NEW VALUE NEW PROSPECTS

THE FUTURE OF ONSHORE WIND OPERATIONS AND MAINTENANCE

accenture
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>6</td>
</tr>
<tr>
<td>CURRENT O&amp;M MARKET LANDSCAPE</td>
<td>10</td>
</tr>
<tr>
<td>KEY FINDINGS AND OPPORTUNITIES</td>
<td>14</td>
</tr>
<tr>
<td>Theme 1: Operators underestimate the bottom-line potential of O&amp;M</td>
<td>16</td>
</tr>
<tr>
<td>Theme 2: Moving to predictive maintenance is a goal across all operators</td>
<td>19</td>
</tr>
<tr>
<td>Theme 3: The optimization of contracting and procurement levers is becoming increasingly important</td>
<td>21</td>
</tr>
<tr>
<td>Theme 4: There is significant opportunity to optimize the spare-parts supply chain</td>
<td>23</td>
</tr>
<tr>
<td>Theme 5: Despite extensive investment to date, workforce optimization remains a big opportunity</td>
<td>25</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>27</td>
</tr>
</tbody>
</table>
The onshore wind industry has grown up significantly over the past decade. With global installed capacity now standing at 420 GW and an average levelized cost of electricity (LCOE) of about $68 per megawatt-hour (MWh), onshore wind is now among the most competitive energy sources globally. However, increased industry maturity brings growing pressure for the industry to stand on its own two feet. This is evidenced by the number of reduced or soon-to-be-ended regulatory incentives, and the demand for even greater emphasis on cost competitiveness.

At the same time, the installed turbine fleet is more than 10 years old, on average, resulting in increased failure rates and the need to consider new technologies for repowering, retrofitting and/or extending the life of current assets.

Much effort to date has centered on reducing development and installation costs, with more than a two-thirds reduction in costs achieved between 1983 and 2014. But the large existing installed base also indicates a significant opportunity to enhance asset value around operations and maintenance (O&M), which currently accounts for about 20 percent of the LCOE. If lean O&M practices were integrated with commercial capabilities and data sets, O&M could drive revenue uplift through a reduction in penalties from more accurate forecasting and through the potential to balance electricity provided to the grid, enabling the provision of balancing grid services as well.

A comprehensive examination of operators across multiple dimensions reveals that they are taking a wide range of approaches, depending on their scale, in-house capability and level of financial investment. Large operators with global portfolios of more than 2 GW have relied heavily on sophisticated control rooms to pool investment and optimize cost and performance across their portfolios. Some players with up to 1 GW within a single country have largely relied on taking the O&M value chain in-house for greater control, enabling optimization across sites in-country. Meanwhile, medium-size independent power producers (IPPs) have focused more on optimizing their energy management capability, choosing to outsource most of their O&M activity to original equipment manufacturers (OEMs). While each of these approaches has driven significant efficiencies to date, more are available. The objective of this study is to examine these approaches and explore opportunities to drive additional value. The study builds on primary and secondary research, including in-depth interviews with leading wind power operators and analysis of benefits captured across other industries with similar processes.

Five key themes emerged from the study.
Theme 1: Operators underestimate the bottom-line potential of O&M

The potential for O&M to impact the bottom line is underestimated, with O&M often not sufficiently factored into decision making. The integration between commercial and operational teams varies dramatically across operators and is influenced by each operator's mindset and ways of working between the two teams, as well as the relative level of digital sophistication. Some operators have invested in digital infrastructure early and have integrated certain commercial and operational data sets to drive a degree of O&M optimization. Others have simply looked to schedule maintenance activity during periods of low wind or grid maintenance.

Despite these varying starting points, we found that all operators had an opportunity to go further. The key to unlocking additional value is the seamless integration of all commercial and operational data sets that could truly enhance the impact on the bottom line. This integration includes all data from the turbine SCADA systems, external market and weather forecasts, work management and the supply chain. To enable this integration, operators should continue to make investments in big data and analytics, while also driving the alignment of commercial and operational teams' targets and incentives.

Theme 2: Moving to predictive maintenance is a common goal across all operators

Accenture primary research revealed that moving to predictive maintenance is a goal across all operators. However, our analysis shows that the share of predictive maintenance currently represents only between 10 and 30 percent of overall maintenance activity, with operators deploying a range of maintenance approaches. In some cases, where the investment in data analytics from the equipment sensors is limited, planned activity can account for up to 80 percent of all maintenance activity. In others with more advanced controls, condition-based monitoring can account for up to 80 percent all maintenance activity. In both cases, moving to a greater share of predictive maintenance could minimize downtime and optimize O&M.

Such a move would also enable operators to make better trade-offs. For example, being able to assess the impact of deferring maintenance in times of high prices and high wind. Those operators that have already invested in digital technologies, could apply predictive algorithms to historical data across hundreds of turbines to understand when a confluence of certain conditions will become an issue. For those that have not, it’s critical to draw on the experience of the technician who can detect the future problem from how the turbine is behaving (e.g., the slightest variation in sound). Beyond pure early-watch alerts and time-to-failure analysis, predictive analytics can help optimize overall O&M and energy management variables, thus maximizing asset value from technical and commercial standpoints.
Theme 3:  
The optimization of contracting and procurement levers is becoming increasingly important

Following the typical three- to five-year warranty period, operators have either renegotiated an extension to the O&M service contract or tendered for their O&M services. With a growing number of operators looking to take back control from OEMs, a more proactive approach to procurement is needed, applying a range of value levers, including price optimization, the introduction of competition, bundling/unbundling of service contracts, and performance management. The differences in how these approaches are applied depends on whether an operator is executing the activity or is being a strong contract manager to other executors. Regardless of which approach is used, procurement levers will be increasingly important to driving bottom-line value.

Theme 4:  
There is a significant opportunity to optimize the spare-parts supply chain

Accenture interviews with operators and industry experts reveal that spare parts can account for up to half of turbine maintenance costs. Traditionally, the spare-parts supply chain has been outsourced to the OEMs, often in bundled deals that meant spare parts and service costs could not be split. As OEM performance was measured on availability, spare-parts costs were often passed on to the operators, and most failures generally resulted in the installation of new parts rather than their refurbishment. Now, operators are taking greater in-house control of spare parts, often starting with major components but also extending to minor components and consumables. They are also developing local supply alternatives for certain parts. As operators continue down this path, they should look to leverage leading practices from other industries with similar processes, such as aerospace.

