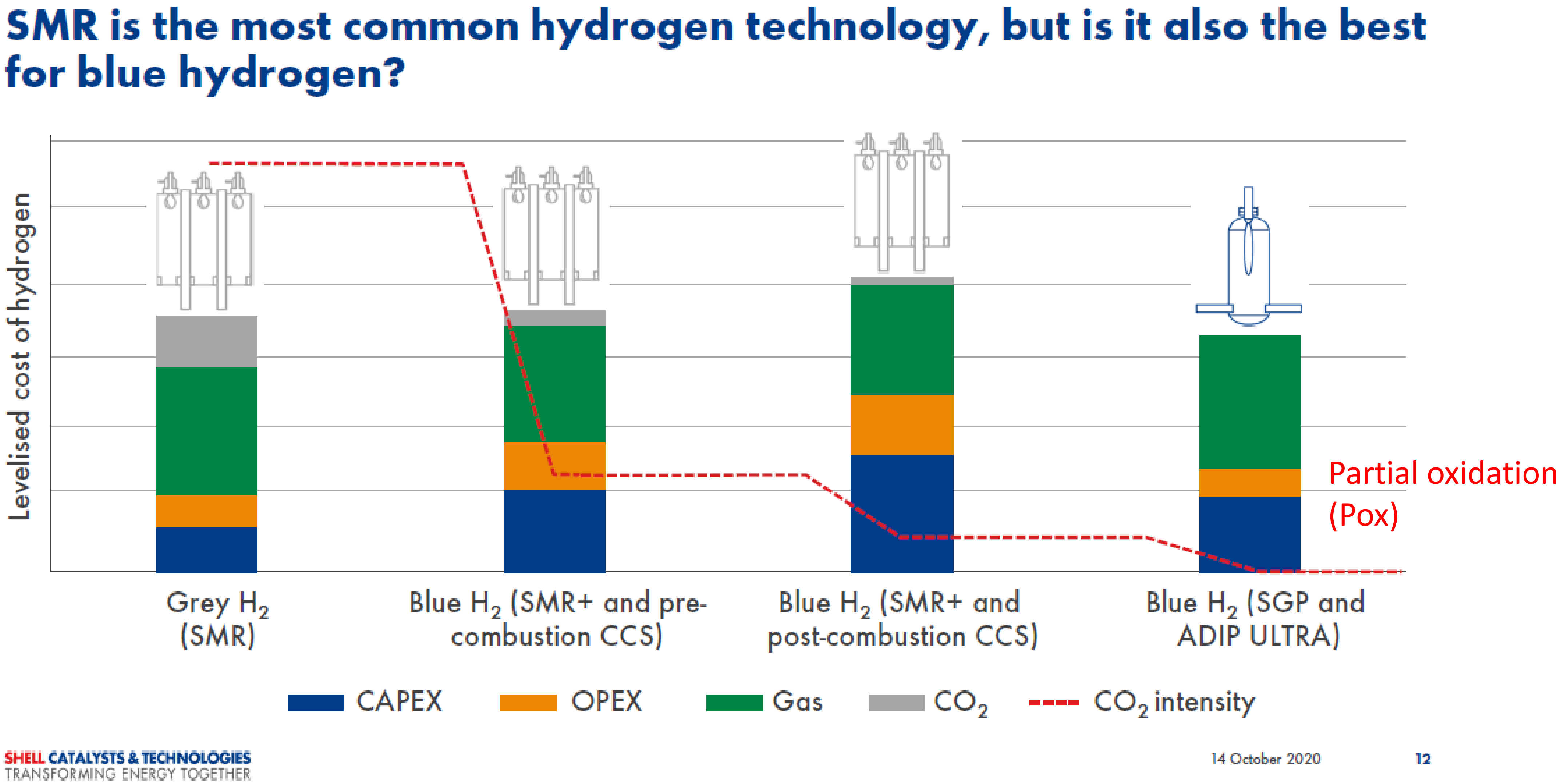


CO2 Capture from single location 99+% + export clean energy & power

Shell Blue Hydrogen Technology, Hydrocarbon Processing Webcast Oct 2020

https://www.hydrocarbonprocessing.com/magazine/2021/june-2021/special-focus-process-optimization/increasing-blue-hydrogen-production-affordability

Hydrogen Manufacture: SMR → ATR → POx



Shell Blue Hydrogen Technology, Hydrocarbon Processing Webcast Oct 2020

https://www.hydrocarbonprocessing.com/magazine/2021/june-2021/special-focus-process-optimization/increasing-blue-hydrogen-production-affordability

Conclusions / Q&A / Follow-up

- CCS= global affordability for energy transition & permanent storage (1000+ years)
- Utilization (CCUS) is challenged as alternative because CO_2 is often re-emitted.
- United States is uniquely advantaged for storage in depleted hydrocarbon reservoirs
- Offshore CO_2 storage can improve stakeholder acceptance
- Blue hydrogen (natural gas conversion + CCS) is already at DOE 1:1:1 targets and offers attractive options for decarbonization

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Thank you!