NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Assessing Floating Offshore Wind Energy Cost Reduction Pathways

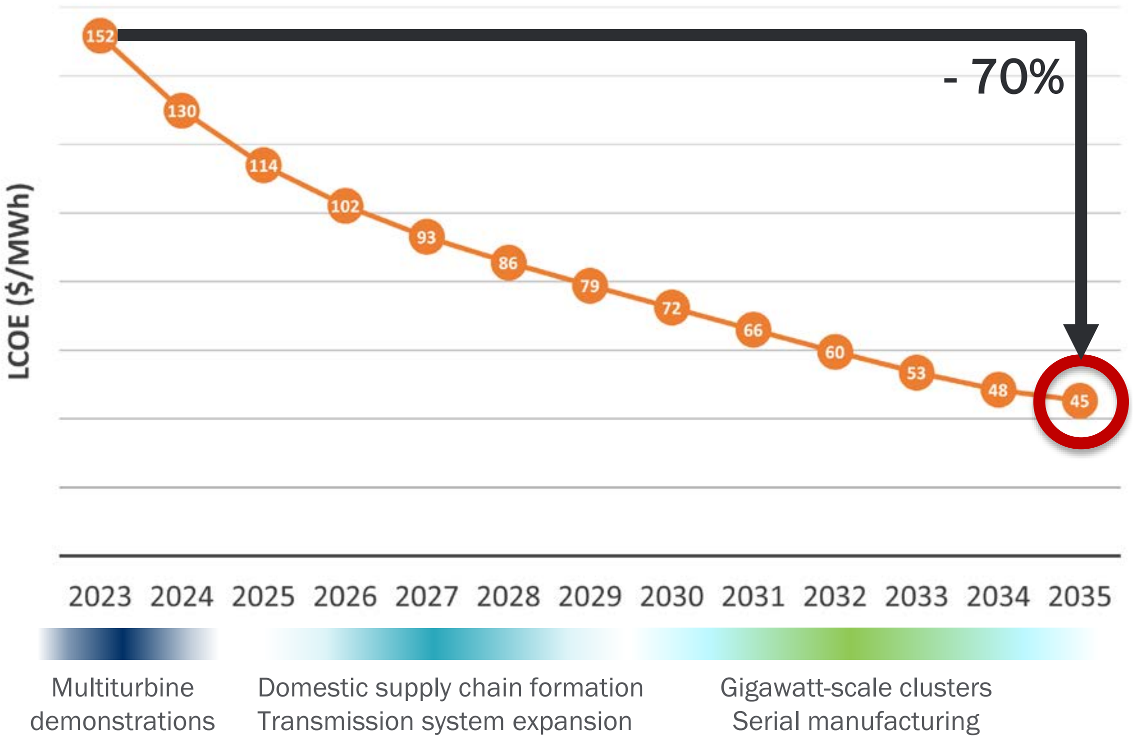
Floating Offshore Wind Shot Workshop

Sacramento, California

Patrick Duffy, Philipp Beiter, Zoe Hemez, Aubryn Cooperman, Matt Shields, and Becca Fuchs

May 8, 2023

Floating Offshore Wind Shot™



LCOE: levelized cost of energy
MWh: megawatt-hour

The Floating Offshore Wind Shot is intended to be ambitious!

