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Creating the Equation for Growth

Opportunity in Global Onshore and Offshore Operation & Maintenance Market

Lucintel Brief

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Lucintel

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Executive Summary

- Global wind energy market grew at a 26% CAGR over last 5 years and is forecast to grow at double digit rates over next 5 years
- Global wind O&M market estimated at US$ 4.2B in 2010, and expected to grow at 19% CAGR to $11.8 B in 2016
  - In 2010, Europe was largest wind O&M market, followed by APAC, NA and ROW
  - China is expected to become largest wind O&M market by 2016
- Gear box, generator and turbine blades are the three main components that need regular servicing and that contribute ~80% of total turbine maintenance cost
- Many wind farms are opting for predictive maintenance which reduces production losses and improves OEE of the turbine, with estimated pay-back period of 5 to 6 months
- ISP's (Independent service providers) are gaining traction in many mature wind markets
- Offshore wind turbines account for 5% of the present O&M market and have a higher O&M cost than onshore O&M
  - Limited accessibility, lower availability of trained personnel and logistic issues make it difficult to render offshore O&M services, resulting in higher cost

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Wind Energy Operation & Maintenance: Overview

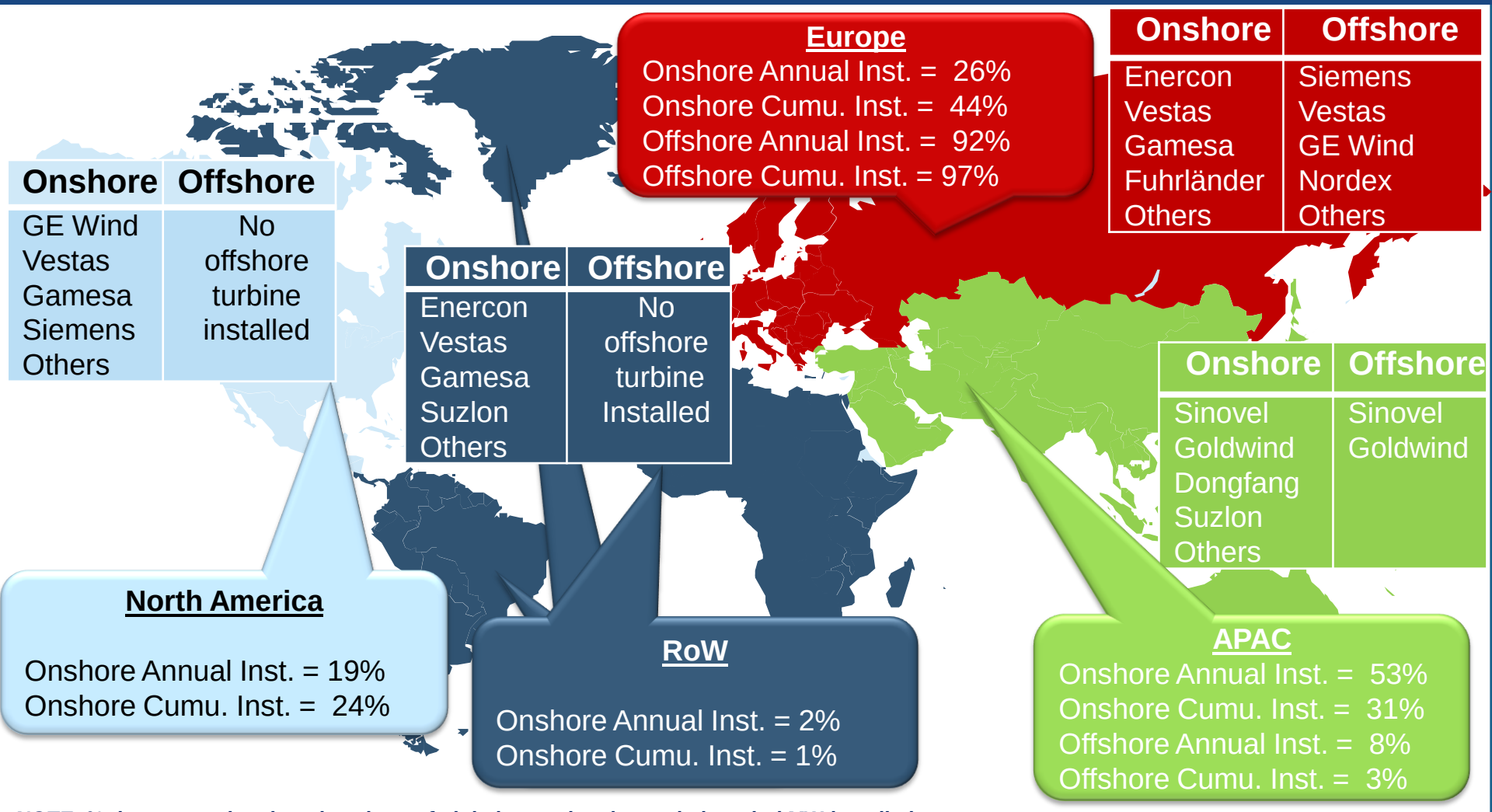
- **Onshore consists of land-based wind turbines whereas offshore refers to turbines installed in the water. Onshore wind energy has the advantages of lower capital cost, lower O&M cost and availability of grid connectivity, whereas offshore has the advantage of a higher capacity factor due to generally stronger and more continuous wind.**

- **There are two main costs associated with wind turbines during their lifetime: capital cost and O&M cost. Capital cost is incurred in the initial installation phase, whereas O&M costs are recurring costs that are necessary for the continuing proper operation of a wind turbine.**

- **Operation costs are control-oriented costs which are necessary to run wind turbines, such as site management, staff, tools & equipment, and SCADA cost. These costs are not directly involved in repairing or overhauling turbine components but play an important role for overall O&M cost.**

- **Maintenance costs are directly associated with wind turbines. Each component has an estimated life time aligned with the overall 20 year turbine lifetime. Maintenance costs are related to turbine size and configuration, and generally escalate over time as the machines age and parts wear out.**

Geographical footprint of Onshore/Offshore Wind Energy with presence of major OEMs



