WHEN TRUST MATTERS

Energy Transition Outlook 2023 – A regional forecast to 2050

North America

Wednesday, November 15, 2023

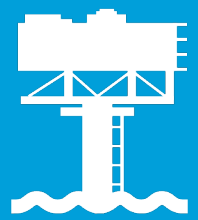
Offshore Energy Port Infrastructure Risk

Craig Reid, Vice President DNV

DNV - Deep Experience Managing Offshore Energy & Port Infrastructure Risk

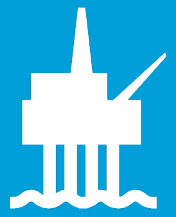
90 YRS

Marine Engineering



53 YRS

Offshore Oil & Gas



159 YRS

Shipping & Ports

46 YRS

Wind Power

North America - regional presentation

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NORTH AMERICA

This region consists of Canada and the US

	Population (MN)	GDP* (USD TRN) GDP/person (USD)	Energy use (EJ) Energy use/person (GJ)	Energy-related CO_2 emissions (GT) Energy-related CO_2 emissions/person (T)
2022	373	28 74 000	104 279	5.2 13.8
2050	419	41 97 000	77 184	1.3 3

*All GDP figures in the report are based on 2017 purchasing power parity and in 2022 international USD.

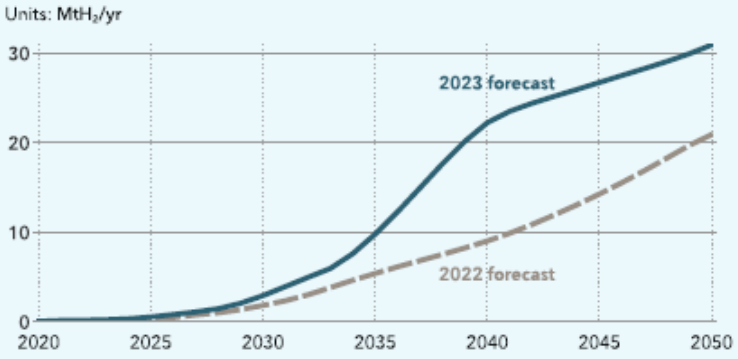
Highlight ETO 2023

The IRA has accelerated North America's energy transition

The energy-industrial policy incentivizes wind, solar, storage, low-carbon hydrogen, carbon capture technologies as well as regional manufacturing, and historically fossil fuel dependent and underserved communities. This year's forecast for solar + storage as a percentage of the electricity mix jumps from 5% last year to 17%, while green hydrogen from dedicated renewables rises from 20% to 35%, overtaking blue hydrogen production by 2040.

HIGHLIGHT 1

Hydrogen production

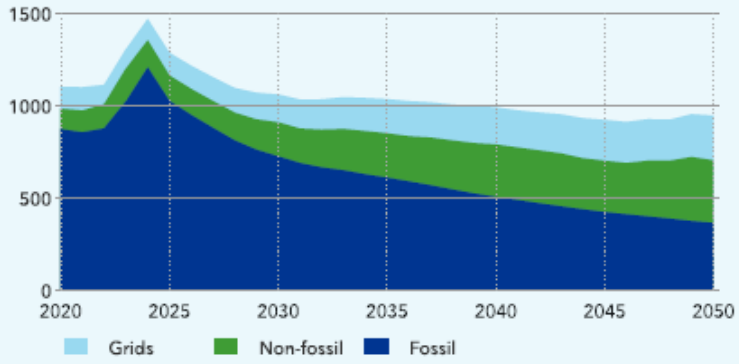


Grid and renewables are a USD 12trn opportunity

By 2050 a cumulative USD 12trn will be spent on clean energy in North America, comprising USD 7trn invested in clean energy sources, including nuclear and hydrogen, and a further USD 5trn on grids and operational expenditure. Non-fossil CAPEX overtakes fossil CAPEX by 2040, making energy and its transmission cheaper and cleaner. Cumulative solar investments of USD 2.3trn, and wind investments of USD 1.6trn will power the renewables market, along with storage solutions. The trend has been firmly set by the USD 240bn already committed in clean investments in the US, as part of the IRA.