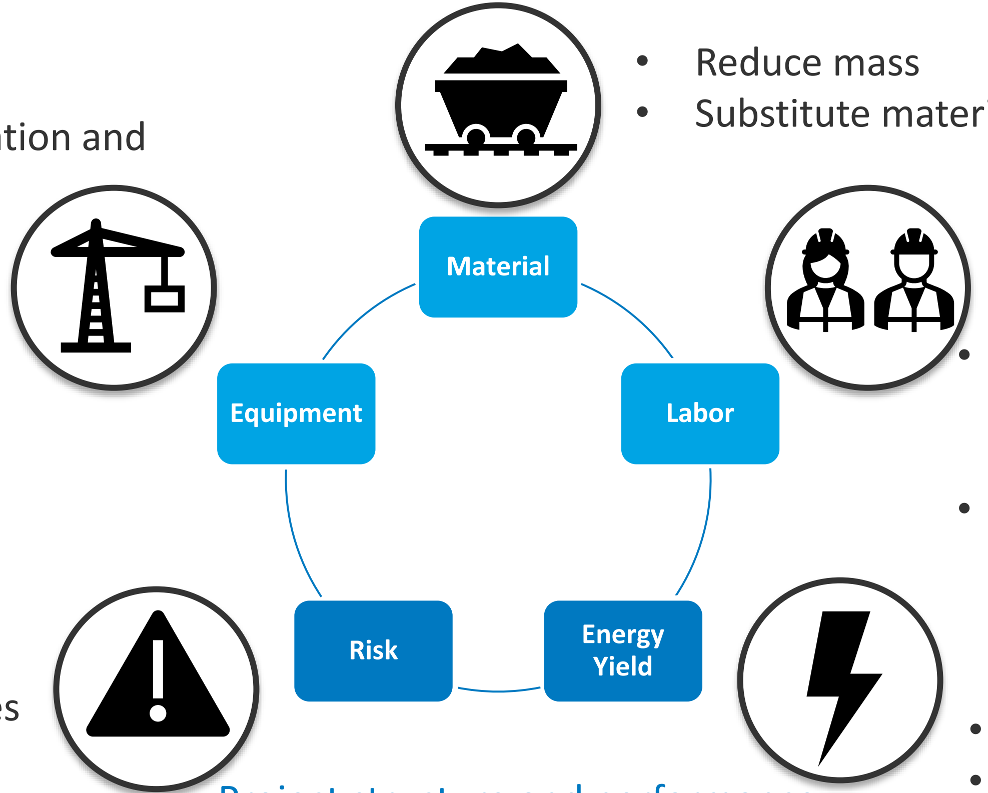
ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

There Are Multiple Pathways To Attain the Shot

- **A systematic framework can help yield insight into viable pathways as well as:**
  - Focus on identifying primary cost reduction mechanisms at the system level
  - Aim to understand the feasibility and trade-offs between different pathways rather than the impact from single innovations.

Five Primary Cost Reduction Mechanisms

Efficiencies



- Reduce mass
- Substitute materials

- Increase productivity through training and experience
- Standardize and automate manufacturing