Europe
Onshore Annual Inst. = 26%
Onshore Cumu. Inst. = 44%
Offshore Annual Inst. = 92%
Offshore Cumu. Inst. = 97%

Onshore	Offshore
Enercon Vestas Gamesa Fuhrländer Others	Siemens Vestas GE Wind Nordex Others

Onshore	Offshore
GE Wind Vestas Gamesa Siemens Others	No offshore turbine installed

Onshore	Offshore
Enercon Vestas Gamesa Suzlon Others	No offshore turbine Installed

Onshore	Offshore
Sinovel Goldwind Dongfang Suzlon Others	Sinovel Goldwind

North America

Onshore Annual Inst. = 19%
Onshore Cumu. Inst. = 24%

RoW

Onshore Annual Inst. = 2%
Onshore Cumu. Inst. = 1%

APAC
Onshore Annual Inst. = 53%
Onshore Cumu. Inst. = 31%
Offshore Annual Inst. = 8%
Offshore Cumu. Inst. = 3%

NOTE: % denotes regional market share of global annual and cumulative wind MW installations

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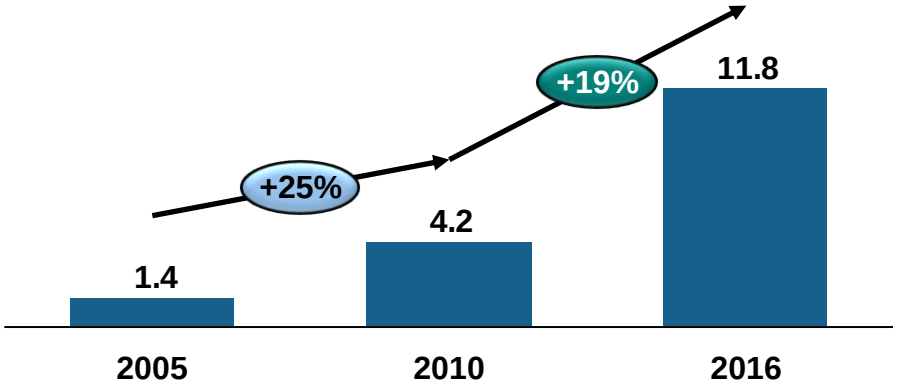
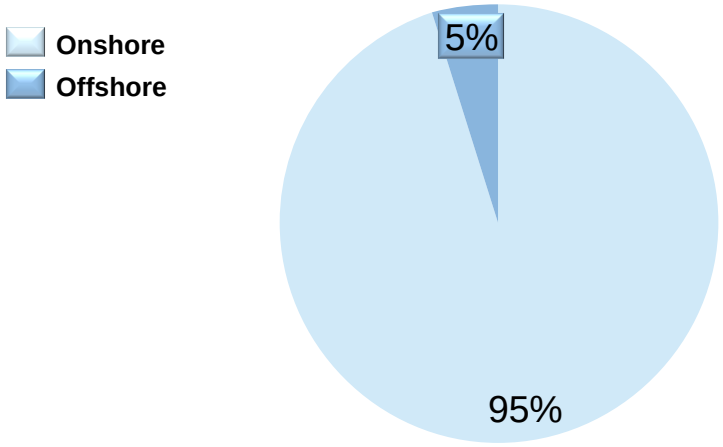
Trend & Forecast in Wind O&M Market

Global Wind O&M Market Trend and Forecast (US$B)



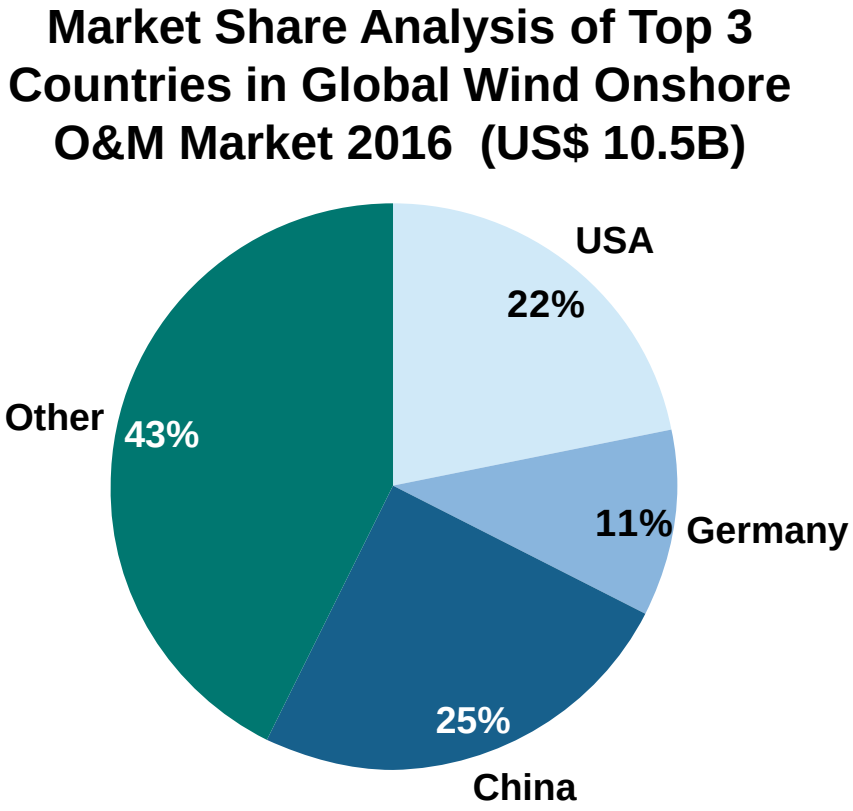
Global Wind O&M Market by Site (US$B) (2010)



Key Insight

- Global wind O&M market estimated at US$ 4.2B in 2010, expected to grow at 19% CAGR from 2010 to 2016
  - Mainly driven by growth of wind market
- Offshore wind turbine installations account for 1.7% of global cumulative wind energy capacity, but represent 5% of the global wind O&M market
- Off shore wind O&M costs are 2 to 2.5 times more than onshore O&M costs
- Europe is the largest wind O&M market