HIGHLIGHT 2

Energy expenditures

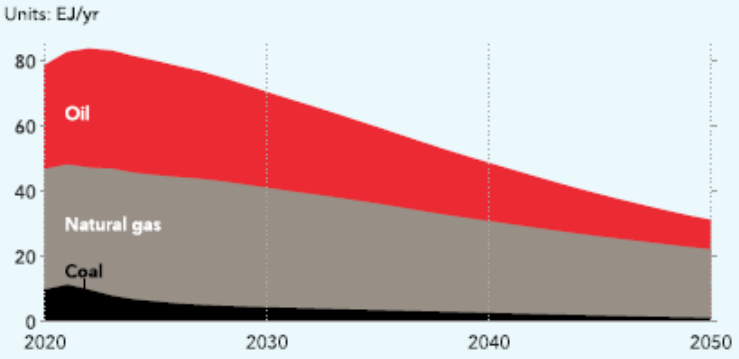


Fossil fuel demand declines 60%, mainly in the transport and power sectors, but exports remain fairly stable

Coal use declines by 80%, oil by 75% and natural gas by 40%. Reduction of oil in North America accounts for almost half of the global oil demand reduction by 2050. Coal demand peaked in 2000, oil demand peaked in 2021, gas demand is forecast to peak in 2024, while production reduces due to declining domestic demand through to 2050. Electrification of transport leads to a drastic cut in oil demand, while coal is phased down in power sector due to the rise of solar and wind.

HIGHLIGHT 3

Fossil fuel primary energy consumption



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Highlights ETO 2023

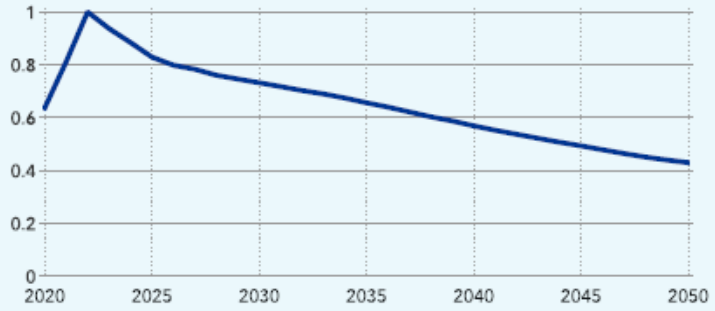
Household energy expenditure halves to 2050

Despite a short-term cost hike, on average, households will spend progressively less on energy, thanks to affordable electrification of demand sectors and improving energy efficiencies. By 2050, household energy expenditure will be half of what it is today, effectively transferring the benefits of the energy transition to the public.

HIGHLIGHT 4

Household energy expenditure

Units: Unitless, 2022 value =1



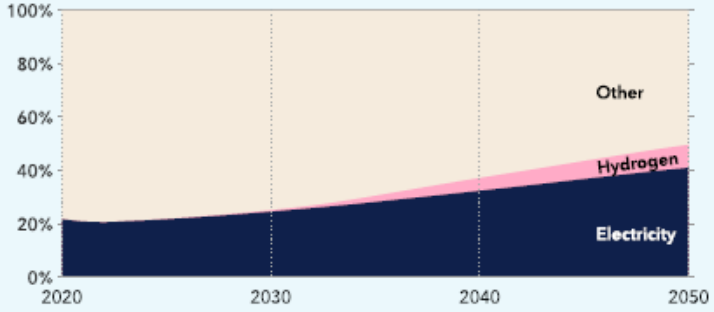
Electrification of final energy doubles and will be the main driver of the North American transition

The North American economy will be powering forward in the next 30 years, growing by over 30%, requiring ever-greater amounts of energy services. Solar grows 15-fold, and wind 8-fold, spurring clean electrification of all demand sectors. Hydrogen and its derivatives also provide indirect electrification.