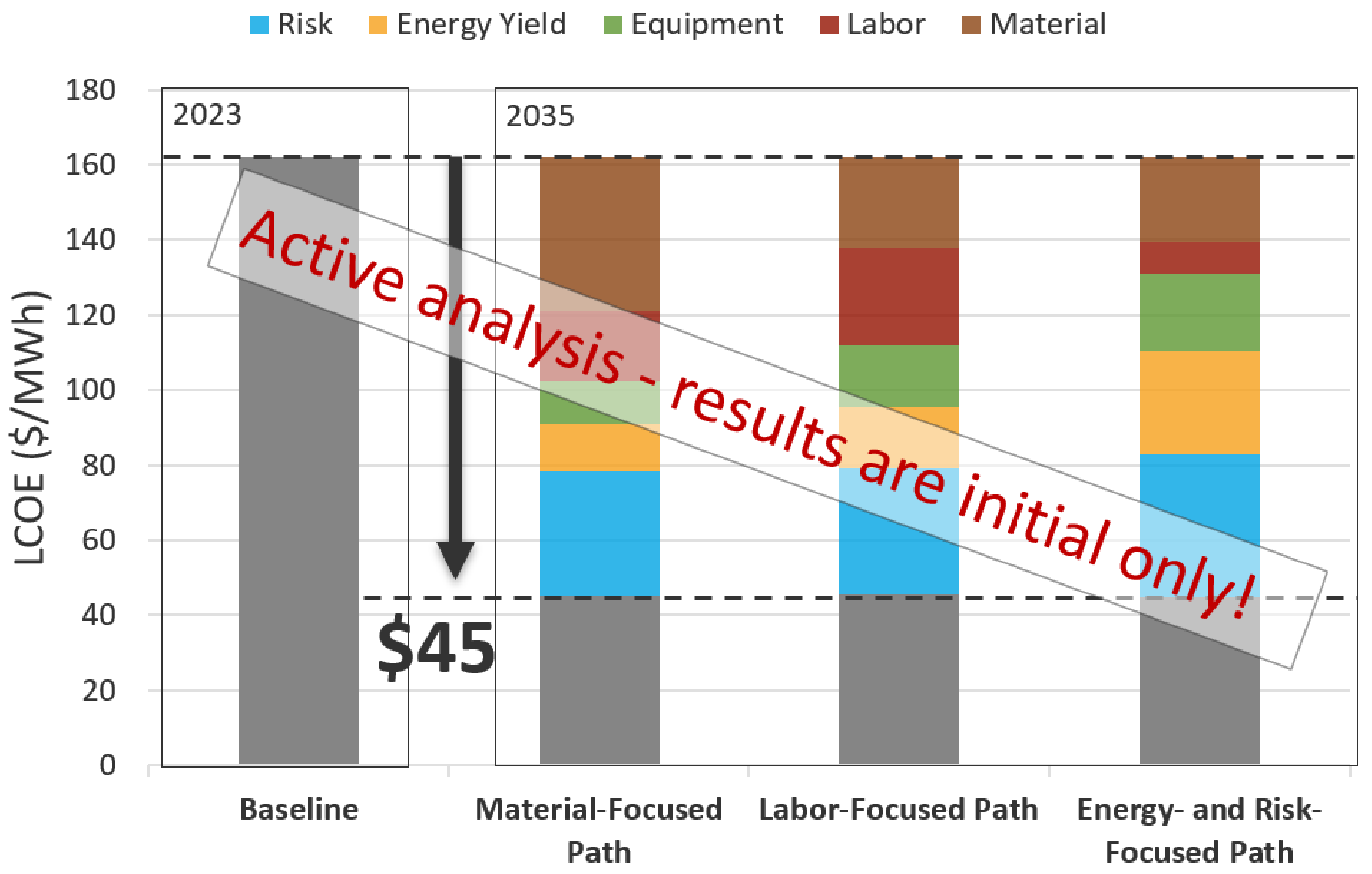
- Increase performance
- Reduce losses

- Lower contingencies