Market Share of top 3 countries in Global Onshore Wind O&M Market



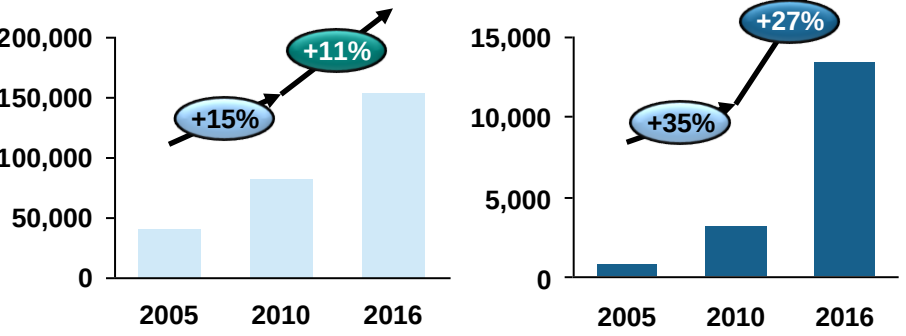
Key Insights:

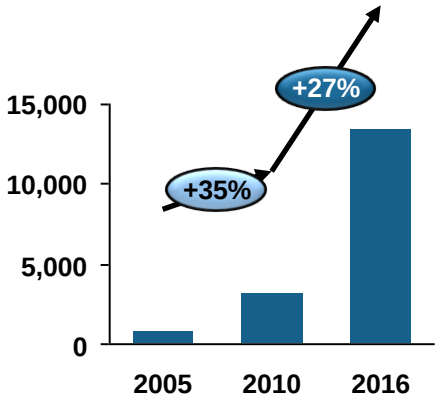
- USA is the largest onshore O&M market in 2010 followed by Germany and China
- China is expected to overtake the USA and become the leader by 2016

Regional Wind Energy Market Trend and Forecast in terms of Cumulative MW capacity - Onshore v/s Offshore

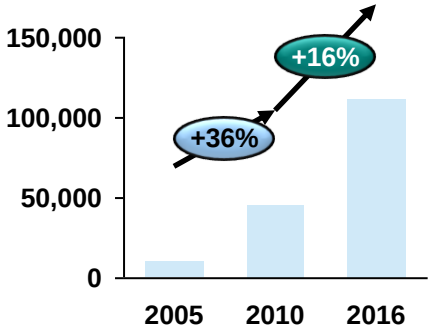
Onshore
Offshore

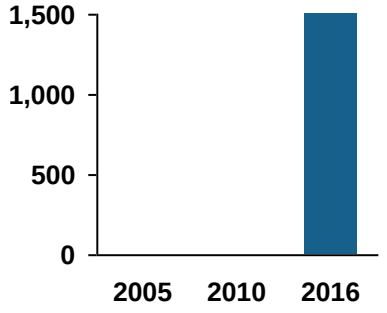
Europe cumulative wind MW CAGR by site



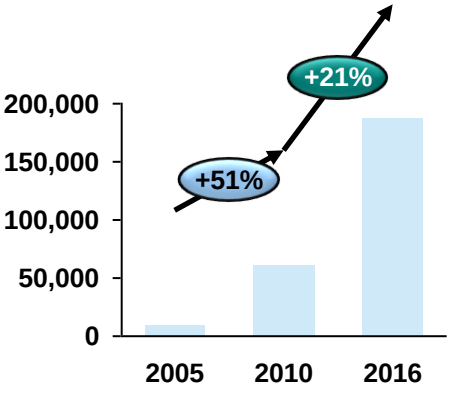


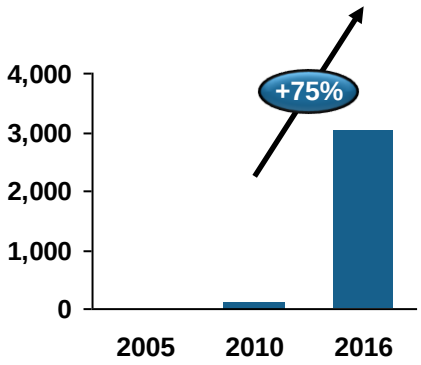
North America cumulative wind MW CAGR by site