Theme 5:  
Despite extensive investment to date, workforce optimization remains a big opportunity

The workforce is the largest O&M cost component. Given the technical nature of many utilities’ field forces, significant efforts have already been made to improve the effectiveness and efficiency of both the operators’ own staff and those of third parties. Tablets and mobile apps have been widely deployed and workers’ locations are readily tracked and available to meet health, safety and environmental (HSE) imperatives. However, without exception, all operators we interviewed still see workforce productivity as an area with significant potential for improvement. This opportunity varies, according to the mix of in-house and third-party staff, as well as the reliance on expertise and knowledge management from the control center versus the field. Specific opportunities range from better management of third parties, contracts and contractors, to the implementation of digital technologies and collaboration tools to further empower the connected worker.

One common thread running through these themes is the deployment of digital technologies as an enabler. These present the largest opportunity of all. The integration of various data sets is foundational to realizing most of the value opportunities we cover in this study.

When it comes to digital investments, size and access matter. Operators that have already started investing in digital have an opportunity to take value capture to the next level, while smaller players need to find another way of obtaining visibility into their entire wind portfolios. This will be the key to shifting O&M from a cost center to becoming a true value driver, supporting real competitive advantage.
INTRODUCTION

STUDY CONTEXT

Onshore wind has experienced tremendous growth over the past decade, reaching 420 GW in 2015 and representing 6.5 percent of global installed energy capacity. This growth has been driven by Asia, Europe, and North America, accounting for 38 percent, 35 percent and 21 percent of 2015 capacity, respectively (see Figure 1).

This growth has largely been driven by governments’ commitments to achieving a low-carbon future, a rapid evolution of onshore wind technology and the implementation of leading practices in project development. Onshore wind is now among the world’s most cost-competitive energy sources, as evidenced in Figure 2, with a global average LCOE now competitive even with combined cycle gas turbines (CCGT) and coal.


FIGURE 2. GLOBAL AVERAGE LCOE, 2009-2016.


Onshore wind growth has largely been driven by governments’ commitments to achieving a low-carbon future, a rapid evolution of onshore wind technology and the implementation of leading practices in project development.
There is now an expectation that the onshore wind industry should begin to stand on its own, without subsidies. Figure 3 contains a review of the policy support across countries with the greatest installed capacity and points to an increasing reliance on market mechanisms over policy incentives to support the industry’s continued growth. China, with the largest installed onshore wind capacity and most ambitious plans for growth, continues to incentivize new developments but is reducing the size of incentives with a reduction in onshore wind feed-in tariffs. Germany’s feed-in tariffs for onshore wind will be replaced in May 2017 with a public tender system, while the United Kingdom’s renewables obligation scheme expired in 2016.

**FIGURE 3. ONSHORE WIND POLICY REVIEW ACROSS COUNTRIES.**

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>INSTALLED ONSHORE CAPACITY (MW)</th>
<th>PLANNED(^1) ONSHORE CAPACITY (MW)</th>
<th>MAIN SUPPORT SCHEMES</th>
<th>SUPPORT SCHEMES OUTLOOK</th>
<th>OUTLOOK DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHINA</td>
<td>144,086</td>
<td>65,219</td>
<td>Feed-in-tariff</td>
<td>Transitioning to greater market influence</td>
<td>In December 2016, China’s National Development and Reform Commission announced a reduction in wind tariffs of up to 15% starting in 2018</td>
</tr>
<tr>
<td>INDIA</td>
<td>25,088</td>
<td>8,750</td>
<td>Tax benefit</td>
<td>Transitioning to greater market influence</td>
<td>The accelerated depreciation (AD) scheme under which part of the project cost is paid back was reduced from 80% to 40% in April 2017. The generation-based incentive (GBI) expired in March 2017</td>
</tr>
<tr>
<td>FRANCE</td>
<td>10,358</td>
<td>1,124</td>
<td>Feed-in-premium</td>
<td>Stable</td>
<td>The French government quickly created a feed-in-premium scheme in 2016 following a European Commission ruling that the previous feed-in-tariff violated European state aid laws</td>
</tr>
<tr>
<td>GERMANY</td>
<td>41,652</td>
<td>6,463</td>
<td>Feed-in-tariff</td>
<td>Transitioning to greater market influence</td>
<td>Feed-in-tariff for onshore wind to be replaced by public tender system in May 2017</td>
</tr>
<tr>
<td>ITALY</td>
<td>9,126</td>
<td>405</td>
<td>Feed-in-tariff</td>
<td>Stable</td>
<td>Feed-in-tariff for non-PV renewable energy sources renewed in 2016</td>
</tr>
<tr>
<td>SPAIN</td>
<td>23,003</td>
<td>1,506</td>
<td>None</td>
<td>Stable</td>
<td>No publicized plans for future support</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>8,750</td>
<td>7,999</td>
<td>Renewables obligation (RO) • Contract-for-differences (CfD)</td>
<td>Transitioning to greater market influence</td>
<td>RO expired for onshore wind in April 2016; currently no plans to include onshore wind in the CfD scheme. RO expired for offshore wind in March 2017, to be replaced with support in CfD scheme</td>
</tr>
<tr>
<td>UNITED STATES OF AMERICA</td>
<td>72,578</td>
<td>23,239</td>
<td>Tax benefit</td>
<td>Uncertain</td>
<td>Current administration may repeal tax credits prior to current expiration date of December 2019</td>
</tr>
</tbody>
</table>

\(^1\) Includes capacity that is partially commissioned, permitted, and for which financing has been secured

Many operators welcome this shift. But to remain competitive they will need to proactively manage many complex variables, including contracts, energy demand, prices, weather and asset health, and optimize their costs and revenues.

Much effort to date has centered on reducing development and installation costs and, as a result of the large existing installed base, O&M is particularly important. If lean O&M practices are integrated with commercial capabilities and data sets, O&M could drive revenue uplift both through a reduction in penalties from more accurate forecasting and through the potential to increase turbine availability enabling the provision of ancillary services to the grid.

Current O&M strategies vary by operator type, capability and size. The objective of this study is to examine this variety of approaches and explore opportunities to continue driving additional value, shifting O&M from a cost center to a true value driver.

**STUDY METHODOLOGY**

This study builds on primary and secondary research, including insights from leading operators to better understand the current O&M approaches, chokepoints and opportunities for further improvement. The study also draws on lessons from other industries with similar processes, to bring to life some of the opportunities captured by those other sectors. Figure 4 outlines the four main steps taken to develop this study.