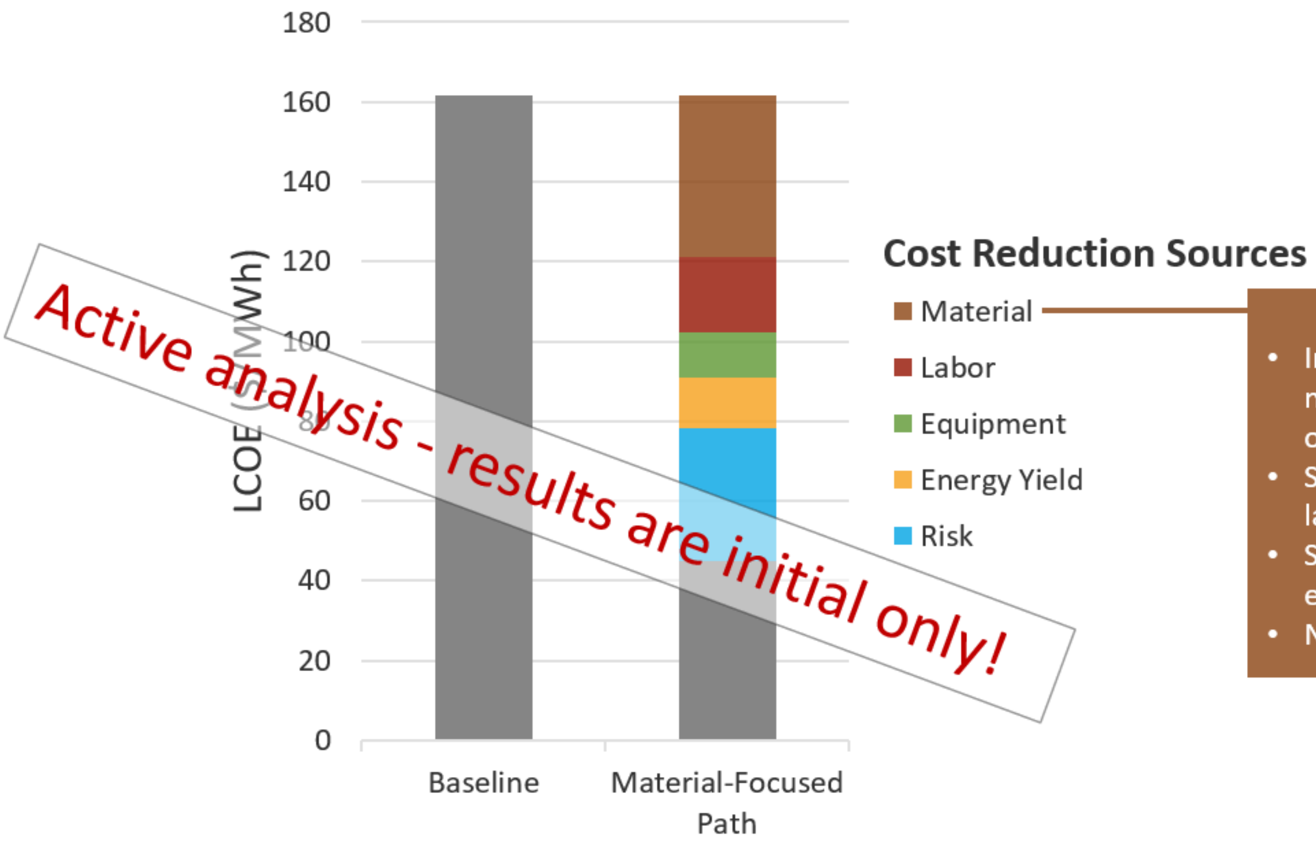
- Optimize installation and operation and maintenance processes
- Fit-for-purpose infrastructure