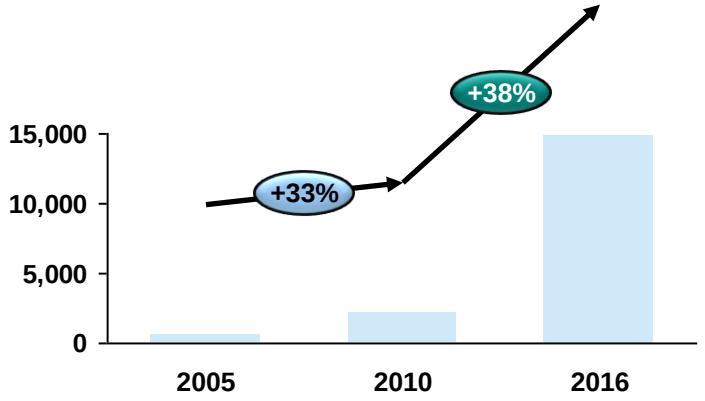


Asia-Pacific cumulative wind MW CAGR by site

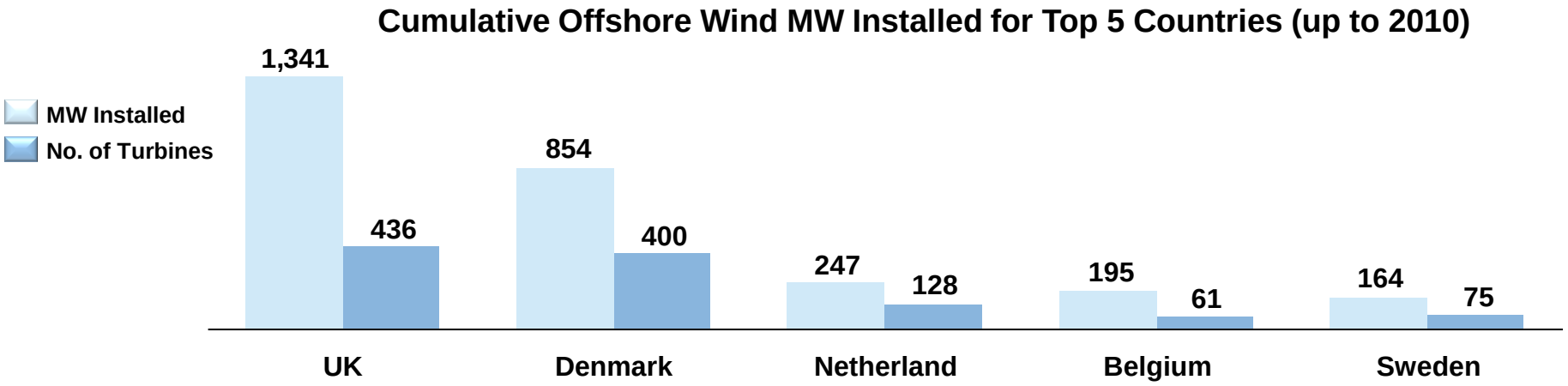




Rest of World cumulative wind MW CAGR by site



Current and Future Leading Countries for Offshore Wind Energy

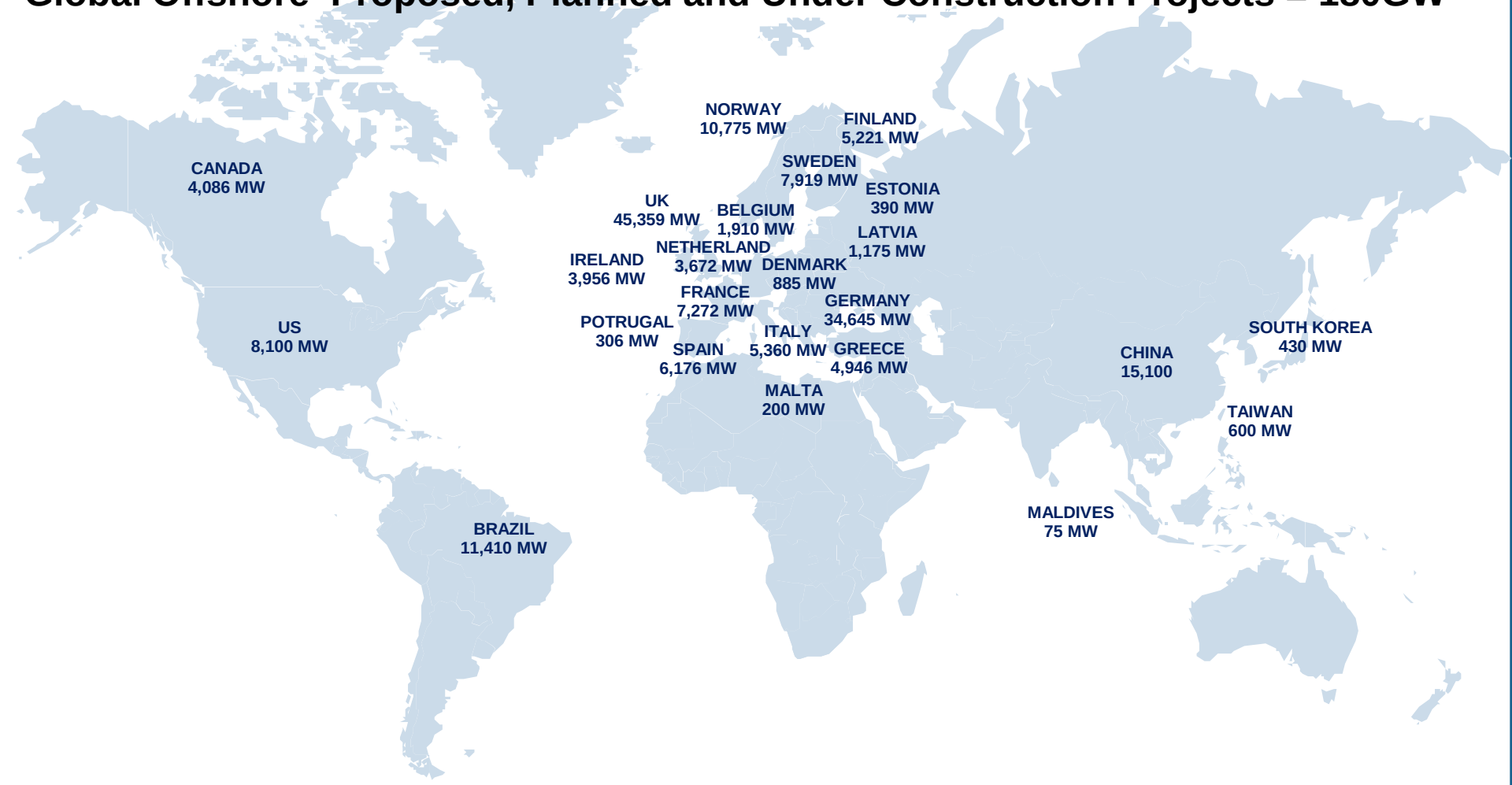


Future major offshore wind energy countries

Offshore wind parks under construction, approved or planned, along with supportive policies and other factors will result in the UK remaining as the leader in offshore wind energy, whereas Germany and China will overtake Denmark and the Netherlands in future offshore wind energy capacity

Offshore Wind Energy Potential: current proposed, planned, and under construction projects

Global Offshore Proposed, Planned and Under Construction Projects = 180GW



Comparison of O&M cost factors: Onshore v/s Offshore

Type of service	Activities	Onshore O&M	Offshore O&M
Operational cost	Site maintenance cost	Low	High
	Equipment and tool cost	Low	High
	Management fees	Low	High
Maintenance cost	Routine maintenance cost	High	Nil
	Repair and replacement cost	Low	High
	Service fees	Low	High

Reasons for high offshore operation cost compared to onshore

- Wave heights
- Low accessibility
- Stormy weather
- Poor visibility
- Transportation vehicles req'd. (boats, helicopters etc.)
- Lifting machines - oil & gas industry type lifting vessels
- Personnel safety equipment
- Difficulty in maintaining and monitoring
- Higher number of staff

