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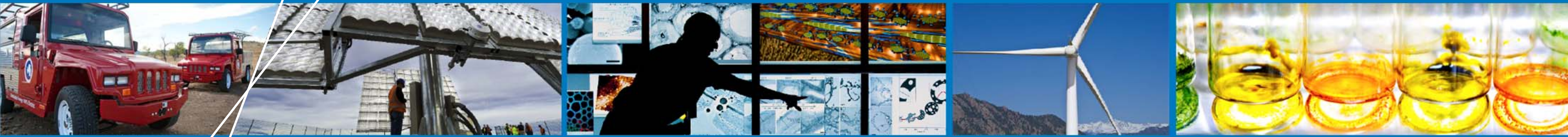
Wind Plant Cost of Energy: Past and Future



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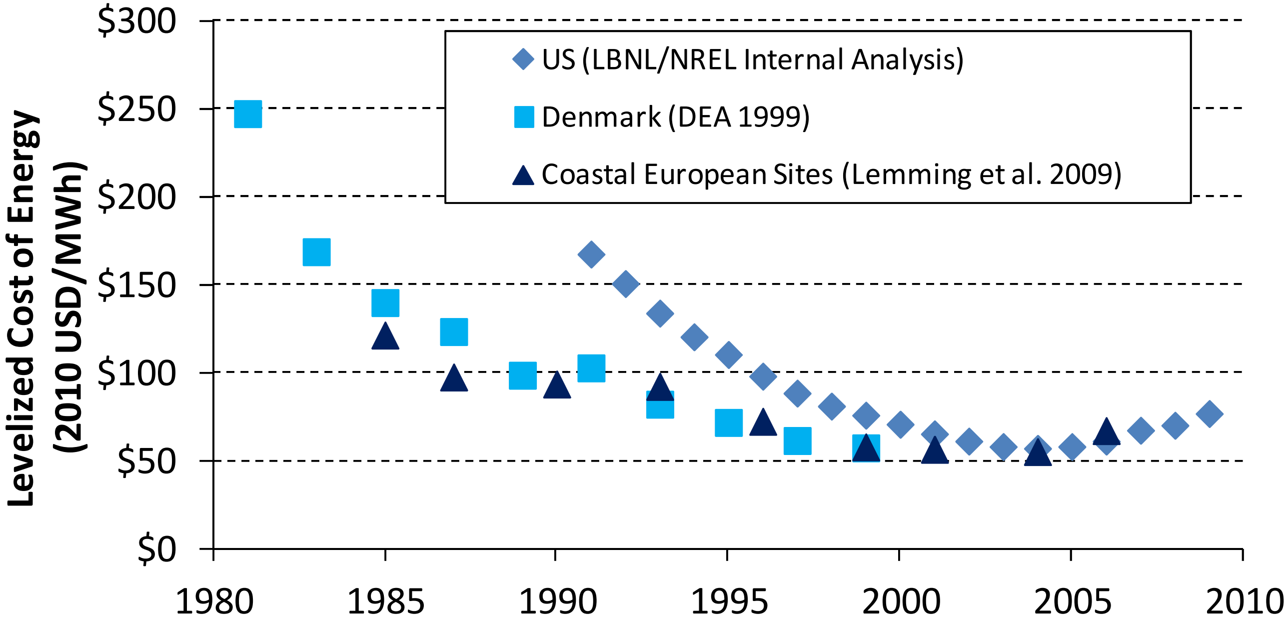
Overview

- Historical trend for wind plant levelized cost of energy (LCOE) including influence of turbine pricing fluctuation and introduction of low wind speed turbine technology
- Projections for future wind plant LCOE based on learning curve, expert elicitation, and engineering-based modeling.