**FIGURE 4. STUDY APPROACH.**

1. **Onshore wind O&M leading practices research**
   - Output: Questionnaire on O&M approaches and areas of opportunity

2. **In-depth interviews with onshore wind leading operators to better understand differing approaches and identify areas of opportunity**
   - Output: Comparative assessment of approaches

3. **Validation of remaining areas of differentiation with Accenture subject matter advisors and industry experts**

4. **Drill-down into key areas of opportunity and lessons learned from other industries**
   - Output: this report
The onshore wind value chain consists of five main stages: development, manufacturing, installation, O&M, and decommissioning. Much attention to date has focused on the first three stages to drive improvements in technology and reduce installation costs. These efforts have been rewarded, as shown by, for example, the historical decline in installation costs by an average of 7 percent each time global capacity has doubled.\(^4\) O&M is the next big opportunity.

**FIGURE 5. ONSHORE WIND VALUE CHAIN AND PRIMARY CHOKEPOINTS.**

<table>
<thead>
<tr>
<th>DEVELOPMENT</th>
<th>COMPONENT AND TURBINE MANUFACTURE</th>
<th>INSTALLATION</th>
<th>OPERATIONS, MAINTENANCE AND SUPPORT SERVICES</th>
<th>DECOMMISSIONING</th>
</tr>
</thead>
</table>

**O&M CONTROL CENTER AND ENERGY MANAGEMENT**

1. Alert for corrective maintenance received
2. Planned or predictive maintenance
3. Work order urgency assessed to determine prioritization
4. Energy management team engaged to optimize work order scheduling
5. Materials availability confirmed (onsite, warehouse, to be ordered)
6. Technician carries out maintenance activity
7. Replaced part sent to onsite warehouse or central warehouse for refurbishment
8. Reference content added to work order
9. Feedback job learnings to planning

**LOGISTICS**

- Technician dispatches to confirm issue and schedule work order
- Technician picks up materials and travels to site to carry out work order
- Technician sends completion data to control room/ERP
- Technician carries out maintenance activity
- Technician picks up materials and travels to site to carry out work order

**MAINTENANCE ACTIVITY**

- Work order urgency assessed to determine prioritization
- Energy management team engaged to optimize work order scheduling
- Reference content added to work order
- Feedback job learnings to planning

**Component and Turbine Manufacture**

- Greater probability of turbine failure post-warranty period, and particularly in second decade of operation, leading to potential for significant downtime
- Increasing share of predictive over planned and condition-based maintenance
- Prioritization of work orders with 15-minute response times required when fault results in turbine downtime
- Integration with energy management priorities to optimize work order scheduling based on forecasted energy price, production and existing commitments, where possible

**Operations, Maintenance and Support Services**

- Visibility of materials with high-failure rates to enable optimal stocking strategies and manage impact on cost and delays
- Interaction between technician and control room
- High cost of spare part replacement
- Feedback by job to ensure continuous learning and improvement

Source: Accenture analysis.
Based on our interviews with industry operators, O&M represents about 20 percent of the LCOE, equivalent to between $20,000 to $30,000 per MW per year.

The O&M process is straightforward, but optimizing it could be challenging. Figure 5 describes the process and highlights its primary chokepoints.

O&M is initially included in the turbine warranty, which typically lasts for three to five years, during which time all O&M activity is carried out by the OEM. Once the warranty period has expired, operators must actively manage O&M. From this point on costs more than double and turbine availability is reduced due to increased turbine material wear and fatigue. That, in turn, leads to a higher probability of part failures. Managing these added costs and minimizing downtime is complex and requires optimization across several factors.

Maintenance activity needs to move toward becoming increasingly predictive. It also requires the prioritization of work orders based on a failure’s impact on downtime and existing production commitments as well as external considerations such as weather and energy price forecasts. Maintenance also needs to be aligned with the workforce and supply chain to minimize non-productive time. Real-time feedback will enable continuous optimization of the process.

The impact of O&M on revenue should also be considered. Integrating O&M with production forecasting could help manage potential penalties from missed forecasts while also driving uplift through the provision of grid services.

For example, Accenture helped a European wind farm operator with approximately 70 MW installed power operating in harsh weather conditions. By improving production forecasting by 5 percent, factoring in operational data access and accuracy, weather conditions and forecasts, and local market and regulation constraints, the operator realized approximately €150,000 per year in savings from a reduction in unbalancing costs.

Integrating O&M with production forecasting can also drive uplift. For example, in the United Kingdom, National Grid utilizes the Balancing Mechanism (BM) to balance electricity supply and demand each half-hour trading period of every day. When National Grid predicts a discrepancy between supply and demand, it accepts “bids” or “offers” to either increase or decrease generation or consumption. The investment that Scottish Power Renewables has made in developing its centralized Renewables Control Centre, incorporating its CORE System, has enabled Scottish Power Renewables to fulfill its Grid Code and Balancing Mechanism (BM) obligations offering ancillary services such as reactive power, frequency control and grid inter-tripping, where portions of the grid are automatically tripped to protect the integrity of the wider network. The CORE is designed to deliver enhanced grid services such as generation aggregation that allows services from a number of wind farms to be combined and delivered co-operatively.
The way each operator has approached O&M varies according to its scale, in-house capability and level of investment to date. Our research reveals three primary archetypes:

1. **Large global portfolio player** with more than 2 GW of global onshore wind capacity, giving it a greater ability to invest, develop capability and optimize across sites and countries.

2. **Large player with single-country operations** with more than 2 GW of onshore wind in total but 300 MW to 1 GW capacity in each country, and an ability to invest and optimize across that country.

3. **The medium-size independent power producer (IPP)** with between 300 MW and 1 GW of onshore wind capacity.

To bring to life the differences in approach, Figure 6 further describes each archetype against five core dimensions.

