Predictive Maintenance scheme for Offshore Wind Turbine using Digital Twin model

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Opportunities in deeper offshore

- ✓ Strong and stable wind powers
- ✓ Fewer space-related conflicts
- ✓ Lower visual impacts
- ✓ Lower environmental interference

Growing size of offshore wind turbines

- The average hub height is projected to grow from 100 meters to about 150 meters in 2035 (DOE)

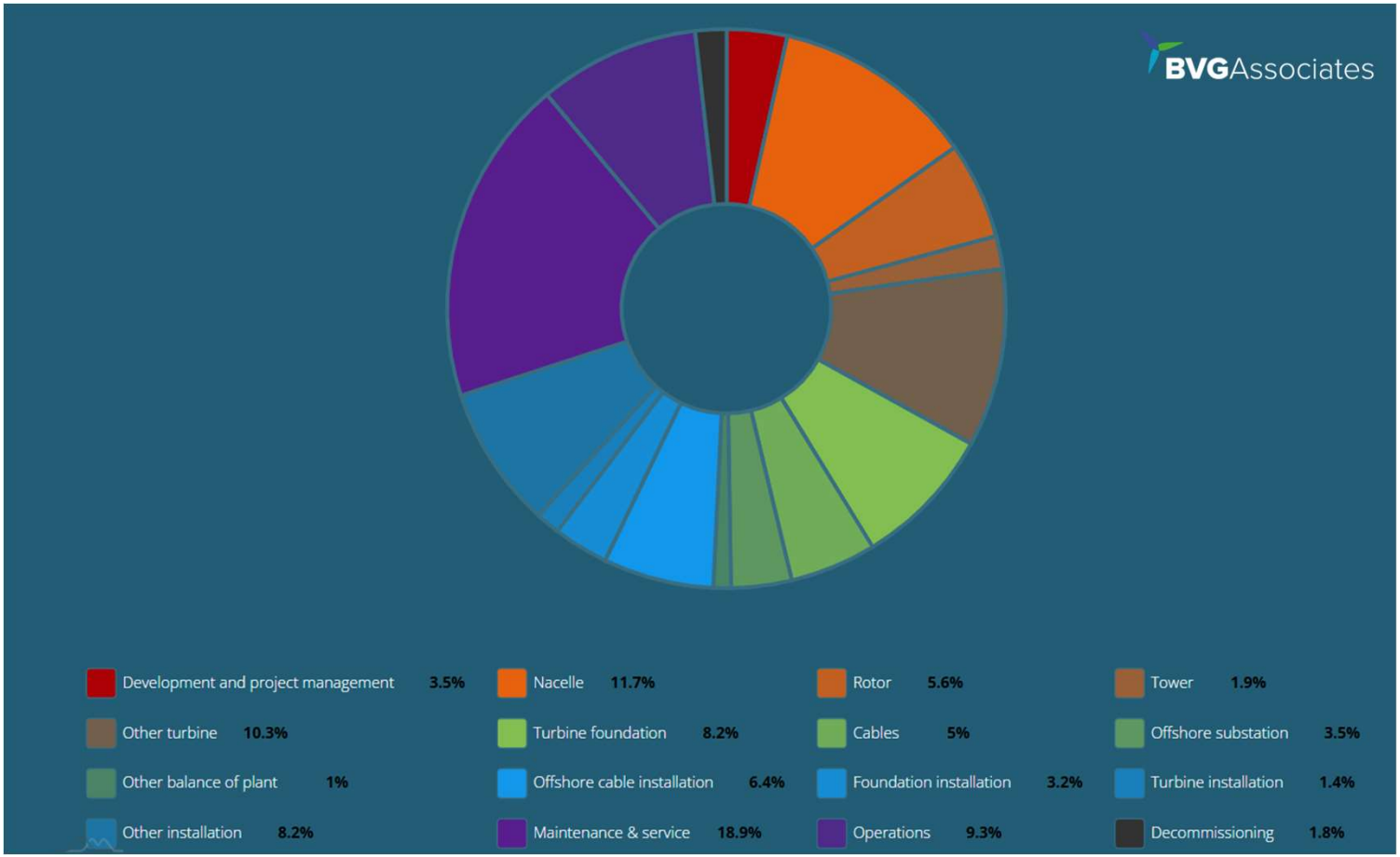
https://www.energy.gov

Challenges in Operation & Maintenance

- **Access and logistics on the high seas**
- **Accessibility in adverse conditions**
- **Security risks**
- **High costs**
- **Fault detection and repair**
- **Complexity in repairs**