HIGHLIGHT 5

Share of electricity and hydrogen in final energy demand

Units: Percentages



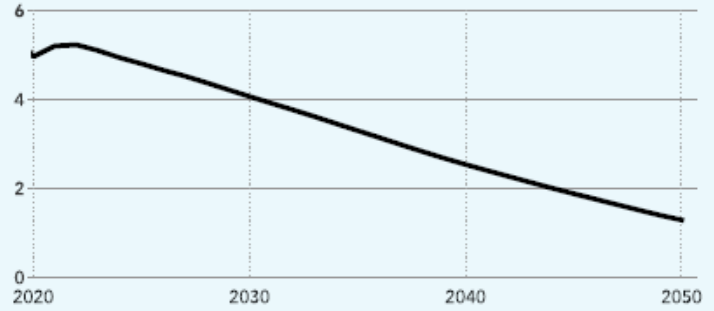
The energy transition is far from fast enough to reach net-zero

1.3 $GtCO_2$ annual emissions remain and residual presence of natural gas in the power mix prevents full power decarbonization before 2050. Electrical transmission will grow 2.5 times by 2050 to support more renewables but initial bottlenecks restrain the pace of development. Much of the existing gas grids can be retrofitted or repurposed for hydrogen and its derivatives, but more pipelines will be needed to meet climate goals, and permitting is currently challenging.

HIGHLIGHT 6

Energy-related CO_2 emissions

Units: $GtCO_2/yr$



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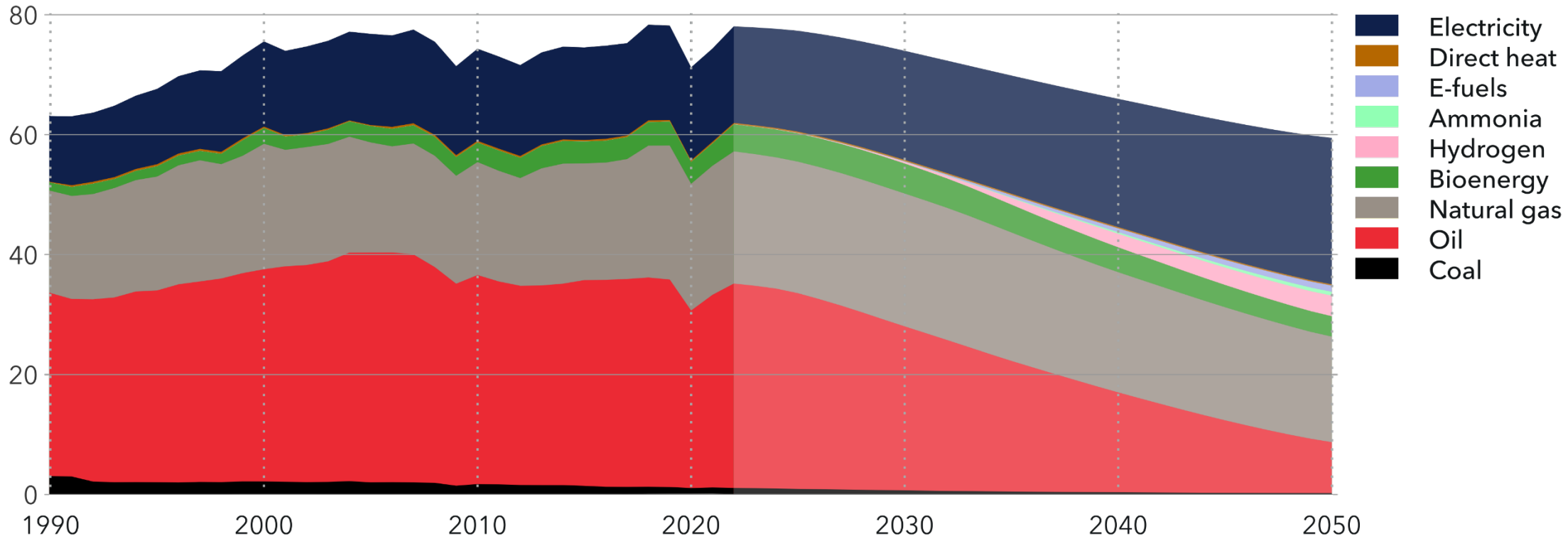
Final energy demand mix

North America

Final energy demand by carrier

Units: EJ/yr



Historical data source: IEA WEB (2023)