**FIGURE 6. ONSHORE WIND O&M ARCHETYPES.**

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>Large, global portfolio</th>
<th>Large, single-country operations</th>
<th>Medium, independent power purchaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contracting maturity and O&amp;M operating model (spectrum of in-house to outsource)</td>
<td>High degree of contracting maturity with hybrid O&amp;M operating model post-OEM warranty period with some activities done in-house, others outsourced to OEMS or independent service providers (ISPs)</td>
<td>Moderate degree of contracting maturity with O&amp;M largely conducted in-house post-OEM warranty period, with few activities outsourced to OEMS or independent service providers (ISPs)</td>
<td>Limited contracting maturity with O&amp;M. Primarily outsourced to OEMS through contract extension post-warranty period</td>
</tr>
<tr>
<td>Profitability objective and alignment/integration of O&amp;M with energy management</td>
<td>High degree of integration with optimization engine using O&amp;M and energy management data to enhance production and minimize unbalancing costs</td>
<td>Limited degree of integration with largely one-way sharing of O&amp;M data from operations control room to energy management</td>
<td>Limited degree of integration with largely one-way sharing of O&amp;M data from the OEM service provider to energy management</td>
</tr>
<tr>
<td>Approach/ability to increase share of predictive maintenance</td>
<td>Use of analytics to support determination of maintenance priorities and definition of maintenance plan resulting in more than 20 percent predictive. Focus on contractor performance management and response times</td>
<td>High reliance on noise/visual detection to drive predictive maintenance resulting in less than 20 percent predictive versus alert-based interventions. Focus is therefore on minimizing response times</td>
<td>Dependent on the service provider but primarily alert-based. Focus is on availability KPIs and minimizing response times</td>
</tr>
<tr>
<td>Spare-parts supply chain approach and capability</td>
<td>Increasing maturity of approach to spare-parts supply chain with focus on improving transparency of spend and development of in-house capability (previously outsourced to OEMS)</td>
<td>High degree of transparency over spend as a result of in-house capability developed following expiry of OEM contracts post-warranty period</td>
<td>Limited transparency over spend with spare-parts management bundled into OEM materials and services contracts</td>
</tr>
<tr>
<td>Workforce—spectrum of investment in enabling infrastructure to investment in field engineer</td>
<td>High degree of investment in the workforce with emphasis on centralized support through integration with control room alerts</td>
<td>High degree of investment in the workforce with emphasis on enabling the field engineers to optimize a set of turbines through, for example, roll out of mobile solutions</td>
<td>Limited investment in the field workforce as majority of O&amp;M activity is outsourced to OEMS</td>
</tr>
</tbody>
</table>

Source: Accenture analysis.
As evidenced in Figure 6, archetypes’ unique starting points have resulted in significant differences in the way they approach O&M. While the large global portfolio player has relied extensively on a sophisticated control room to optimize O&M in the context of overall profitability, the large player with single-country operations has tended to rely on taking the O&M value chain in-house for greater control to optimize across in-country sites. Meanwhile, the medium-size IPP has focused more on optimizing its energy management capability, choosing to outsource most of the O&M activity to OEMs.

Despite these differences, all the archetypes share a common opportunity: to make significant improvements to O&M.
KEY FINDINGS AND OPPORTUNITIES

To better understand the different O&M approaches taken and identify opportunities to further optimize O&M across each archetype, Accenture conducted a series of in-depth interviews with leading operators.

This research and analysis revealed five key themes:

1. Operators underestimate the bottom-line potential of O&M
2. Moving to predictive maintenance is a common goal across all operators
3. The optimization of contracting and procurement levers is becoming increasingly important
4. There is a significant opportunity to optimize the spare-parts supply chain
5. Despite extensive investment to date, workforce optimization remains a big opportunity

Figure 7 summarizes the findings and opportunities by theme and archetype. The extent of the opportunity has been defined based on the number of interviewees who recognized the opportunity and its significance.

The following sections explore each theme in greater detail, drawing out the main differences by archetype and the resulting opportunities. The importance of digital technologies and enablers such as big data and analytics is a common thread to truly optimize O&M.
The future of onshore wind operations and maintenance | 15

FIGURE 7. ONSHORE WIND VALUE CHAIN AND PRIMARY CHOKEPOINTS.

THEME 1: OPERATORS UNDERESTIMATE THE BOTTOM-LINE POTENTIAL OF O&M

The potential for O&M to maximize the bottom line is underestimated and thus O&M is often not sufficiently factored into decision making. A number of tactics should be considered to drive integration between commercial and operational teams and elevate O&M to enable improved outcomes. These include transparent and shared KPIs, increased use of collaboration tools, performance benchmarking and sharing of leading practices across the portfolio.

THEME 2: MOVING TO PREDICTIVE MAINTENANCE IS A COMMON GOAL ACROSS OPERATORS

Moving to predictive maintenance is a common goal across operators, but not all have invested in the analytics infrastructure or have access to data to do this, requiring them to optimize O&M in different ways, e.g., through significant investment in the workforce. Initial investment into analytics infrastructure should be further leveraged to increase the share of predictive maintenance. Resources should be pooled to invest in the analytics infrastructure and data access to drive improvements beyond those enabled by a workforce strategy alone. While the move to predictive maintenance will be limited, investment should be made to support low-tech knowledge capture, including through the workforce.

THEME 3: THE OPTIMIZATION OF CONTRACTING AND PROCUREMENT LEVERS IS BECOMING INCREASINGLY IMPORTANT

Early efforts by many operators have focused on increasing market competition to drive down contract prices. As operators take back control from the OEMs, they should look to optimize a wider range of procurement levers. A number of levers should be explored to drive the industrial development of procurement. These include pooling demand for materials and services across wind farms, splitting materials and services and competitively tendering for them, taking a total cost of ownership approach to procurement, bringing engineering and procurement closer together, and improving the contract management and performance management of suppliers.

THEME 4: THERE IS A SIGNIFICANT OPPORTUNITY TO OPTIMIZE THE SPARE-PARTS SUPPLY CHAIN

While traditionally spare parts were outsourced to OEMs, operators are moving more of this in-house while also looking to improve the integration between field technicians and procurement, materials planning and management, and logistics. Opportunity to share investment in tools and analytics to support demand planning, material planning and inventory optimization, to centralize sourcing, track and manage supplier performance, and create specialization by material/vendor. Opportunity to pool investment in toolset to drive visibility across country operations. In particular, focus should be on improved integration between field technician and procurement, materials planning and management, and logistics. Opportunity to benchmark cost of spare parts as part of service provider costs. Consider carving out major components from bundled deals.

THEME 5: DESPITE EXTENSIVE INVESTMENT TO DATE, WORKFORCE OPTIMIZATION REMAINS A BIG OPPORTUNITY

The workforce represents the largest O&M cost component and many investments have already been made to date, e.g., in field-force effectiveness tools, but room for continued optimization remains. Opportunity to further support the workforce from the control center and to use digital technologies to ensure all information, data and history is available to every technician and job. Most importantly the learnings, performance data and insights from each job should be captured for future use and benchmarking. Focus on empowering the in-house workforce to maximize his/her productivity; e.g., remote access to equipment specifications/job history, real-time information on spare parts availability, with the deployment of low-tech workforce solutions to facilitate this. Opportunity to track productivity of contractor workforce, and to consider investment in workforce applications to support the contractor workforce as part of the selection consideration.