Wind Plant LCOE Declined by More Than 2/3 Between the Early 1980s and 2000s

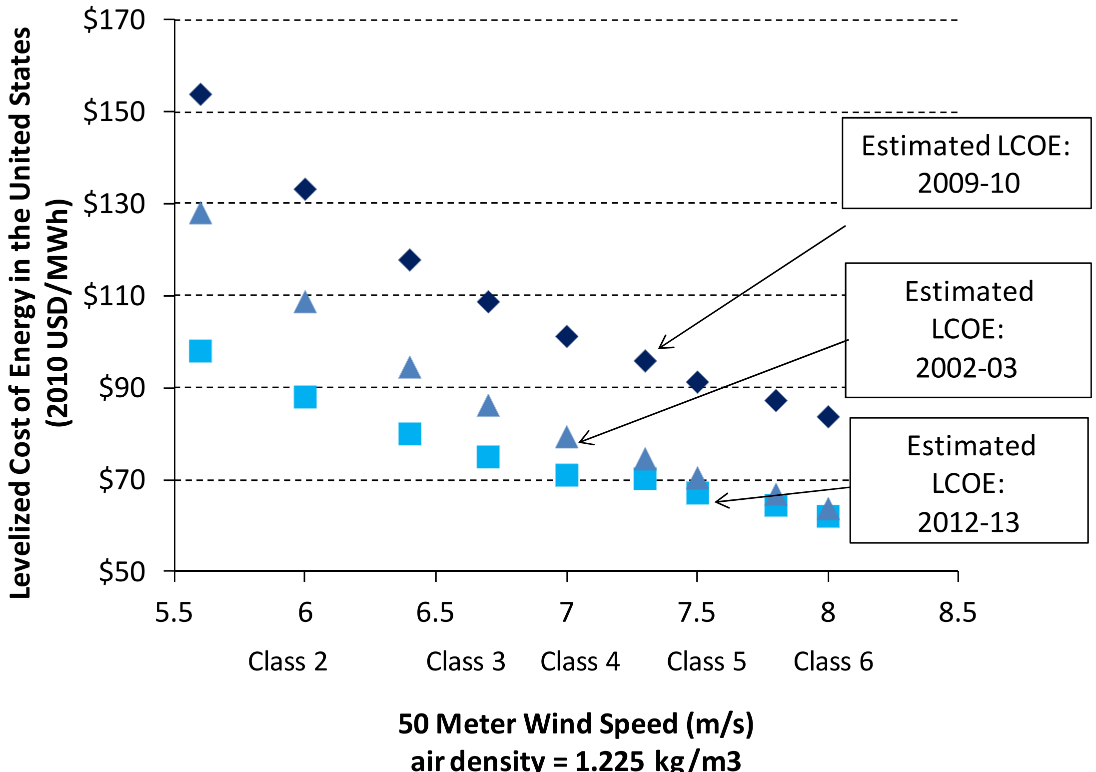


Source: Lantz et al. 2012

Escalation in wind power capital costs since 2003 resulted from:

- Rising commodity and raw material prices
- Increased labor costs
- Improved manufacturer profitability
- Turbine upscaling.