Reasons for high offshore maintenance cost compare to onshore

- Generally do not perform routine maintenance due to accessibility issues
- Component failure
- Corrosion due to salty water
- Longer down time
- Low proximity of OEM's
- Low availability of technicians
- Work in difficult weather conditions

Typical failure causes & corrective repair activities for wind turbines: gearbox, generator and blade systems represent significant portion of repair cost

Component	Typical Cause for failure	Repair activity
Gear box	• Severe wear in a bearing • Worn out planet bearing • Wear particles on magnet • Grinding temper on gear wheel • Broken tooth on gear wheel	• All tooth surfaces inspected, gearing is replaced if deterioration detected. • Seals and oil filters are replaced and gearbox is filled with new oil in accordance with environment conditions. • All tolerances are measured to return the gearbox to optimal performance.
Generator	• Wear effects due to heat and wind • Bearing failure • Coupling failure due to misalignment	• Complete re-wind of generator with replacement of bearings and thermal protection.
Blades	• Scaling of topcoat due to air trapped in the manufacturing process • Repair of cracks in trailing edge • Large repairs near root • Longitudinal crack in trailing edge due to vibrations • Damage from lightning strike • Abrasion of surface due to dust, sand, etc.	• Inspection of blade surfaces • Cleaning of blades • Tensioning of blade bolts • Surface repairs, re-painting

Major Reasons for Wind Blade Failure

Manufacturing Failure

- Failures as a result of faulty materials and/or manufacturing process, such as air trapped during manufacturing of wind blades

Manufacturing Failure

Topcoat damage due to air trapped during the manufacturing process

Blade Distortion/ Bending Failure

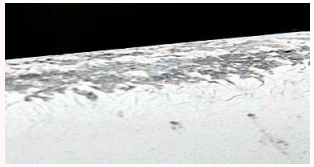
- Increase in length increases stress and deflection, resulting in blade distortion/bending

Bent Blade

Bent Blade

Fatigue Failure

- Continuous compression and tension increases fatigue effects
- Pressure load cycle due to wind gradient



Leading Edge Deterioration

Cracks in Trailing Edge

Failure due to Natural Calamities

- Natural calamities such as lightning, storms, icing, bird strikes etc. cause wind blade failures

Blade Tip Damaged by Lighting Strike

Wind Blade Damage by Heavy Storm

Factors involved in wind turbine O&M: Onshore v/s Offshore

Factor	Onshore	Offshore	Description
Accessibility to wind farm site	Moderate	Difficult	Gaining access is difficult for offshore as boat, helicopter etc. are required to access the site
Availability level of OEMs for O&M actions	High	Low	Proximity of wind farms to OEMs is high for onshore
Time required for mobilization of components	Short	Long	Less time required for sourcing and mobilization of components in onshore
Impact of weather conditions	Minimal	High	Harsh winter and stormy conditions create hurdles for offshore O&M
Repair and replacement of components	Low	High	Repair and replacement costs are higher in offshore due to overhauling performed generally after 5 years
Average time required for servicing generator	20-40 hours	50-80 hours	Accessibility, height and sea conditions result in longer down time