https://inspenet.com

Maintenance & LCOE

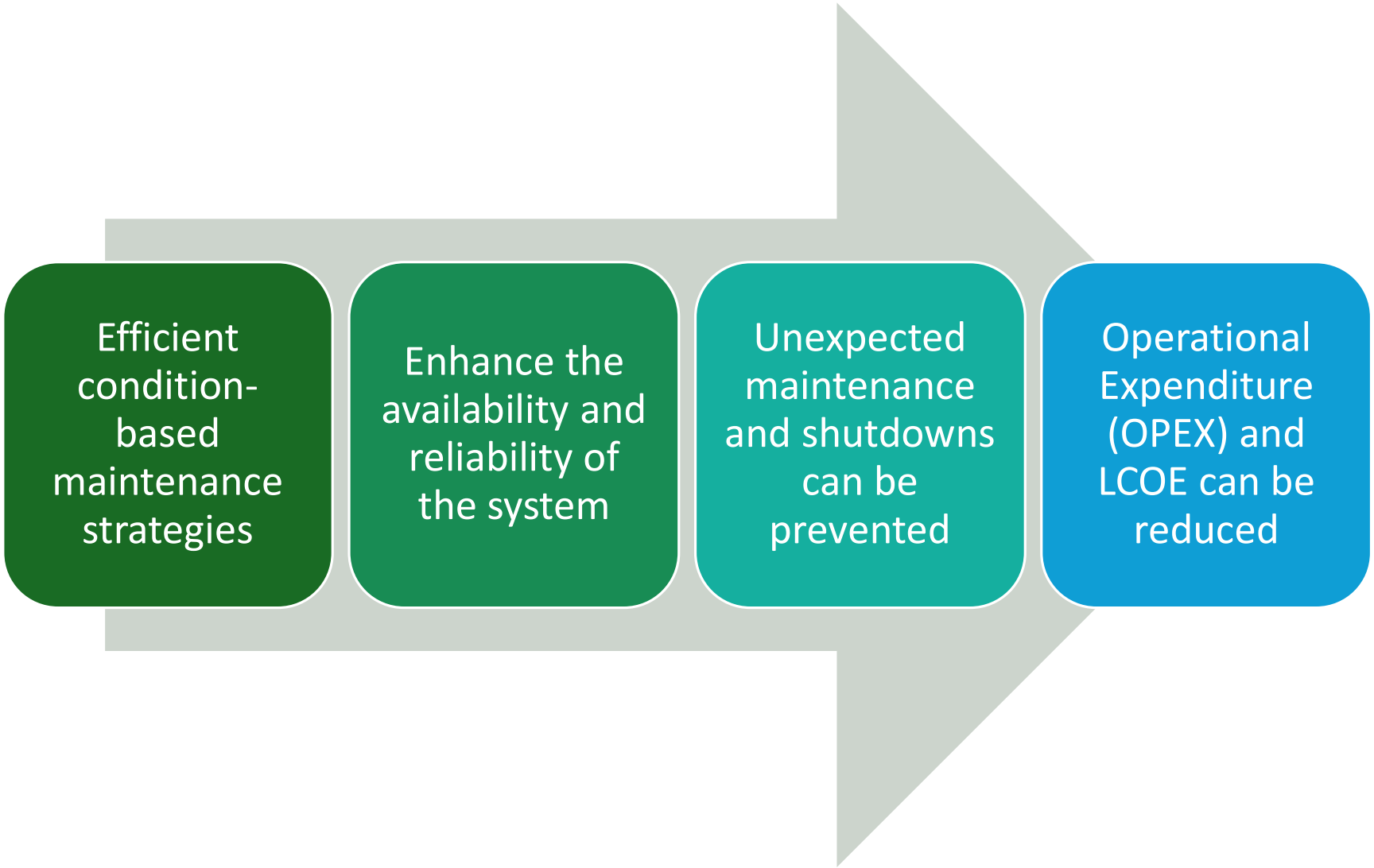


https://guidetoanoffshorewindfarm.com

Maintenance Strategies

Strategy	Summary	Setup Cost	Advantages
Corrective (or Reactive)	Repair after a breakdown or failure has occurred	Low	The best strategy for low-priority equipment
Preventive	Maintenance is scheduled on a regular basis in advance either based on time or usage before a failure occurs	Medium	Best strategy to implement without detailed knowledge of component condition
Condition-Based	Maintenance on an as-needed basis based on equipment condition evaluated through measurement, observations, modeling, and data analytics	High	Timely condition monitoring provides many insights into asset's behavior and its projection
Predictive	Use sensors and data to detect trends in the health of a system and predict when failure will occur	High	Earlier detection of failure than condition-based and more cost savings
Prescriptive	Use sensors, data, and advanced analytics (based on modeling, analysis, and database, and so on) to determine root causes of a potential failure so specific corrective action can be prescribed	High	Earlier detection of failure than predictive, substantial cost savings, and highly effective

