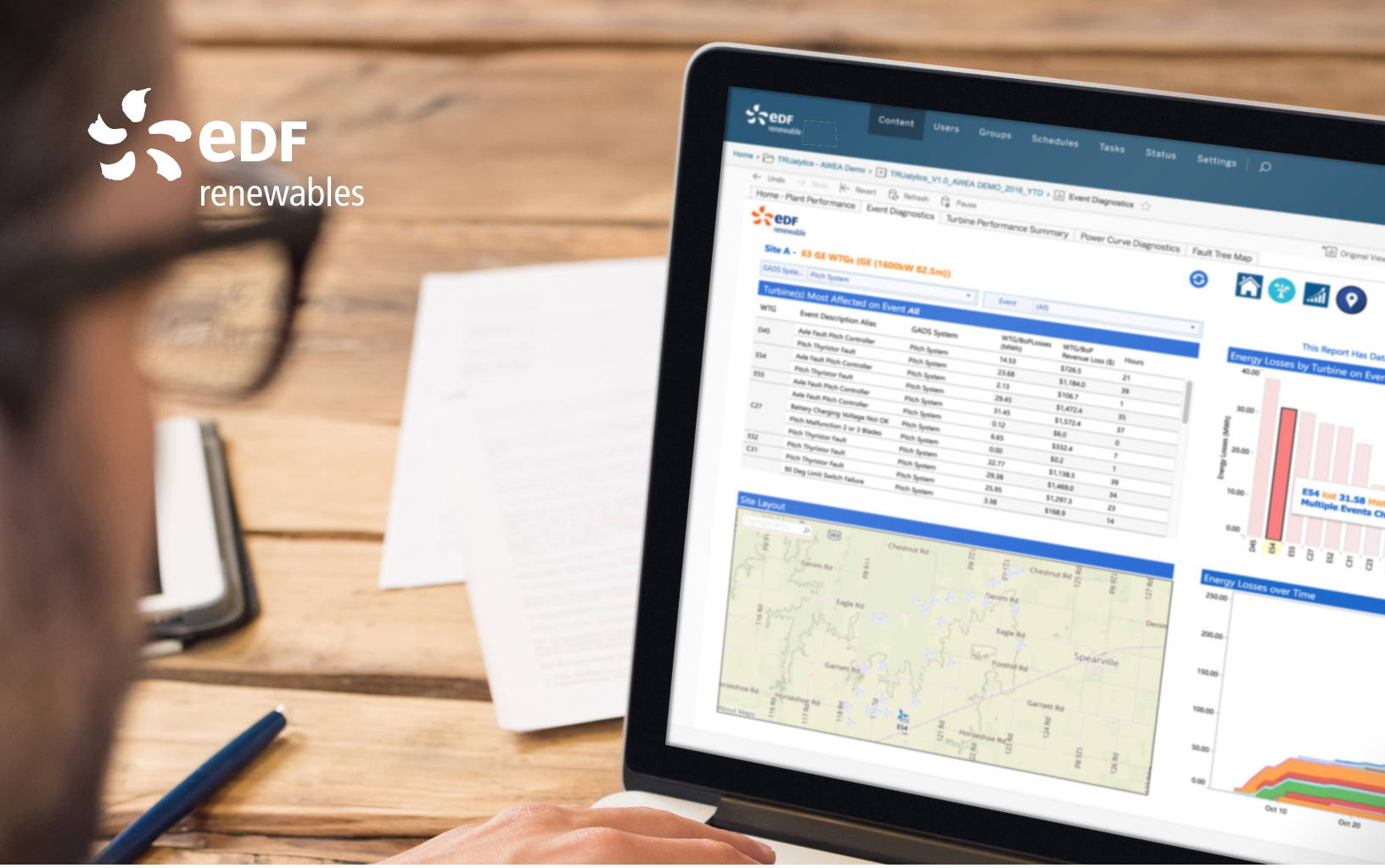



# BOOSTING PROJECT PROFITABILITY

## with Centralized Inventory

# THE POWER OF CENTRALIZED INVENTORY

Renewable energy projects are attractive to investors of all stripes due to their ability to provide predictable and stable cash flows. Intelligent asset management is vital to maximizing a project's return on investment, and optimized operations and maintenance (O&M) is perhaps the most critical element of asset management.