Source: Accenture analysis.
Theme 1: Operators underestimate the bottom-line potential of O&M

The potential for O&M to impact the bottom line is underestimated, with O&M often not sufficiently factored into decision making. The degree of integration between commercial and operational teams differs dramatically across operators. It is influenced by the operator’s mindset, and in the ways of working between the two teams, as well as their level of digital sophistication.

Some operators have invested in digital infrastructure early and have integrated certain commercial and operational data sets to drive a degree of O&M optimization. For example, one operator we spoke to explained that production forecasting is embedded into their control room dashboard. This enables their systems to leverage external factors, such as weather forecasts and the electricity price, to directly inform O&M plans.

Those that have not had the opportunity to similarly invest in digital infrastructure have had to take a more manual approach, looking at different data sets separately to determine the best time to schedule maintenance activity. Yet others have merely treated maintenance plans as an input to commercial optimization.

Despite varying starting points, we found that all operators had an opportunity for further action. Truly maximizing bottom-line impact requires seamless integration of all commercial and operational datasets.

There are two key enablers: big data and analytics and the target and incentive alignment of the commercial and operational teams. Big data and analytics allow for the integration of data sets to drive optimal decision making, while also enabling performance benchmarking across the portfolio. The alignment of targets and incentives by implementing collaboration tools and shared KPIs allows both teams to share leading practices and work together toward the same goal.

Building on this, Accenture has defined the concept of a “digital wind hub,” implementation of which would drive a further step change in the industrialization of renewables, unlocking optimization across the portfolio while offering a real-time work environment for O&M managers (see Figure 8). This step change would require a transformation away from the use of local control rooms, ERP and legacy systems toward a new digital architecture that integrates a variety of external and internal factors to drive asset value maximization.

This vision would even provide leading operators with the opportunity to enter the market of O&M and energy management digital services as a market aggregator and position them as disruptors in digital innovation.
The future of onshore wind operations and maintenance

Remote ops monitoring
Production optimization
Predictive maintenance
Maintenance and supply chain
Workforce management
Forecasting and management
Remote intelligence
Production optimization

Routine tasks executed without human intervention

Mobility solutions extending to the industrial arena

Integration of operations and information technologies

Physical activities conducted by machines

Cloud platforms providing new ways of delivering services

Cognitive analytics and big data applications

Protection for the connected ecosystem

Premium collaboration and multidisciplinary decision making

EXTERNAL PRESSURES
e.g., complexity, cost and capacity

FIGURE 8. ACCENTURE’S VISION FOR A DIGITAL WIND HUB.
Figure 9 shows a prototype, created by Accenture, to visualize what a dashboard view of the key metrics to track across fleet operations, production optimization, asset management, workforce management, energy management, materials management and logistics could look like.

FIGURE 9. ILLUSTRATION OF A DIGITAL WIND HUB.
Accenture’s interviews revealed that moving to predictive maintenance is a goal for all operators. However, our analysis shows that predictive maintenance currently represents only between 10 and 30 percent of overall maintenance activity. In some cases, where the investment in data analytics from the equipment sensors is limited, planned activity can account for up to 80 percent of all maintenance activity. In others with more advanced controls, condition-based monitoring can account for up to 80 percent of all maintenance activity. In both cases, moving to a greater share of predictive maintenance could minimize downtime and optimize O&M. Indeed, the ability to respond quickly to maintenance issues is a critical KPI given requirements for operators to retain high wind availability.

All turbines produce significant data which is available in the control systems. Analytics to monitor rotating equipment’s wear and tear and performance issues are widely deployed in many industries. Even our motor vehicles currently alert us about maintenance needs given the duty cycle and readings of various sensors. These same algorithms are used in onshore wind condition-based monitoring approaches. However, condition-based monitoring approaches do not predict an issue, they alert the operator to an existing fault. In addition, depending on the investment in the ownership, access and ability to analyze alert data, the effectiveness of condition-based monitoring varies across operators.

For operators where planned maintenance dominates the approach, it is usually because the expertise of the technician is a manual approach to “prediction.” For example, one operator we spoke to described how they have optimized their workforce, parceling their portfolio into regions, each managed by a regional manager. These managers in effect “own” their set of turbines and, over time, build up invaluable knowledge which enables them to “predict” when something is wrong, generally through visual or auditory inspection.

Moving to predictive maintenance cannot only reduce downtime; it can also optimize O&M. A predictive approach would also improve decision making. For example, it can address questions such as: In times of high prices and high wind, what is the impact of deferring maintenance? Operators that have already made some digital investment, such as predictive algorithms, could apply these to historical data across hundreds of turbines to understand when a confluence of certain conditions will become an issue. For those who have not, the experience of the technician who can detect the future problem from how the turbine is behaving (e.g., the slightest variation in sound) is critical. Beyond pure early watch alerts and time-to-failure analysis, predictive analytics can help optimize overall O&M and energy management variables, thus maximizing asset value from technical and commercial standpoints.

One global renewables operator conducted research in collaboration with MIT to assess predictive maintenance for two wind farms. This research resulted in several models with varying degrees of accuracy for different components and enabled time-to-failure predictions to optimize production and extend components’ useful life. A new statistical model for reliability analysis was also studied to distinguish between the latent internal vulnerability of the equipment from the vulnerability caused by temporary external sources. This pilot resulted in increased plant availability and a reduction in unplanned maintenance costs.7
CASE STUDY:
Leveraging analytics to enable intelligent operations

CONTEXT

LARGE INDEPENDENT LNG PLANT OPERATOR

The client has an extensive portfolio of offshore facilities, LNG trains and an expanding portfolio of global exploration opportunities—positioning them well for further international growth.

The client’s vision is to be a data-driven company, powered by analytics. In particular, the client wants to drive intelligent operations, supported by predictive insights and recommendations enabling measurable business improvements.

SOLUTION

Accenture is teaming with the client to realize its vision as a data-driven company. To date this has consisted of:

- Use of predictive analytics for reliability engineers to improve maintenance decisions
- Use of predictive analytics for surveillance engineers to make more informed process control and plan management decisions
- Creation of a flexible, scalable analytics environment compliant with the client’s security policy

OUTCOMES

Value delivered as a result of this analytics program has exceeded $200 million, achieved through:

- Measureable reliability improvements through predictive maintenance
- Increased production volumes through predictive process control

THE OPPORTUNITY TO MOVE TO A PREDICTIVE MAINTENANCE REGIME VARIES BY ARCHETYPE:

The large, global portfolio player with investment in digital infrastructure can deploy more sophisticated data analytics to integrate a greater share of predictive maintenance (e.g., for specific types of events that would cause failures) into the maintenance approach.