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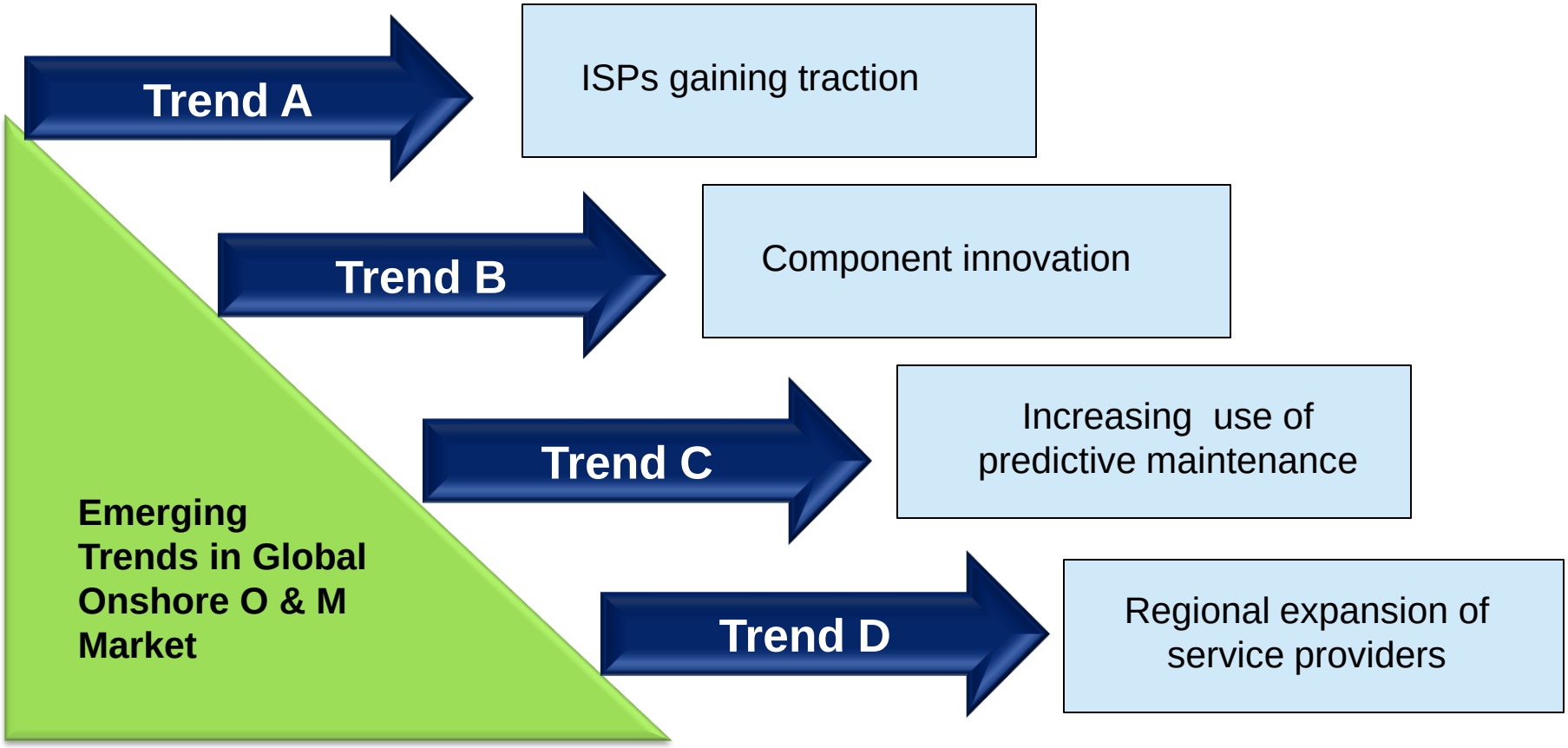
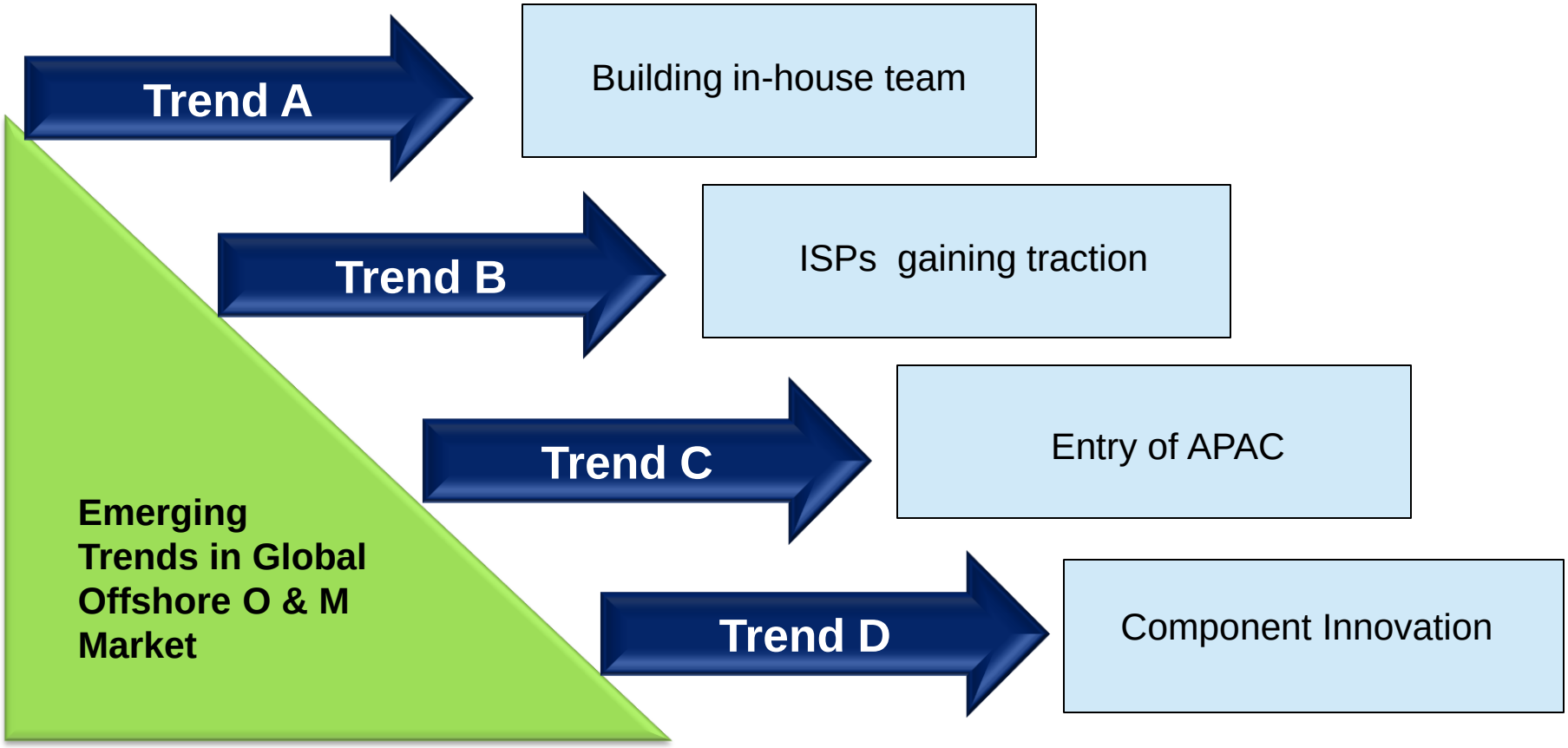
Emerging Trends in Onshore O & M Market



Emerging Trends in Offshore O & M Market



Examples of ISPs Gaining Traction in Onshore O&M

Agreements between OEMs and ISPs

B9 Energy provides O&M services in UK and Ireland on behalf of OEMs such as Gamesa and Acciona

Strategic alliances between ISPs

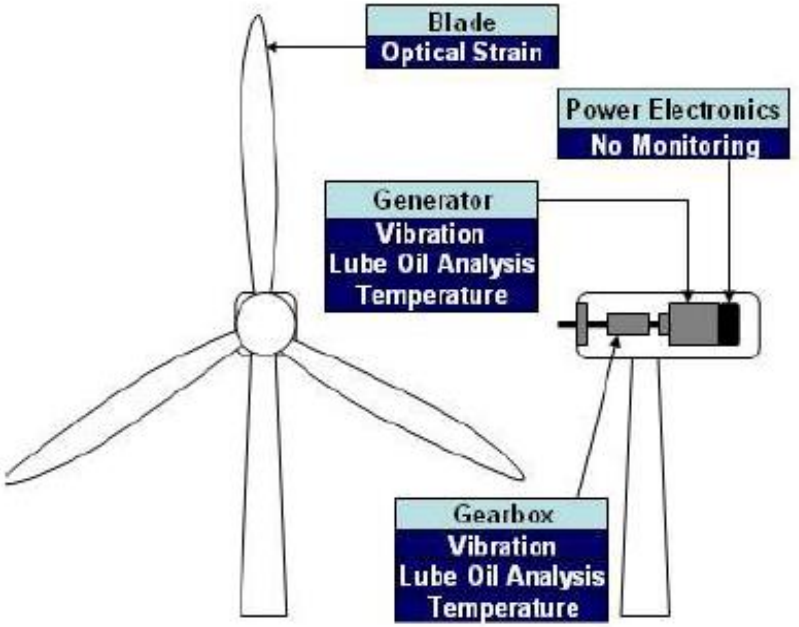
European ISPs are looking for an agreement with NA's ISPs for improving their O&M services

Contracts with developers

enXco signed an O&M agreement with Southern California Public Power Authority in 2010

UpWind Solutions has signed multi-year O&M agreements for 4 wind farm projects in 3 states in US, totaling 310 MWs

Increasing use of predictive maintenance



Condition Monitoring System (CMS)

- System monitors the status of all components subject to wear such as the gearbox, bearings and generator
- Compares ideal and actual situation and in the event of a discrepancy signals a preventive maintenance service
- Possible to significantly reduce unforeseen downtime resulting from wear or damage to components.