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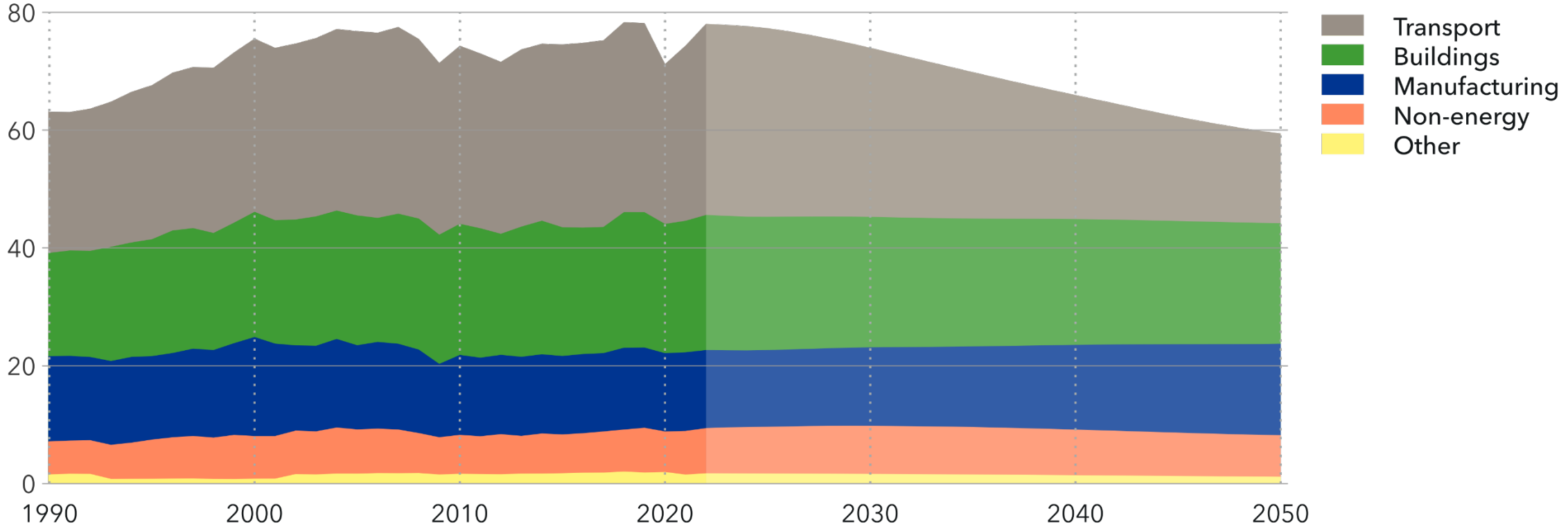
Final energy demand

North America

Final energy demand by sector

Units: EJ/yr



Historical data source: IEA WEB (2023)