The large, single-country wind operator should pool investments in the analytics infrastructure across the country sites (even if this data is not integrated). Otherwise, predictive maintenance is limited to the individual engineer’s experience and cannot easily be scaled.

The medium-size IPP has limited opportunity to move to predictive maintenance, but some investment could be made to support low-tech knowledge capture, so there is some level of manual prediction.
After the three to five-year warranty period, the default approach to contracting and procurement is to either renegotiate an extension to the O&M service contract or retender O&M. But O&M does not need to be a single contract. In fact, there are various scopes of work, materials and services in the O&M category.

The more sophisticated operators apply the traditional value levers to the O&M category as illustrated in Figure 10. Value levers that can quickly deliver benefits to the O&M category include price and buying optimization, bundling/unbundling, and performance management.

**Theme 3:**
The optimization of contracting and procurement levers is becoming increasingly important

After the three to five-year warranty period, the default approach to contracting and procurement is to either renegotiate an extension to the O&M service contract or retender O&M. But O&M does not need to be a single contract. In fact, there are various scopes of work, materials and services in the O&M category.

The more sophisticated operators apply the traditional value levers to the O&M category as illustrated in Figure 10. Value levers that can quickly deliver benefits to the O&M category include price and buying optimization, bundling/unbundling, and performance management.

**FIGURE 10. CATEGORY MANAGEMENT VALUE LEVERS.**

<table>
<thead>
<tr>
<th>CATEGORY MANAGEMENT VALUE LEVERS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| E2E supply chain                | • Optimize end-to-end value chain with integrated planning and optimization of physical delivery of goods and services  
• Drive innovation by partnering with suppliers |
| Demand management               | • Product standardization  
• Re-engineer specifications  
• Develop product/service alternatives |
| Price optimization              | • Focus on total cost of ownership  
• Supplier should cost models  
• Leverage market variations |
| Buying optimization/Introduce competition | • Develop buying consortiums  
• Develop product/service/supply alternatives/introduce competition  
• Drive to optimum price |
| Outsource non-core spend management | • Outsource to leading providers |
| Bundling/Unbundling             | • Bid out different operating models  
• Carve out different scopes, separate materials and services |
| Performance management          | • Consistent, rigorous contract and contractor performance management  
• Implement appropriate KPIs  
• Measure outcomes and continuous improvements |

Source: Accenture analysis.
PRICE OPTIMIZATION
An important lever is the focus on total costs. The inclusion of spare-parts provision with services might seem like a benefit, as OEMs get a volume discount; however, this is not necessarily the case. For the OEM, the less risky option of full replacement for every fault can also be a costly one for operators. Another example is the trade-off between a new control system that might have new and better functionality but also the added cost of training engineers and managing multiple systems. Indeed, bringing procurement and engineering closer together is critical in a total cost of ownership (TCO) approach.

BUYING OPTIMIZATION
One of the most effective value levers has been the introduction of new service providers into local markets. One operator we interviewed cited an approximate 30 percent reduction in the cost of certain O&M services. European service markets are all at different levels of maturity, and bringing in O&M service providers from Germany and Spain into the United Kingdom, for example, helped improve the supply market availability of O&M service providers, drove down costs, and improved the quality of service. This trend has also resulted in an expectation that OEMs can maintain turbines other than their own, leading to a workforce that has become more flexible.

BUNDLING/UNBUNDLING
Operators have taken different approaches to the unbundling of OEM support to O&M. In some cases, an operator team plans and manages the jobs and all execution is managed by the OEM or independent service provider (ISP). In other cases, work is split by different job types, and OEMs or ISPs are called in for specific jobs. Finally, another approach consists of carving out materials (major components, minor components, consumables) of OEM contracts.

PERFORMANCE MANAGEMENT
Beyond availability targets, the performance management of service providers is a critical lever. In addition to confirming response times to call outs and tracking productivity, service providers should be measured on how well they close-out jobs and record learnings and data, as continuous improvement and benchmarking are key in a high-turbine-count environment.

As operators continue to take back control from OEMs, they should also consider other value levers. For example, an application of the end-to-end supply chain value lever would be a factor in the sourcing strategy. Demand management involves working with engineers and the commercial team to segment services and materials to understand minimum acceptable specifications or service levels. Finally, operators should consider selective non-core outsourcing agreements, e.g., working with a logistics provider on fleet management or with an electrical supplies vendor to implement a catalogue for consumables.

APPLYING O&M CATEGORY VALUE LEVERS BY ARCHETYPE:

Across operators, the biggest difference in how the O&M category value levers should be applied is whether the operator is executing the activity or being a strong contract manager to those executing the activity. However, improving contracting and procurement and the use of the O&M category value levers is applicable to all archetypes.
Our interviews with operators and industry experts revealed that spare parts can account for up to half of turbine maintenance costs. Traditionally, the spare-parts supply chain has been outsourced to the OEMs, often in bundled deals that could not split the costs of spare parts from those for services. In onshore wind, OEM performance was measured on availability, spare-parts costs were often passed on to the operator, and most failures generally resulted in the installation of new parts rather than parts refurbishment.

Now, operators are taking greater in-house control of spare parts, often starting with major components but also extending to minor components and consumables. They are also developing local supply alternatives for selected parts such as minor electrical components.

There are thousands of components in a turbine. The intelligence regarding part failure, specifics and quantity of what to stock, what to refurbish and replace—all meant to reduce turbine downtime and TCO—is critical to balancing the desire to minimize the cost of parts with availability targets and maintenance costs. There are valuable leading practices from other industries such as aerospace that can be applied to spare-parts management for onshore wind.

Theme 4: There is significant opportunity to optimize the spare-parts supply chain

There are thousands of components in a turbine. The intelligence regarding part failure, specifics and quantity of what to stock, what to refurbish and replace—all meant to reduce turbine downtime and TCO—is critical to balancing the desire to minimize the cost of parts with availability targets and maintenance costs. There are valuable leading practices from other industries such as aerospace that can be applied to spare-parts management for onshore wind.

THE NATURE AND SIZE OF THE SPARE-PARTS SUPPLY CHAIN OPPORTUNITY DIFFERS BY OPERATOR ARCHETYPE:

The large, global portfolio player has the scale to invest in the data and analytics infrastructure to improve demand forecasting and inventory planning, as well as optimization tools to run a world-class supply chain. The workforce can specialize by part and/or vendor sourcing, planning and expediting across multiple sites and developing benchmarks for the spare parts.

The large, single-country wind operator could pool investment in demand forecasting and inventory planning and optimization tools with other country site operations. Visibility of parts availability across countries can also help with locating difficult-to-source parts for older turbines. Much can be done via collaboration across country operations or with local competitors. Another important improvement lever is the integration between the field technicians and the spare parts supply chain.