Project structure and performance

Modeling Shows a Diversity in Cost Reduction Strategies



Pathway Focus: Material



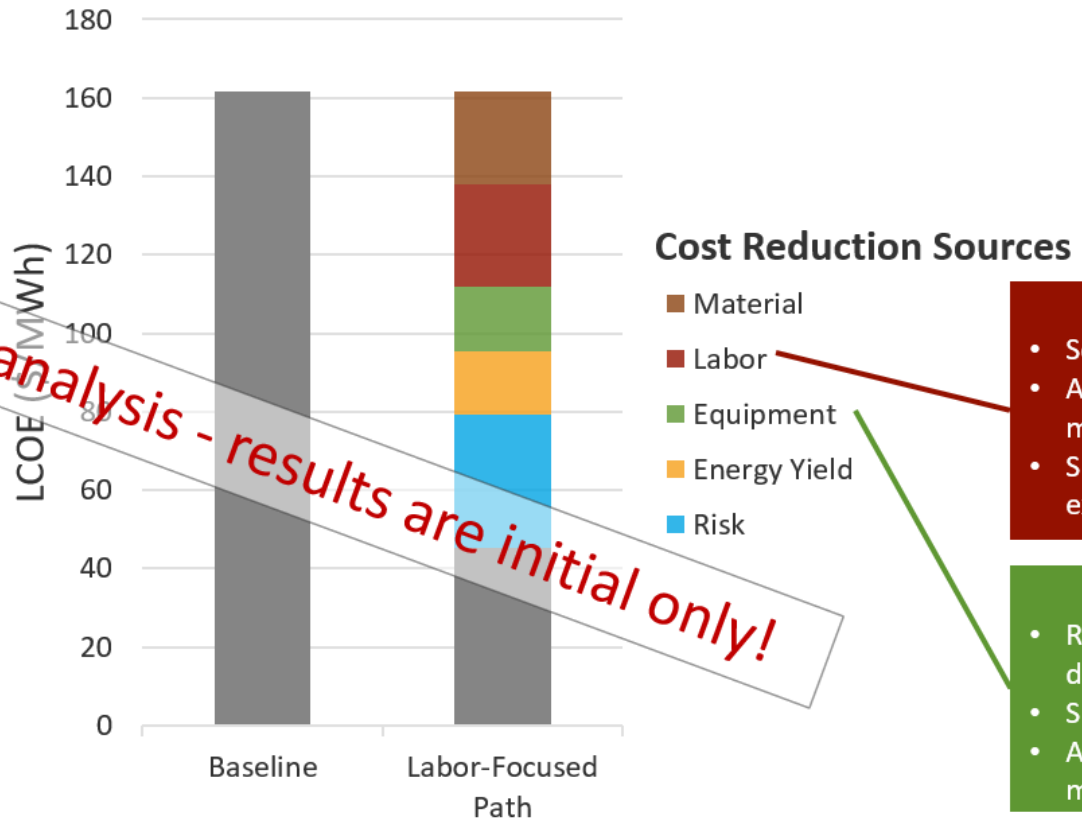
<u>Examples:</u>

- Integrated system-level, multidisciplinary design optimization
- Substitute for lighter and longer-lasting materials
- Shared anchor and mooring points, export cable system
- Novel generator technologies.

Examples from Barter, Robertson, and Musial (2020)
Adapted for California based on Sathe et al. (2020)

Note: Baseline cost breakdown: 43% materials, 21% labor, 21% finance and contingencies (risk), 16% equipment

Pathway Focus: Labor



Examples:

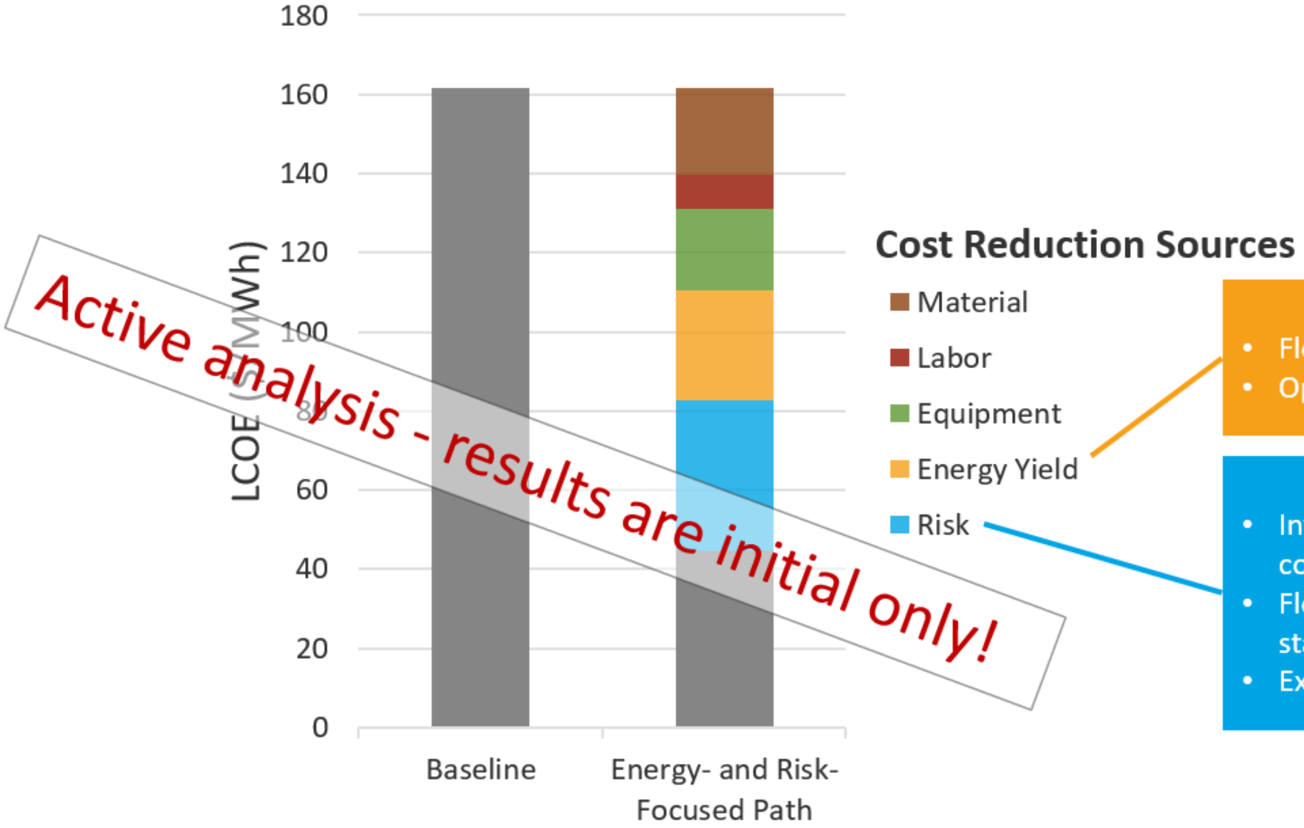
- Serialized turbine and substructures
- Automation in manufacturing and maintenance
- Shared anchor and mooring points, export cable system