https://www.energy.gov/

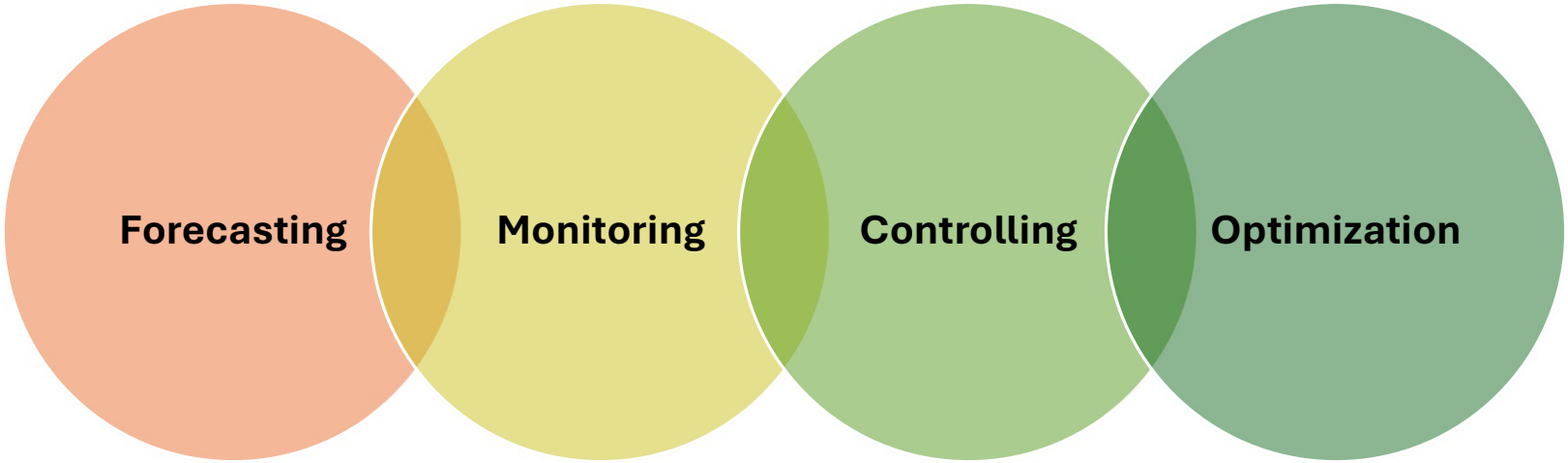

Efficient condition-based maintenance strategies
Enhance the availability and reliability of the system
Unexpected maintenance and shutdowns can be prevented
Operational Expenditure (OPEX) and LCOE can be reduced

Digital twin technology

- Digital representation of physical asset based on **data** and **simulation**

https://www.offshore-mag.com

Digital twin technology – Industry 4.0



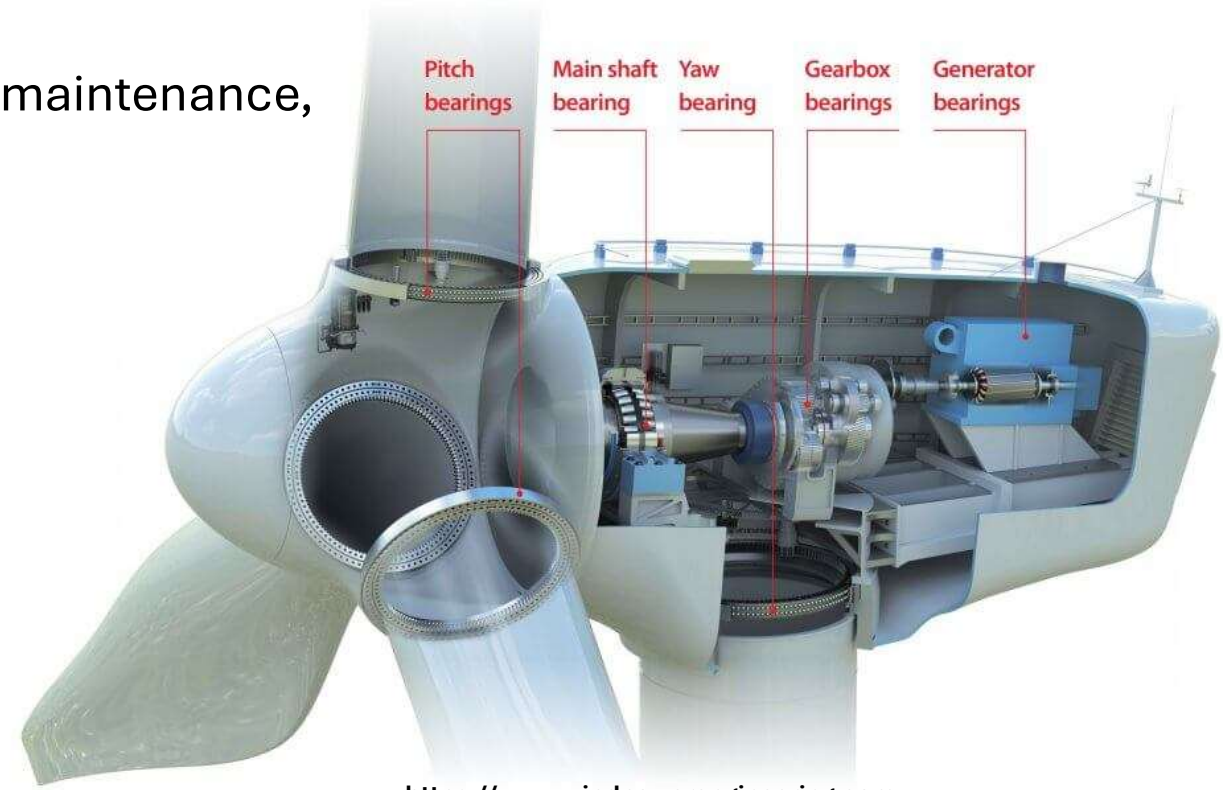
A solution to:

- ✓ Enhance efficiency and safety
- ✓ Reduce maintenance and operating costs
- ✓ Support asset life extension

Energy production downtime

- Bearing & Gears

  Major source of unscheduled maintenance, repairs, and replacements



https://www.windpowerengineering.com

Monitoring the bearings

Predict degradation process

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Prevent total failures

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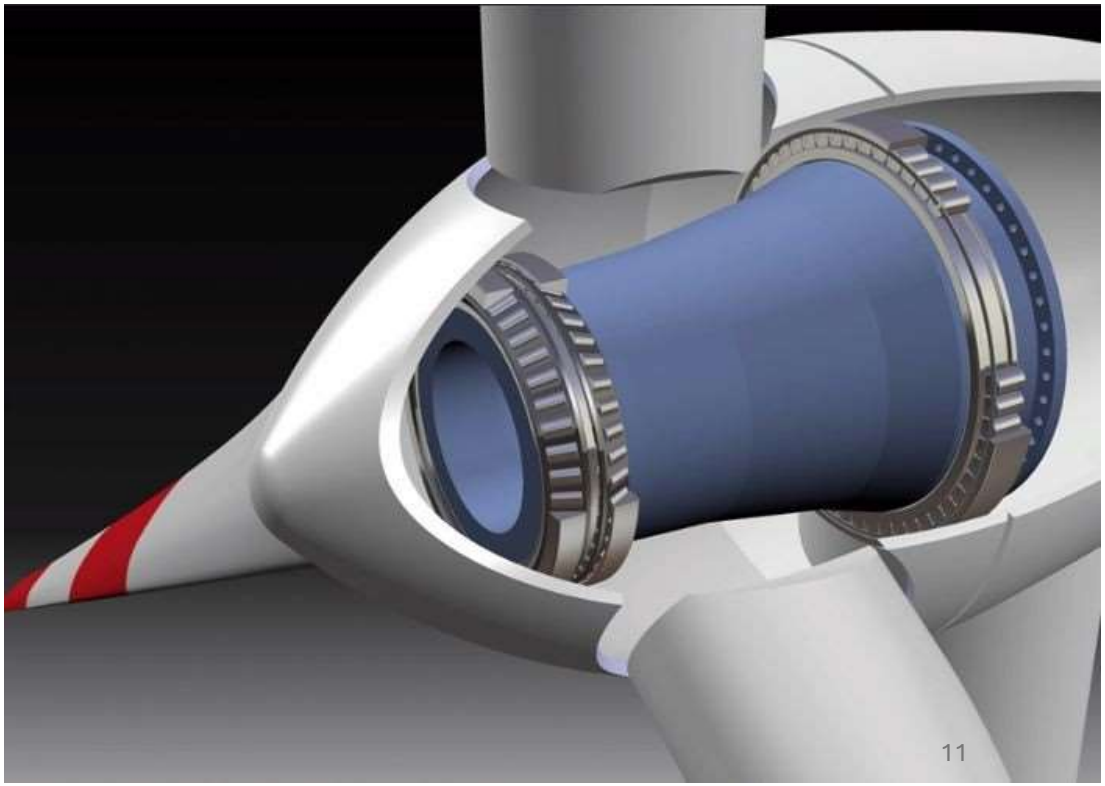
Reduce maintenance costs



Vibration monitoring systems

- ✓Optimize the performance of wind turbines
- ✓Extract useful information from vibration signals
- ✓Forecast the potential failures

Machine Learning Models

- ✓Forecasting the future trend based on the built model
- ✓Analyze a massive amount of raw data from wind turbines
- ✓Generate insights, identify issues, and enable predictive analytics

Vibration-based Predictive Maintenance scheme for mechanical parts of Offshore Wind Turbine