The medium-size IPP is unlikely to be able to control or manage its spare parts supply chain. Therefore, the focus should be on obtaining visibility on spare part costs versus the service costs. This will enable IPPs to be better informed when negotiating contracts with OEMs.
Spare-parts management in the aerospace industry is both complex and demanding. The spare-parts supply chain in aerospace supports two main processes: (1) spare parts to minimize aircraft on ground time (AOG) for planes waiting at airports for parts and (2) parts for the manufacture of new engines. As the same parts are used in both processes, optimization of spare parts needs to balance and consider performance indicators of minimizing AOG and hitting the manufacturing timeline. To keep airplanes in the air requires spare parts to be available nearly on-demand—a challenging feat which the industry struggles with. With respect to the manufacturing of engines, airplanes are consistently three or more years late in being delivered and a concentrated supply market means aerospace operators are often fighting for the attention of suppliers.

For one Accenture client, these challenges resulted in limited visibility of optimum inventory requirements with a frustratingly low spare-parts order fill rate. In the manufacturing process, more than half of risks were highlighted within just three weeks of promised delivery (too late to adjust the manufacturing schedule) resulting in activity delays and high costs.

The client turned to Accenture for help. Awarded end-to-end management of the clients’ materials and spare-parts value chain, Accenture implemented a series of analytics solutions to drive improved outcomes:

- Inventory segmentation according to cost, volume and volatility
- Demand planning and service level agreements based on the characteristics of each inventory segment
- Scenario planning to define requisite inventory and service levels
- Inventory and supplier management to deal with unplanned events and drive down unpredictability

The end-to-end view of the clients’ materials and spare-parts value chain paired with analytics capability enabled Accenture to arm the client with value-adding insights to optimize inventory levels, improve service levels and reduce costs.

Key outcomes achieved include:

- Improvement in the first order fill rate of almost 60 percent
- Approximately 80 percent improvement in supplier on-time delivery
- Reduction of supply risks within three weeks of materials/spare parts promised delivery by over 30 percent
- Optimized inventory mix (took out one-third of inventory but also added items that should have been stocked)
- AOG due to waiting for spare parts reduced by almost 40 percent

CASE STUDY: Optimizing the aerospace spare-parts supply chain using analytics
The future of onshore wind operations and maintenance

Theme 5: Despite extensive investment to date, workforce optimization remains a big opportunity

The workforce is the largest O&M cost component and significant effort has been put into improving the effectiveness and efficiency of both the operators’ own staff and that of third parties. Tablets and mobile applications have been widely deployed and workers’ locations are readily tracked and available, fulfilling health, safety and environmental (HSE) imperatives. However, in our interviews with operators, they noted—without exception—that improving workforce productivity is still seen as an area with significant room for improvement, scoring 9/10 in potential. The extent of this opportunity is evident when assessing workforce efficiency, often measured in megawatt per FTE (MW/FTE). Operators we spoke to indicated a large variation in MW/FTE, of 10 to 15 MW/FTE.

Workforce models depend on the mix of own staff and third parties and the reliance on expertise and knowledge management in the control center versus in the field. Some operators interviewed had a high degree of centralized control, providing remote support to the field engineers from the control room, i.e., central allocation of engineers to jobs, supported by the provision of technical documentation, history and access to experts. Others had a lighthouse model where the field engineer “owns” a set of turbines.

A consideration for workforce strategy is the management of third parties. Even in-house models still use third parties for specific jobs or during peak demand. Leveraging third-party services is not only about getting the best deal, but also confirming that the third party delivers the contracted performance. In many industries, waste arises from duplication of effort, handovers, inefficient interfaces and miscommunication and through a lack of collaboration between operators and their service providers.

In an Accenture study on high performing unconventional operators, the highest value area identified by top-quartile performers was the management of services, and the ability to achieve consistency in getting the same contractors because of the learning curve.8

Contract and contractor management has always been a challenge, as an organization’s commercial and operational groups must come together to enhance the value from the deal and reduce contractor non-productive time (NPT).

The commercial arm needs to negotiate and write contracts that reward productivity and have operational objectives that can be understood and managed by operations. Operations needs to understand and manage the contract bottom line, including considerations around engineering staffing levels and agreed service levels. The contract and contractor KPIs need to balance commercial and operational considerations.

Digital technologies and enablers provide new opportunities for contract and contractor management. With the visibility and tracking available in current workforce tools, including contractor dashboards that can alert when the contract or contractor is outside of commercial or operational parameters, different contracts can be written to take advantage of data, and continuous improvement is easier to see and incentivize. With the collaboration tools available, duplication, interfaces and miscommunication could be minimized or avoided.
CASE STUDY: Leveraging digital technologies to enable the connected worker

THE CONNECTED INDUSTRIAL WORKER
Various digital technologies and applications increase quality, safety and productivity of the field staff, achieve increased process efficiency and significantly reduce costs for failure.

CONTEXT AND SOLUTION
Airbus, a leading aerospace company, needed to improve the accuracy and reduce the time it took operators to complete the seat-making process for its A330 airplanes. Using the latest wearable technology, Accenture delivered a proof of concept that uses smart glasses to show workers where to place seats.

OUTCOMES
The solution reduced the complexity of seat placement, and it ultimately expected to enable lesser skilled people to step up to jobs without having to read a training manual, instead relying on the data from the smart glasses in real time.

THERE ARE SLIGHT DIFFERENCES IN THE OPPORTUNITIES FOR WORKFORCE OPTIMIZATION FOR THE THREE OPERATOR ARCHETYPES:

- **The large, global portfolio player** with a large workforce mix of its own staff and third-party staff and supports the workforce from control center can use digital technologies to verify all information, data and history is available to every technician and job. This infrastructure is critical to large operations as the learnings, performance data, and insights from each job can be captured for future use and benchmarking. The contract/contractor management aspect is also particularly important to driving improved productivity.

- **The large, single-country wind operator** with a largely in-house model should focus on empowering the in-house workforce to enhance productivity through remote access to equipment specifications/job history, real-time information on spare parts availability, and through the deployment of low-tech workforce solutions.

- **The medium-size IPP** is reliant on a third-party workforce. This archetype needs to track the productivity of the contractor workforce. When selecting a third-party service provider, the investment in workforce applications to track, report and improve productivity should be a consideration for selection.
CONCLUSIONS

The largest opportunity to improve O&M performance is in the deployment of digital technologies and enablers. The integration of the various data sets from turbine SCADA systems, external market and weather forecasts, work management and the supply chain is key to drive value realization from most of the themes covered in this report.