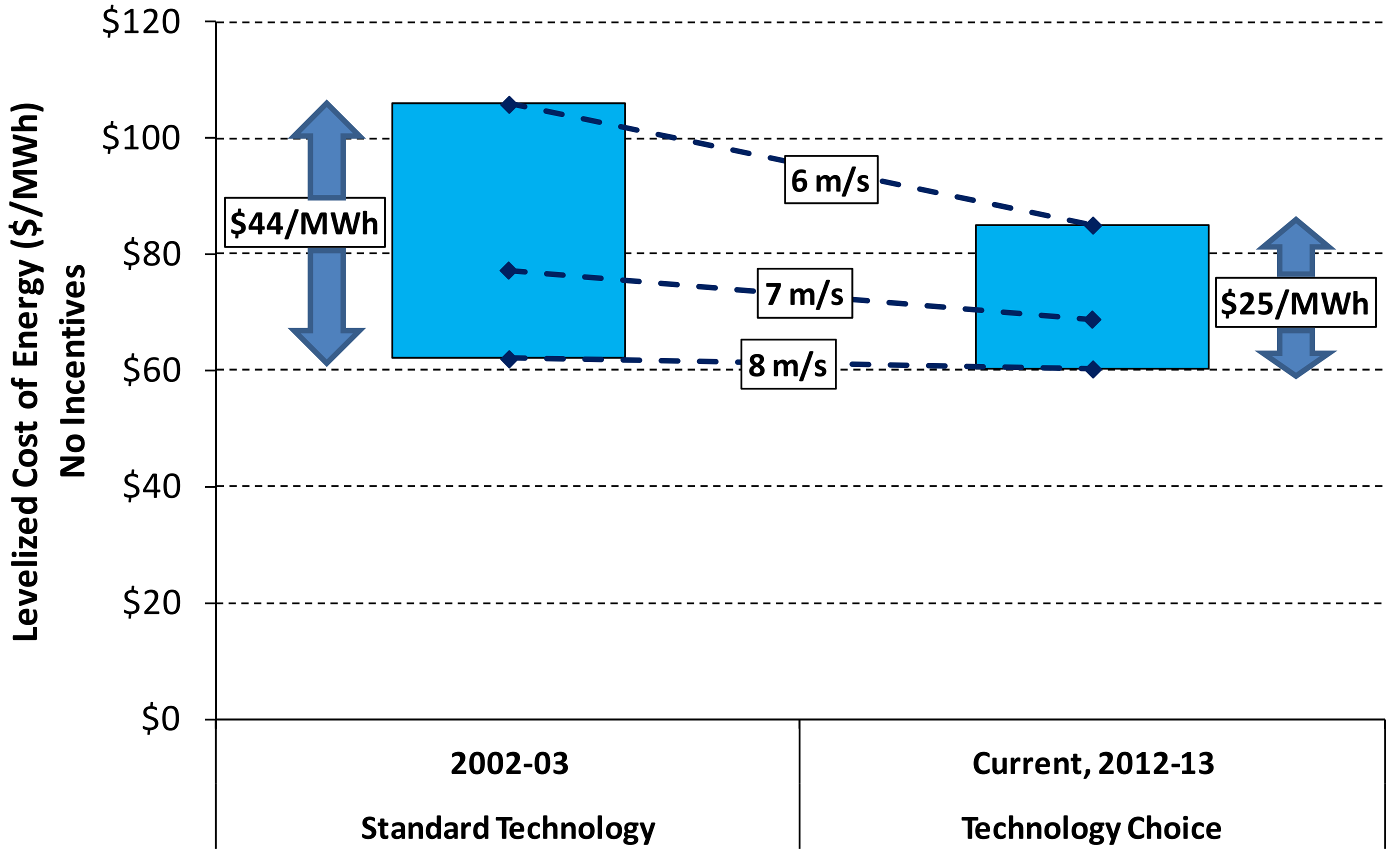
Lower Turbine Prices Since 2009 Along With Improved Wind Turbine Performance May Yield a Return to Historically Low LCOE Levels in 2012–2013



Source: Lantz et al. 2012

- Estimated wind plant LCOE based on observed market variation in capital investment and modeled wind plant performance
- Incentives or policies that reduce price of wind energy in wholesale power markets (e.g., production tax credit) excluded.