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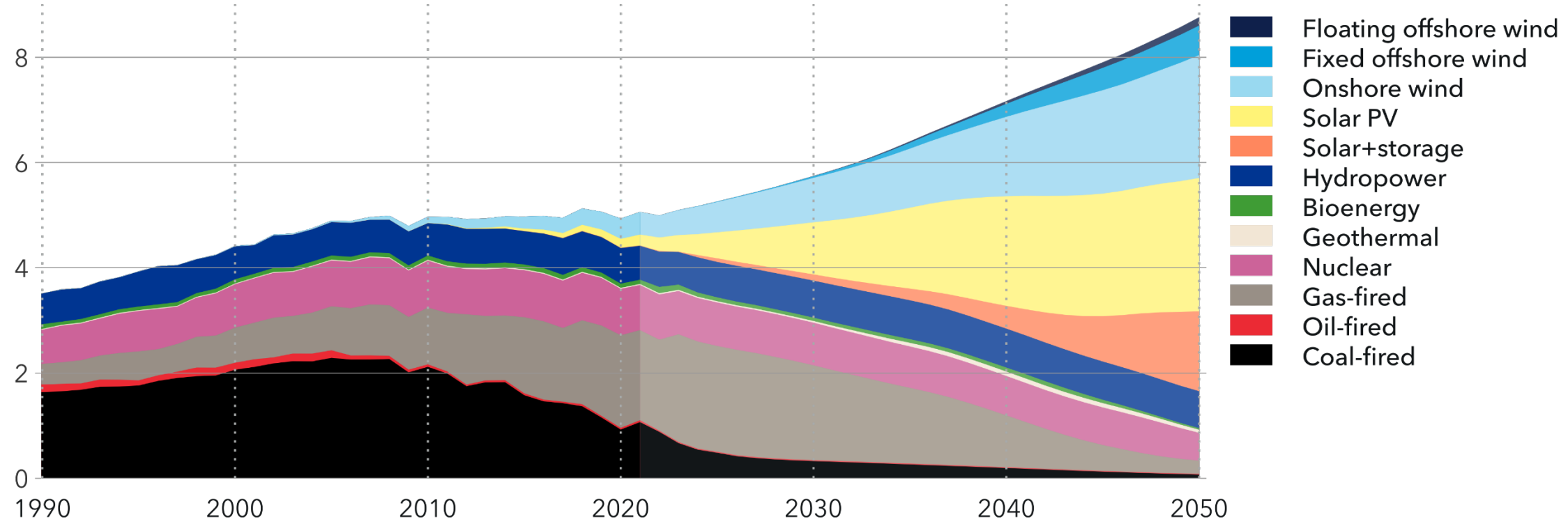
Electricity generation mix

North America

Grid-connected electricity generation by power station type

Units: PWh/yr



Historical data source: IEA WEB (2023), GlobalData (2023)