Leveraging O&M to improve the bottom line requires integration of operational and market data. Predictive maintenance relies on algorithms applied to diverse data sets. A good spare-parts supply chain relies on data analytics regarding parts stock, and visibility of the parts availability, including tracking supplier performance. Mobile field-force effectiveness tools are critical to enhancing productivity and minimizing paperwork and “windshield” time.

Onshore wind operators vary widely in their use of digital technologies and enablers. With fleets of turbines often procured from a variety of different OEMs, some leading operators have invested in a common control center that can integrate various SCADA systems, allowing operators to optimize, prioritize and benchmark operations across the fleet. For more advanced operators, the control room is integrated with energy management where real-time market data on energy prices, offers and demand and turbine production now-casting can be dialed up or down to optimize bidding strategy and profit. Using big data and advanced analytics applied to turbine performances, weather conditions and work history, maintenance can move from reacting to alerts to predictive maintenance approaches. The control room can also be linked to operators’ work management, materials and logistics systems, enabling the safe, connected worker, and allowing optimized scheduling and maximizing turbine availability.

The other key opportunity area is in contracting and procurement and supply chain. In any high count/instance industry like aerospace, automotive and unconventional oil and gas, supply chain is a key value lever. The extent to which procurement and supply chain is optimized varies dramatically by operator. In our interviews, some operators have focused on sourcing and procurement, while others on the spare-parts supply chain. No single operator would say that they have mastered both contracting and procurement and the spare-parts supply chain. Contractor productivity and workforce effectiveness remains a challenge and an opportunity.

Figure 11 details the value levers highlighted in this report and defines what basic, advanced and visionary capabilities look like against each lever. Often already advanced, the large global portfolio player could take integration to unlock additional value through increased use of collaboration tools, analytics and through enhanced integration across all systems. The large, single-country wind operator should pool resources to enable an infrastructure investment. The medium-size IPP has a bigger challenge, and should look for co-investment opportunities, such as building a shared platform.
In summary, size, scale and data access matters when it comes to digital investment needed to leverage the data produced by all the sensors. All view big data and analytics as a big opportunity (even the most advanced players with a global control room, one system, and a portfolio view) but the extent to which this has been leveraged varies tremendously. Larger players can take it to the next level.

Smaller ones need to find a way to obtaining visibility into their entire wind portfolios. This will be the key to shifting O&M from merely being a cost center to becoming a true value driver, providing real competitive advantage.

---

**FIGURE 11. MATURITY MODELS FOR ONSHORE WIND VALUE LEVERS.**

<table>
<thead>
<tr>
<th>DIGITAL HUB COMPONENT</th>
<th>BASIC</th>
<th>ADVANCED</th>
<th>VISIONARY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRODUCT OPTIMIZATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote operations monitoring/control room</td>
<td>Competing OEM SCADA systems, alerts not fully integrated with workforce and supply chain</td>
<td>Fully integrated control room, spare parts and logistics</td>
<td>Big data analytics and 3D interactive visualization of entire portfolio</td>
</tr>
<tr>
<td>Production optimization</td>
<td>Power curve and benchmarking of turbine behavior and performance</td>
<td>Analytics models to correct power curves and automated alert system</td>
<td>Edge analytics and use of drones/visual analytics for inspections</td>
</tr>
<tr>
<td>Predictive maintenance</td>
<td>Less than 20 percent predictive versus alert-based interventions. Focus on response time</td>
<td>More than 20 percent predictive; partial integration with maintenance planning</td>
<td>Approximately 80 percent interventions; time-to-failure integrated with maintenance planning</td>
</tr>
<tr>
<td><strong>RESOURCES OPTIMIZATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance optimization/supply chain management</td>
<td>Maintenance uses control room data to drive planning; bundled materials and services OEM contracts</td>
<td>Integrated work planning with control room data; some contracts unbundled</td>
<td>End-to-end visibility of activities and costs; unbundled spare parts; blockchain for contract management</td>
</tr>
<tr>
<td>Workforce management</td>
<td>Workforce beginning to deploy mobile solutions; partial integration with control room alerts</td>
<td>High contractor productivity; materials and people movements aligned to minimize NPT</td>
<td>Liquid workforce fully integrated with certification and management systems</td>
</tr>
<tr>
<td><strong>ENERGY MANAGEMENT &amp; O&amp;M OPTIMIZATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production forecasting/energy management</td>
<td>One way sharing of data from control room to energy management</td>
<td>Optimization engine uses O&amp;M and energy management data to maximize production and minimize unbalancing costs</td>
<td>Interactive collaborative work environment for O&amp;M and energy management teams</td>
</tr>
<tr>
<td>Remote intelligence</td>
<td>Availability and production data partially linked to forecasting and energy management</td>
<td>Analytics and visualization to illustrate financial impact and risk of trade-off O&amp;M decisions</td>
<td>Control room linked to real-time market data on energy prices, offers and demand to optimize profit</td>
</tr>
</tbody>
</table>

Source: Accenture analysis.
REFERENCES

3. Ibid.
5. How we balance the country’s electricity transmission system, National Grid, Balancing the network, http://www2.nationalgrid.com.

AUTHORS

MELISSA STARK
Global Renewables Lead

CAROLINE NARICH
Renewables Strategy

CONTRIBUTORS

CRISTIAN CORBETTI
Europe Renewables Lead

CARLOS SANZ ALONSO
Spain Renewables

RUTH WOODARD
Utilities Strategy

ABOUT ACCENTURE

Accenture is a leading global professional services company, providing a broad range of services and solutions in strategy, consulting, digital, technology and operations. Combining unmatched experience and specialized skills across more than 40 industries and all business functions—underpinned by the world’s largest delivery network—Accenture works at the intersection of business and technology to help clients improve their performance and create sustainable value for their stakeholders. With approximately 401,000 people serving clients in more than 120 countries, Accenture drives innovation to improve the way the world works and lives. Visit us at www.accenture.com.

DISCLAIMER

This document is produced by consultants at Accenture as general guidance. It is not intended to provide specific advice on your circumstances. If you require advice or further details on any matters referred to, please contact your Accenture representative.

This document makes descriptive reference to trademarks that may be owned by others. The use of such trademarks herein is not an assertion of ownership of such trademarks by Accenture and is not intended to represent or imply the existence of an association between Accenture and the lawful owners of such trademarks.

Copyright © 2017 Accenture
All rights reserved.

Accenture, its logo, and High Performance Delivered are trademarks of Accenture.