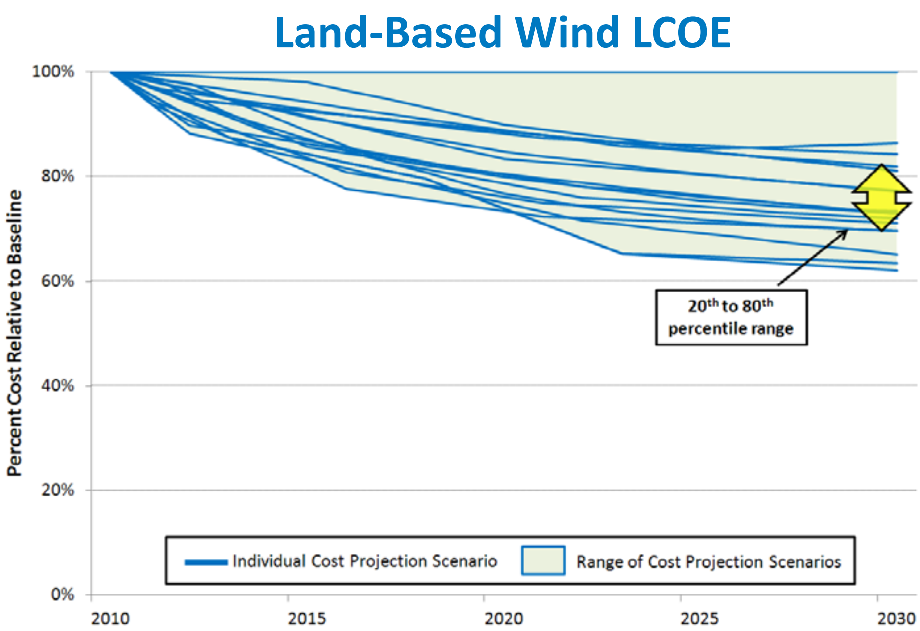
New Technology Options Reduce Variability in LCOE Across a Range of Wind Resource Sites

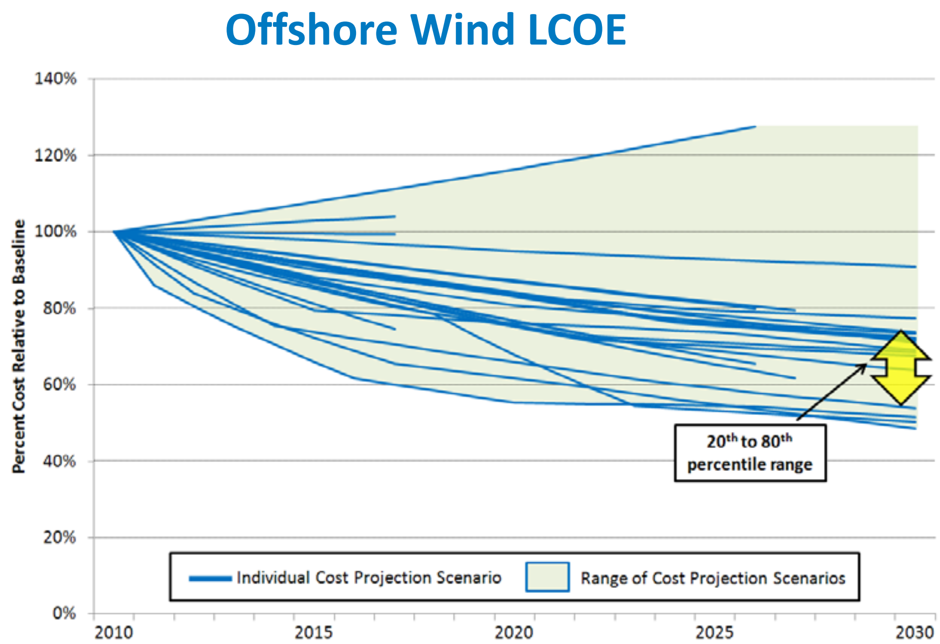


Source: Lantz et al. 2012

- Low wind speed technology designed for International Electrotechnical Commission Class III sites provides Technology Choice in 2012–2013 for annual average sea level equivalent wind speeds at 50 meters.