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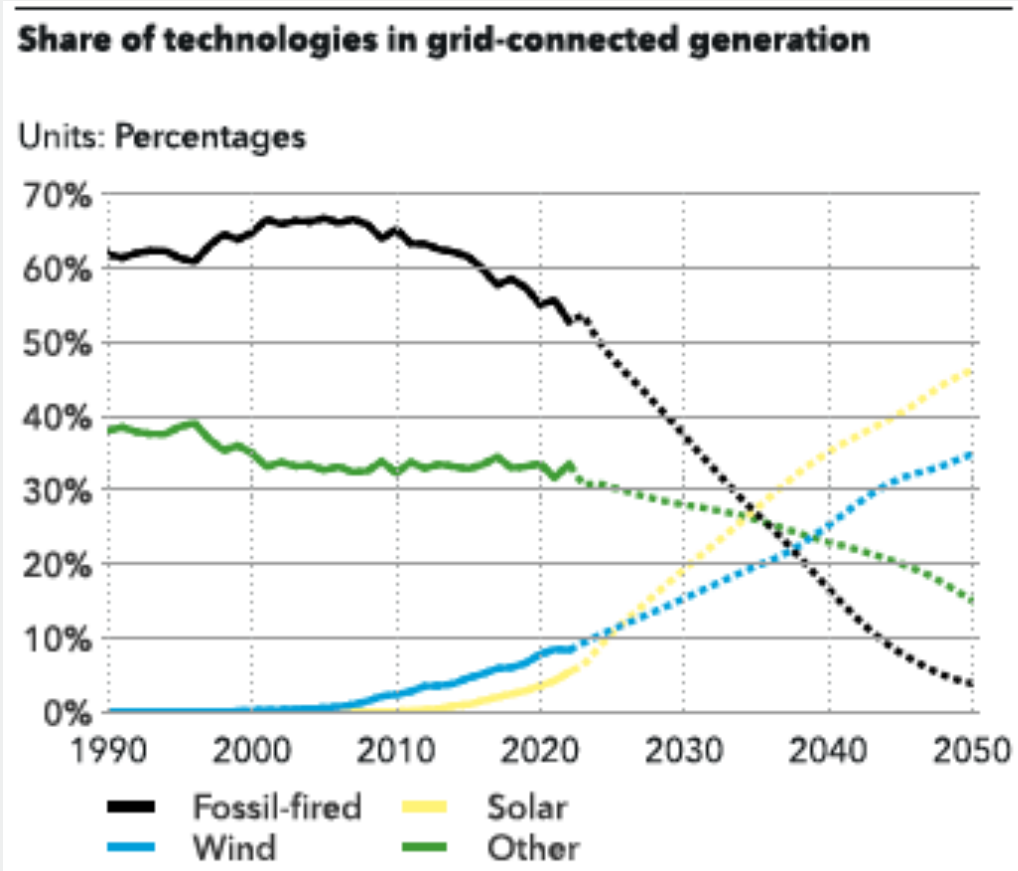
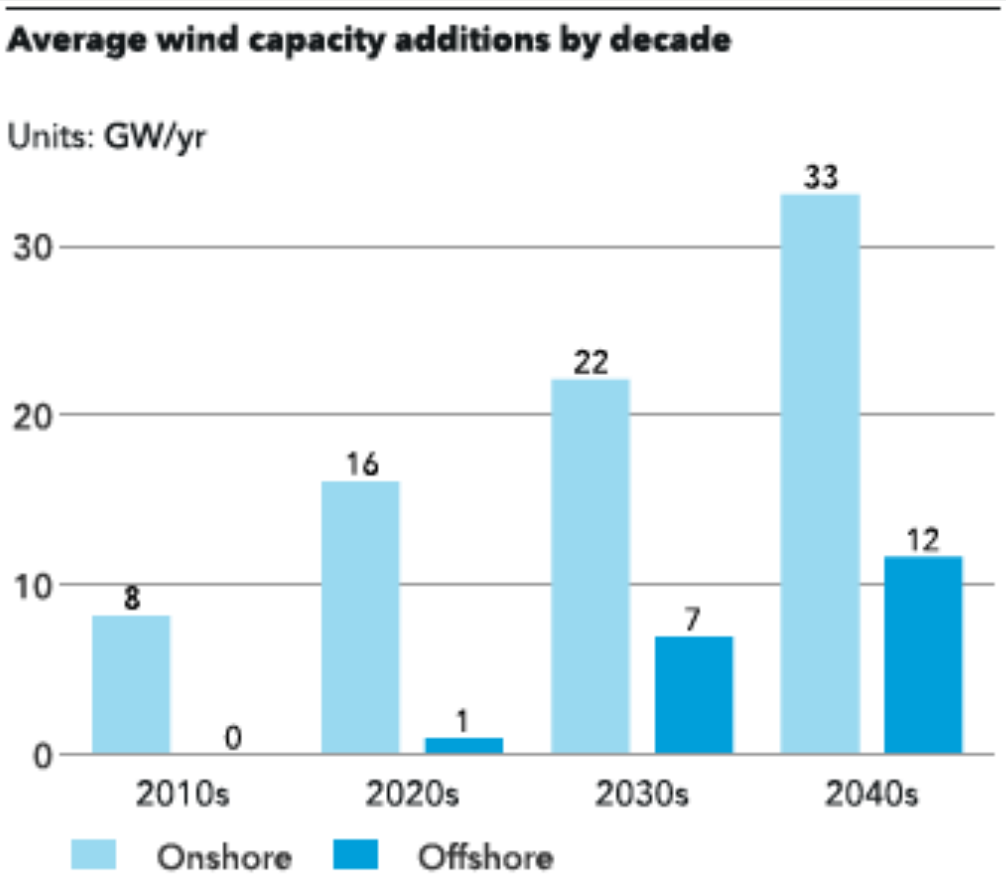
Electricity generation mix – Offshore Wind





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What Ports are needed and when

Time period / deployment goals

- **Anchored in supporting 30 GW by 2030**
- Recognizes that if a port project isn't already in development, it will be difficult pre-2030 deployment
- **Charting a pathway to 110 GW by 2050**
  - OR – 3 GW by 2035
  - NY – 9 GW by 2035
  - LA – 5 GW by 2035
  - NJ – 11 GW by 2040
  - CA – 25 GW by 2045