Examples:

- Rapid assembly and tow-out designs (towability)
- Shared anchor and mooring points
- Automation in manufacturing and maintenance.

Examples from Barter, Robertson, and Musial (2020)
Adapted for California based on Sathe et al. (2020)

Pathway Focus: Energy and Risk



<u>Examples:</u>

- Floating wind plant controls
- Optimized layout

<u>Examples:</u>

- Integration of uncertainty considerations
- Floating turbine classes (design standards)
- Experience through project volume.

Examples from Barter, Robertson, and Musial (2020)
Adapted for California based on Sathe et al. (2020)

Conclusions

- **There are multiple pathways to attain the Floating Offshore Wind Shot**
  - Attaining the goal requires focused investments, strategic coordination, and economies of scale
- **A systematic framework can yield insight into viable pathways**
  - Real-world strategies to reduce costs tend to weigh materials use, labor, equipment, energy production, and risk differently
  - The most viable pathway depends on a combination of regional infrastructure, the cost of commodities, labor availability, incentives, and other factors
- **Understanding that a set of technologies, infrastructure assets, and policies are part of a pathway can help align resources**
  - Promising strategies and technologies exist, but they need to be integrated holistically
- **A better understanding of innovation impacts can yield a more targeted research agenda and efficient use of public funds**
  - Funds amounting to $3 billion between the late 1970s and 2017 in wind energy research alone (Wiser and Millstein 2020).

Thank You

www.nrel.gov

Patrick.Duffy@nrel.gov

NREL/PR-5000-86316

This work was authored by staff from the Alliance for Sustainable Energy, LLC, the manager and operator of the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding was provided by the Department of Energy's Wind Energy Technologies Office. The views expressed in this document do not necessarily represent the views of the DOE or the U.S. Government.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