Most Projections for Wind Plant LCOE Anticipate Future Reductions With Opportunities for Greater Reductions in Offshore Wind Plant LCOE

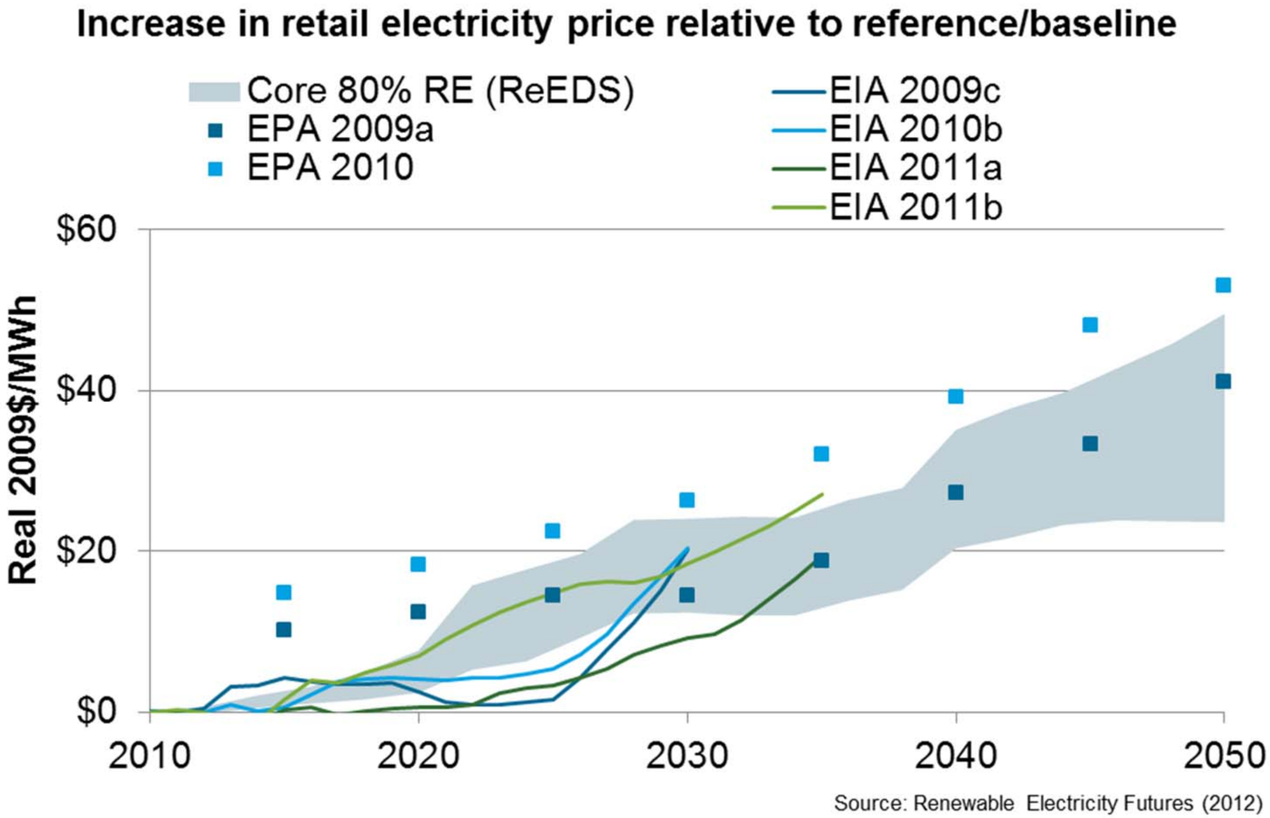




Source: Tegen et al. 2012

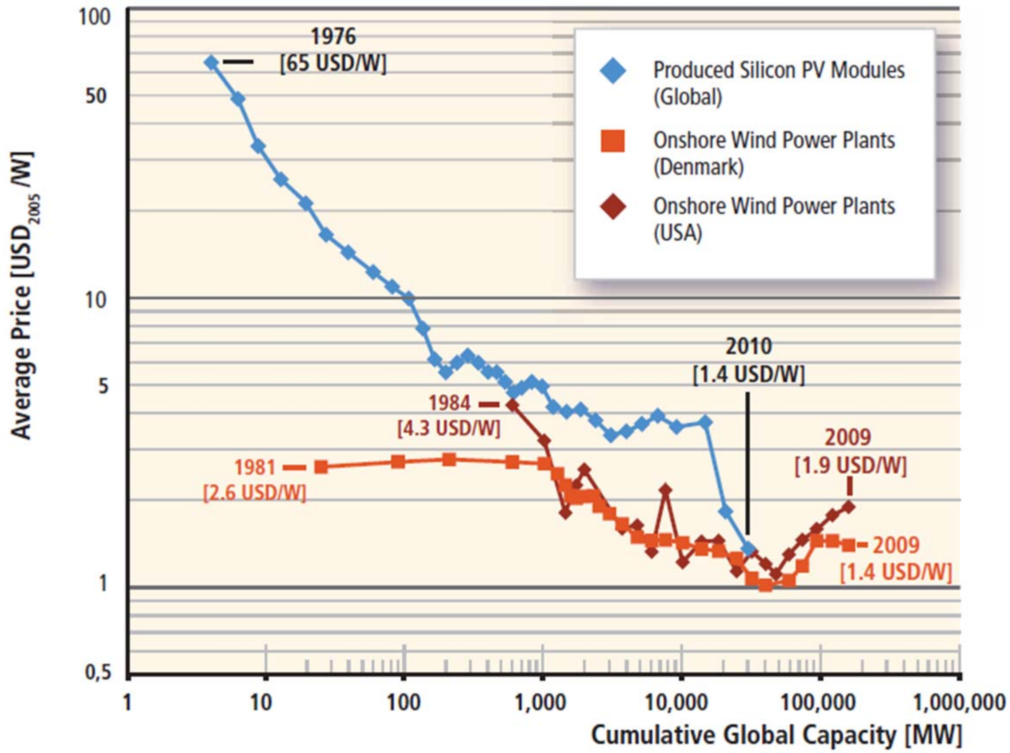
- Projections included here were published and derived from a variety of methods including learning curves, expert elicitation, and engineering-based models.

Demonstrating Future Cost Reduction of Wind Energy is Important for Understanding Future Electric Sector Evolution



- Renewable Electricity (RE) Futures showed that the incremental cost of high RE scenarios is comparable to published cost estimates of other clean energy scenarios
- Improvement in the cost and performance of renewable technologies is the most impactful lever for reducing this incremental cost.

Learning Curves Capture Industry-Level Advances but Do Not Provide Insight Into the Role of Technology Research and Development Specifically