THE BUSINESS NETWORK FOR OFFSHORE WIND

BUILDING A NATIONAL NETWORK OF OFFSHORE WIND PORTS

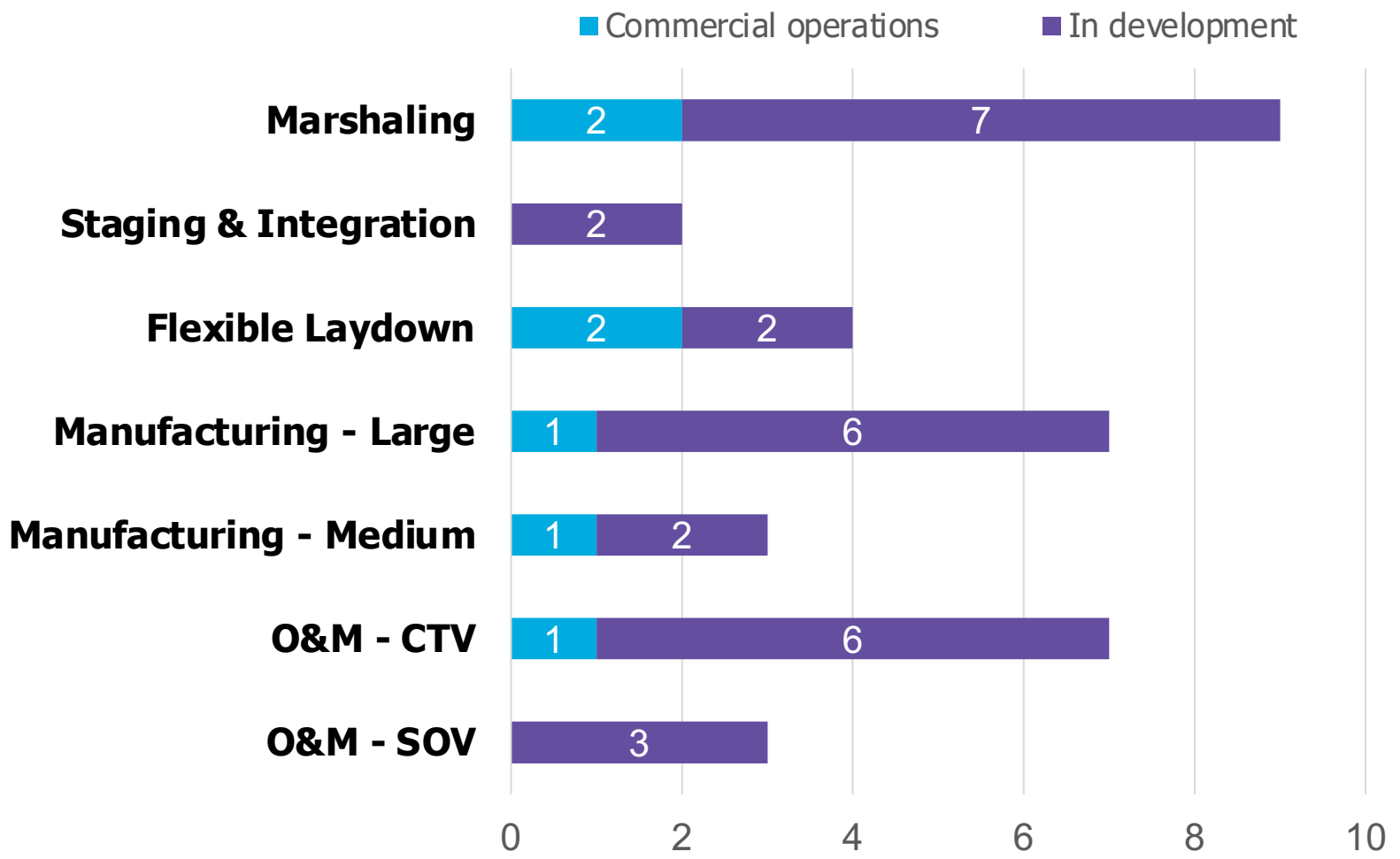
A $36B Plan for Domestic Clean Energy Infrastructure

Authored By:
Brian Sabina, Clean Energy Terminals
Business Network for Offshore Wind Ports Working Group