Benefits from CMS

- Predict failures before they occur resulting in cost saving by reducing down-time
- Money saved on repairs due to the fact that defects are detected in an early stage, easier to fix
- Typical cost savings :
  - Cost of CMS system ~ $12,000-$20,000
  - Pay back period ~ 5-6 months
- Predict how much service life is left in the turbine.

Other examples of Emerging Trends in Onshore O&M

Innovations in components

Enercon direct drive concept reduces the use of gearbox in wind turbines resulting in major reduction in O&M cost

Siemens also launched direct drive based wind turbines

Regional expansion of service providers

enXco, leading O&M service provider in NA, opened office in Europe to render O&M services

GES and B9 energy are major service providers in Europe, also in North America

Examples of Emerging Trends in Offshore O&M

Building in-house teams

Major offshore energy based European utilities are building in-house teams for future O&M

Dong Energy took over 100% in-house maintenance for Horns Rev 2 (capacity of 209 MW with 91 turbines)

Entry of ISPs

B9 energy (Europe) registered its ability to provide O&M services for offshore wind O&M market

Increasing turbine size

RE Power installed 5MW turbines in UK

Sinovel, Gamesa and Clipper Windpower are in the development phase of 10 MW wind turbines for offshore wind energy

Other Examples of Emerging Trends in Offshore O&M

Innovations in components

Siemens patented process to manufacture seamless blade (one component blade - no need of bonding two blade halves)

Increasing number of OEMs

In 2010, Sinovel debut in offshore market with installation of 3MW turbines in Donghai Bridge, China

Entry of APAC

China registered first commercial installations in 2010 with significant potential in foreseeable future

South Korea is also expected to install offshore wind turbines in near future

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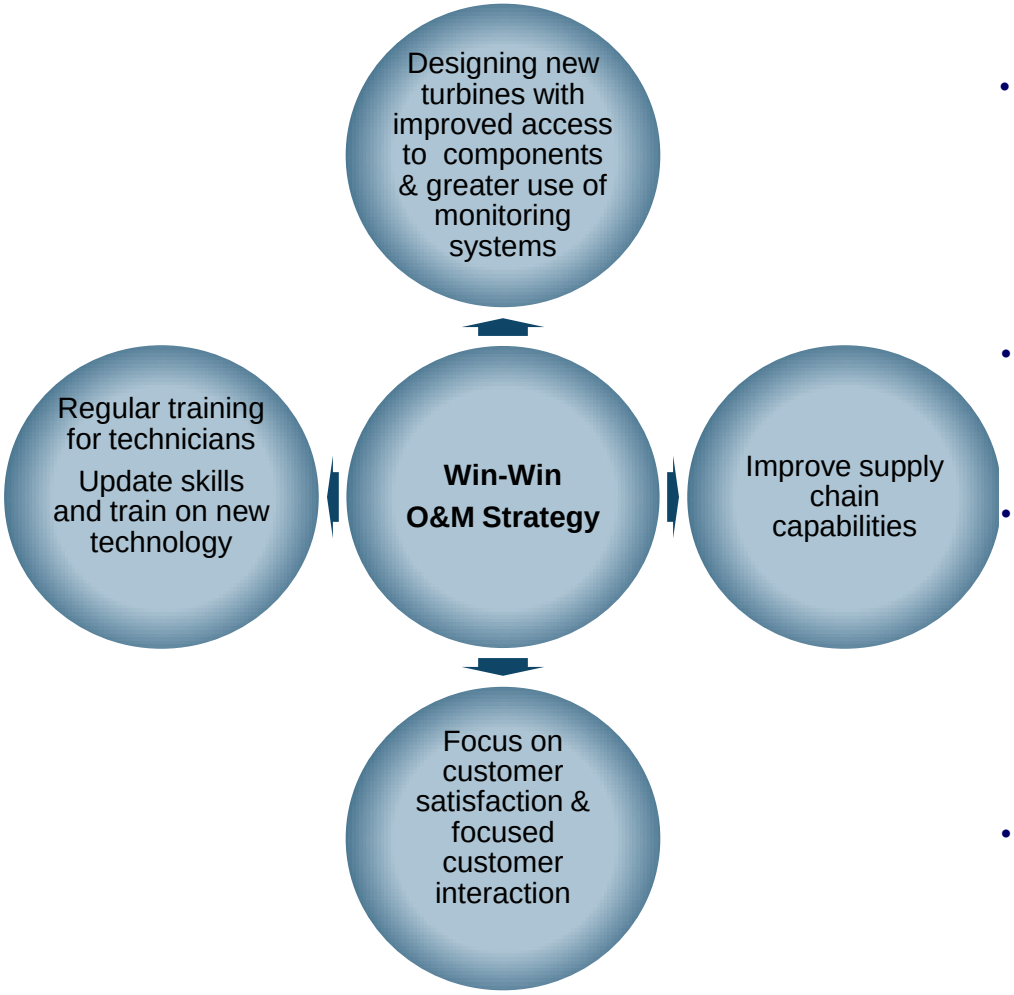
Developing Better Maintenance Strategies for OEMs