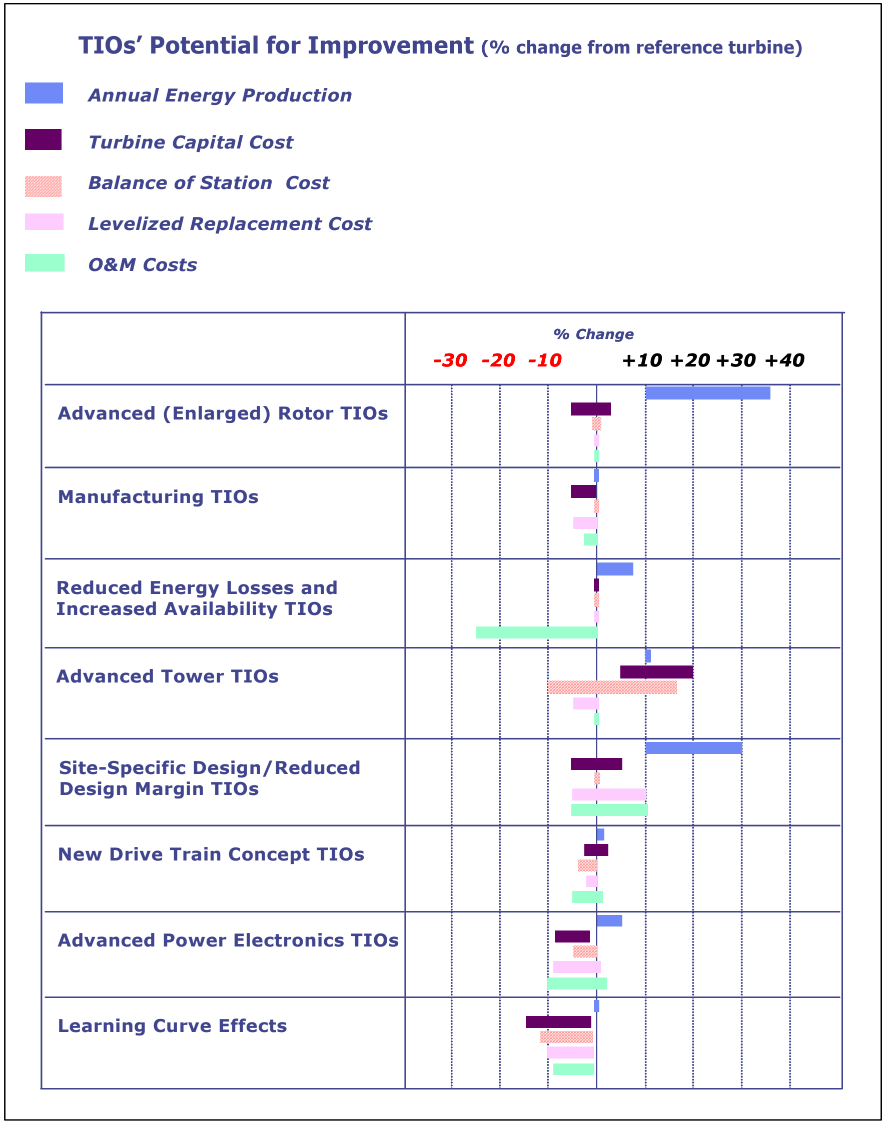


Source: IPCC 2011

- Describe cost reduction potential as a function of cumulative experience related to cumulative installed capacity
- Do not attempt to identify specific factors that yield cost reductions
- Represent learning by research and development (R&D), learning by experience, learning by deployment, learning by doing, and so on.