SEPTEMBER 2023

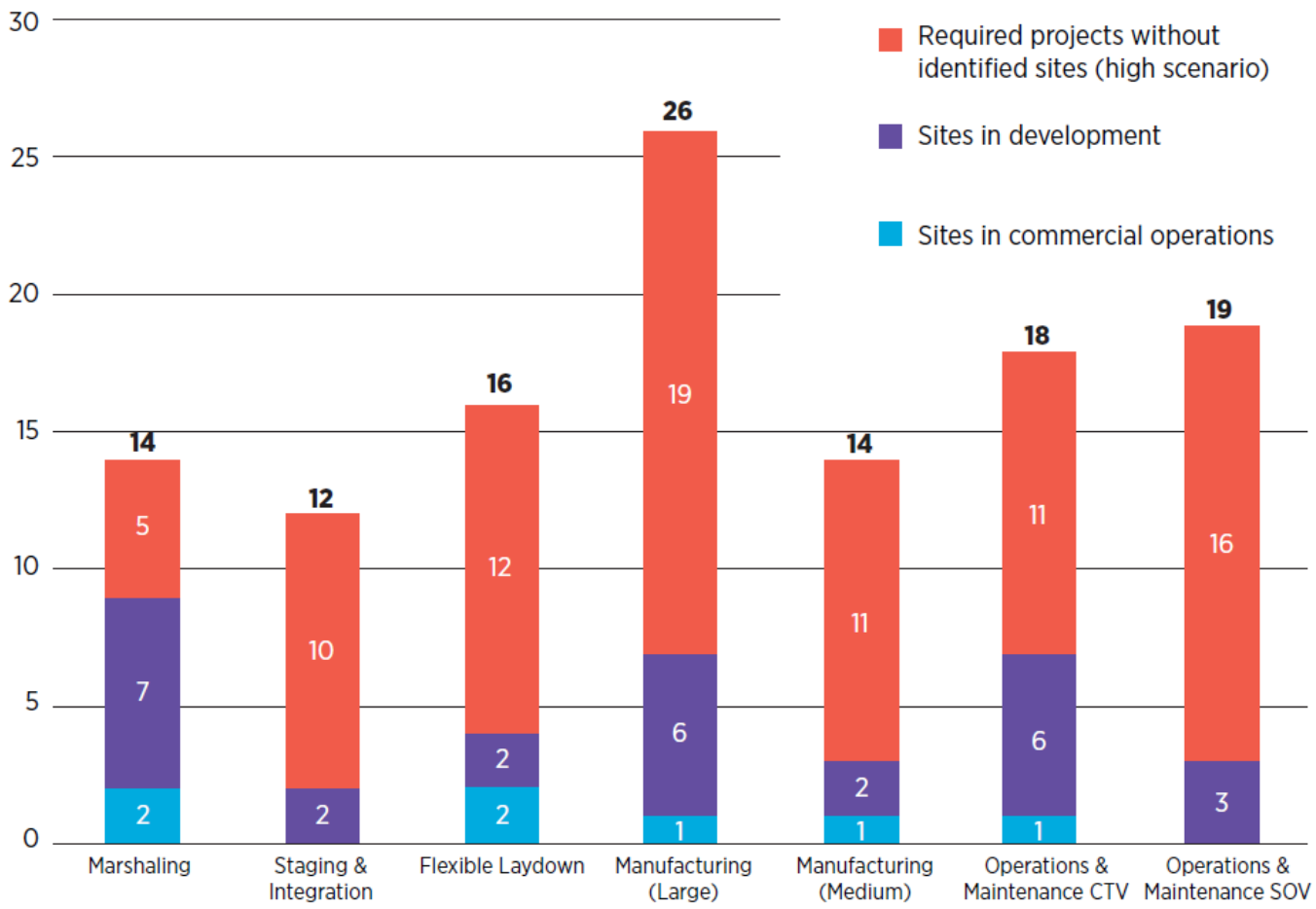
There are already 35 offshore wind port projects under development, mostly in the Northeast and Mid-Atlantic

Figure 1: *Completed or in-development offshore wind ports*



Forecasts U.S. OWF development needs 99 to 119 ports across the East Coast, the West Coast, and the Gulf of Mexico.

Graphic 1: *Offshore wind port infrastructure requirements by port type and project status*



The nation is currently facing an offshore port infrastructure gap of 64 to 84 projects

Hornsea 2 Offshore Wind Farm – 1.3 GW

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