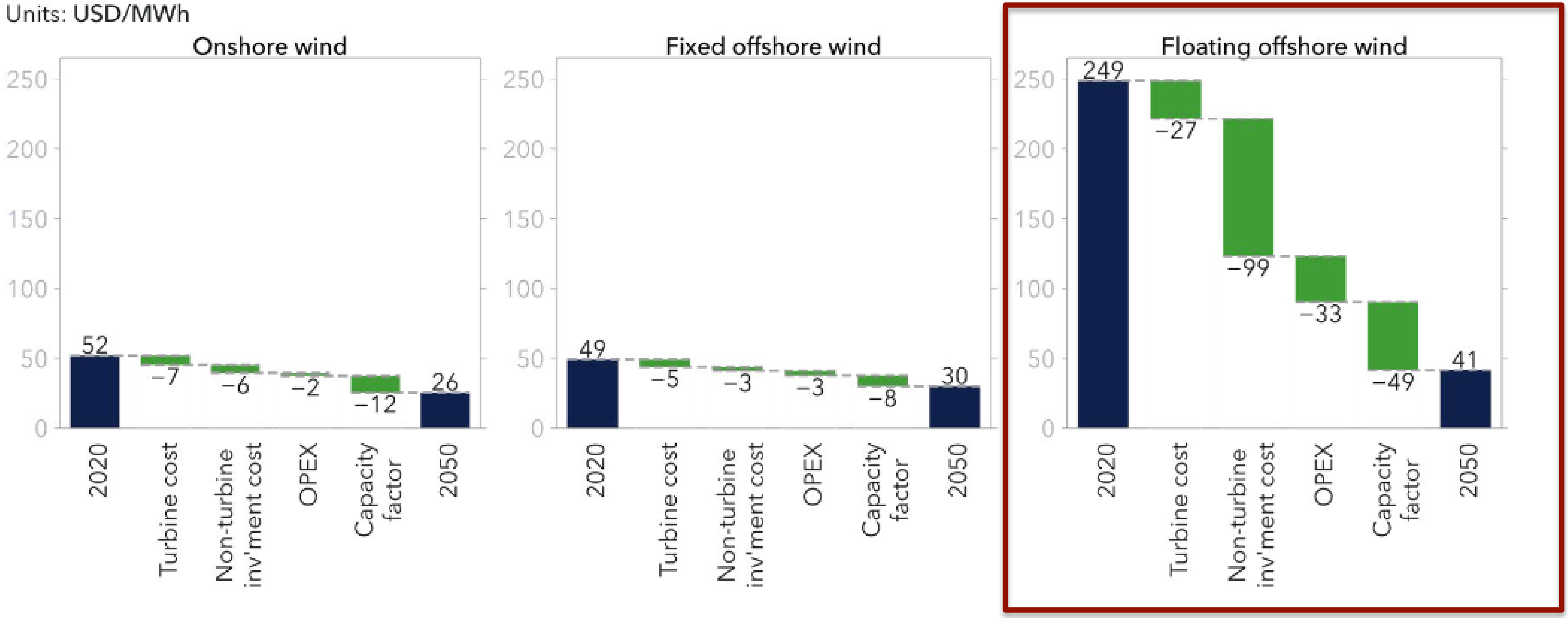
Supplemental

DNV's Energy Transition Outlook

FIGURE 3.11

Source: Energy Transition Outlook 2022

Drivers of change for the global average levelized cost of wind between 2020 and 2050



Energy Transition Outlook estimates $45/MWh floating wind in Europe by 2042 and North America by 2045

References

- Barter, Garrett, Amy Robertson, and Walter Musial. 2020. “A systems engineering vision for floating offshore wind cost optimization.” *Renewable Energy Focus*. Vol 34:1—16. https://doi.org/10.1016/j.ref.2020.03.002.
- Sathe, Amul, Andrea Romano, Bruce Hamilton, Debyani Ghosh, Garrett Parzygnot (Guidehouse). 2020. *Research and Development Opportunities for Offshore Wind Energy in California.* California Energy Commission. Publication Number: CEC-500-2020-053.
- Wiser, Ryan and Dev Millstein. 2020. “Evaluating the economic return to public wind energy research and development in the United States.” *Applied Energy*, Vol. 261, 114449. doi:10.1016/j.apenergy.2019.114449. https://www.sciencedirect.com/science/article/pii/S0306261919321373.

Additional Note

- When calculating the reduction contribution from each item in a waterfall, the order of the items can matter. This was addressed by averaging across all permutations of the waterfall order.