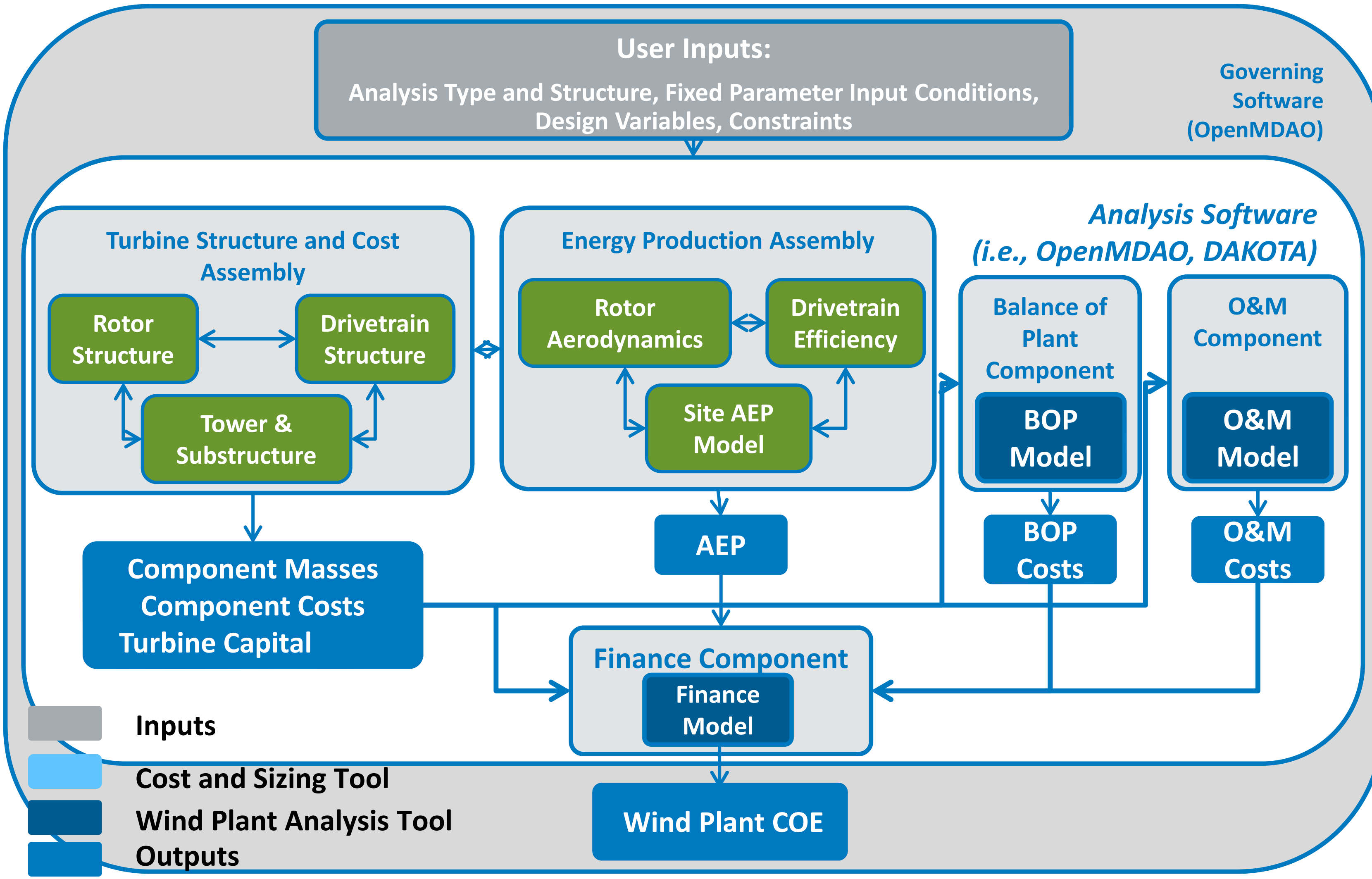
Expert Elicitation Can Represent Deep Knowledge and Experience but Is Difficult to Translate Into LCOE

- Survey industry experts for a range of possible technology outcomes to achieve future cost reductions
- Develop probability distributions associated with various technical outcomes to represent the likelihood of successful innovations
- Difficult to capture interactions between component innovations that impact system LCOE.



Source: Cohen et al. 2008

Engineering-Based Modeling and Analysis Can Capture Interactions Between Components to Quantify the Impact of Specific Technology Innovations on LCOE at the System Level



Source: NREL

Conclusions

- Wind energy LCOE has decreased since the 1980s and is likely to continue this downward trend
- Projections for future cost of wind energy with greater precision in magnitude and likelihood will influence electric-sector evolution scenarios
- Engineering-based models provide the opportunity to quantify the impact of innovative concepts on wind plant system LCOE.

References

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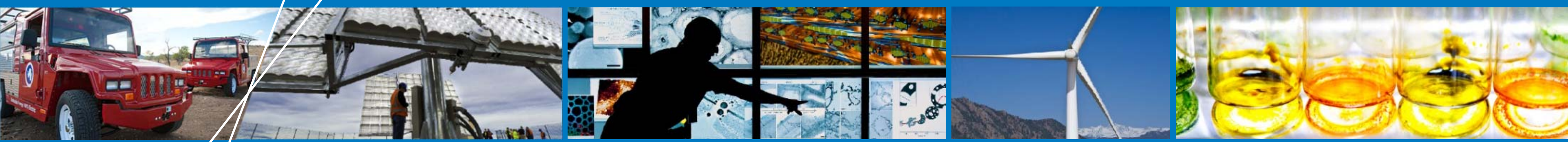

Thank you. For more information…

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