Key Insights

- **Investment in turbine design development**
  - **Improving the reliability of wind turbines through continual R & D efforts**
  - **Making turbines more O&M friendly with better accessibility for the service team**
- **Regular Training for Technicians**
  - **Requirement of proactive hiring and training of new personnel and continual skill update**
- **Focus on customer satisfaction**
  - **Higher dissatisfaction among wind developers for OEM O&M services in Europe; need for complete understanding of O&M requirements, setting achievable maintenance schedules, and responsive service for repair needs**
- **Improve supply chain capabilities:**
  - **Building a strong network of component suppliers**
  - **Partnership with Oil & Gas industry service providers**

Conclusions:

- Global wind O&M market is expected to grow at CAGR 19% to reach US$ 11.8B by 2016
  - Mainly driven by growth of wind energy market
- Most wind farm operators prefer OEMs as their O&M service providers
  - ISPs are gaining traction in O&M market, mainly in US, Germany and Spain.
  - Some wind farm operators, such as Florida Power and Light Company (FPL) and Iberdrola Renewables, are developing in-house capability
- European onshore wind O&M market offers higher opportunity relative to other regions
  - Large installed base, many older turbines
  - Expected stable growth in future
  - Low competition among service providers as compared to NA
- Offshore O&M market is in a nascent stage, having few service providers
  - Less attractive as current low installed base
  - Higher O&M cost relative to onshore O&M
  - Different skill sets, equipment and logistics required than onshore wind O&M

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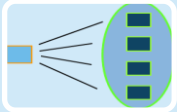
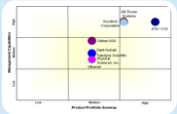
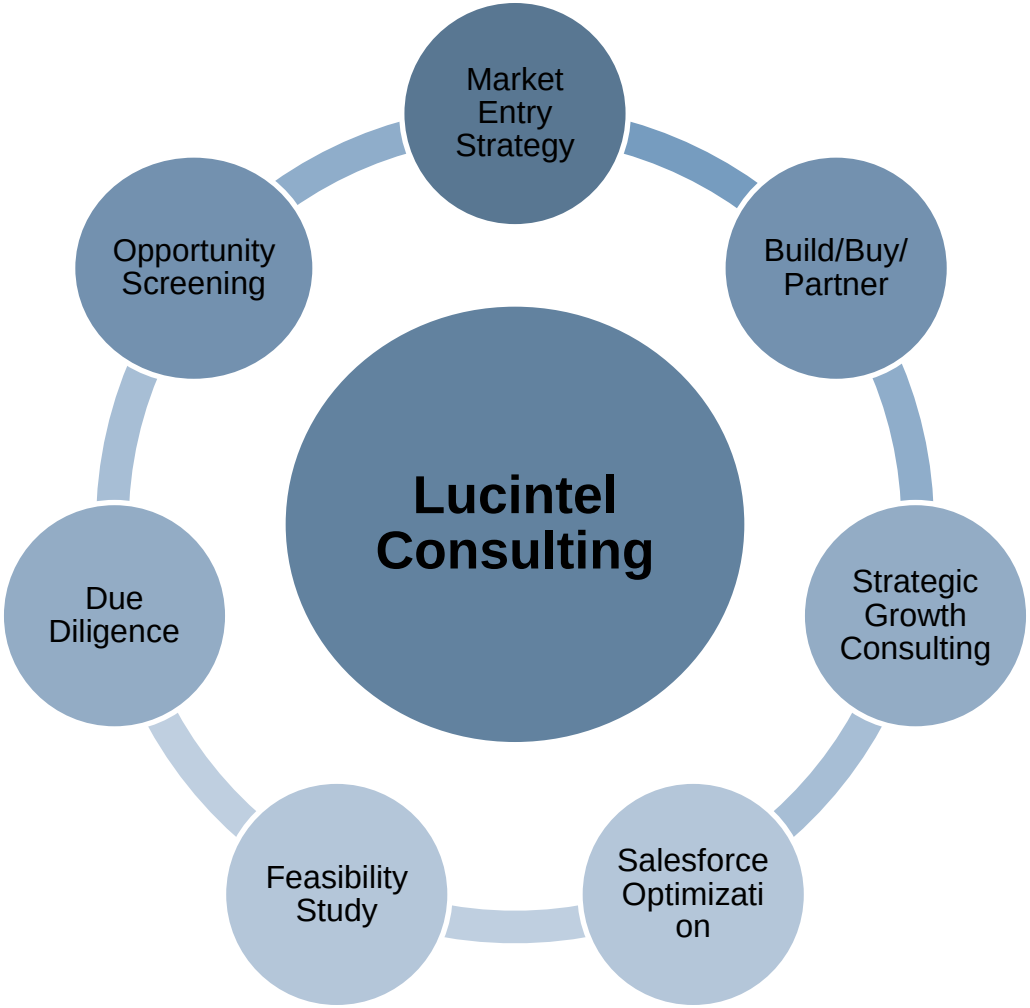

Opportunity Screening


Partner Search and Evaluation


Due Diligence and M&A


Market Entry Strategy

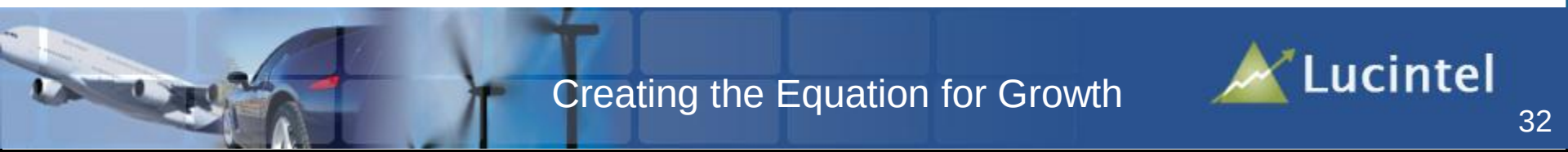
Lucintel has an extensive toolkit to address key strategic questions for increasing your company's profitability and market presence



Key Questions

- **Is market space / opportunity of current product offerings sufficiently robust?**
- **Markets are focus for many: how can my company profitably differentiate?**
- **Based on our core skills, where should we focus?**
- **Should we build or buy? Is build even an option?**
- **What game changer actions exist and/or is a more incremental approach best?**
- **What is the order sequence of market entry segments / products?**

Clients around the world value our services



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