All renewable energy assets must be periodically taken offline for preventative maintenance. However, optimized O&M can help ensure that necessary downtime is minimized and scheduled appropriately. It also increases the efficiency of maintenance, thereby reducing O&M costs. Today, as much as 40 percent of a project's costs can be incurred from O&M – so reducing O&M costs even slightly can translate into a meaningful increase in profitability.

The trifecta of optimized O&M includes:

1. AI-driven predictive maintenance;
2. minimized costs for spare parts inventory; and
3. rapid, cost-effective parts replacement.

Achieving all three can have a noticeable impact on a project's bottom line.

### Optimized O&M Achieves Two Things

1. It maximizes production by minimizing downtime.
2. It minimizes O&M costs by maximizing efficiency.

# Centralized Inventory: The Critical Link in the Supply Chain

The traditional approach to spare parts inventory management at wind and solar facilities has been for each project to own and maintain siloed inventories on site, placing periodic orders for consumable parts and replenishing other items as needed.

This approach has many drawbacks. Aside from the fact that it's economically inefficient and ties up capital, it also results in redundant inventory. This approach fails to incorporate underlying demand characteristics like seasonality, consumption patterns, or lead time variability among suppliers. As a result, substantial and costly safety stock must be kept in inventory to avoid frequent stockouts of critical parts.

Maximizing profitability means minimizing costs and using a centralized inventory of spare parts can reduce O&M costs by 2 to 5 percent, depending on the technology. As fulfillment specialists like Amazon and Costco have demonstrated, economies of scale are the key driver of cost efficiencies. It is much more cost-effective to maintain an optimized inventory of critical parts and have the ability to deploy those parts with agility for 5,000 megawatts (MW) of assets than it is to do so for 500 MW.

In addition, the use of a centralized inventory system greatly strengthens quality control and quality assurance capabilities. Parts can be carefully examined, tested, and if they fail to pass inspection, can be returned, thereby avoiding future costs and delays that would otherwise have been caused by faulty parts.

## / Safety Stock /

A level of extra stock that is maintained to mitigate the risk of stockouts caused by uncertainties in supply and demand. Items with variable demand and/or long lead times may require high safety stock levels to ensure availability.

# Robust Supply Chain Logistics = Reduced Downtime and Increased Performance

A centralized inventory program enables asset managers of large fleets to leverage their purchasing power and access preferential pricing for both replacement parts and shipping costs, thereby providing the most cost-effective way to address ongoing part replacement needs.

Centralized inventory programs also allow for improved inventory control, planning and shipping accuracy, thus avoiding the need to have costly, redundant inventories of parts. In addition, analysis performed by EDFR has found that a centralized approach can enhance availability and make it possible to reduce stockout-related downtime by up to 50 percent.

A centralized approach to inventory and distribution gives asset managers the ability to:

- Leverage economies of scale (pricing, access, shipping costs)
- Optimize inventory levels
- Maximize parts availability across the fleet
- Minimize downtime
- Reduce transactional workload related to decentralized replenishment
- Shift focus to value-added tasks – reverse logistics, parts identification, quality and supplier performance management

## / Parts Identification /

### What's in Your Turbine?

Wind turbines contain thousands of parts. Although some larger and more expensive components can only be sourced from the original equipment manufacturer (OEM), many smaller, simpler parts can be replaced quickly and at a lower cost with non-OEM substitutes. However, selecting a suitable substitute requires correctly identifying each original part. This may not be cost-effective for smaller owner/operators, leaving them with the OEM as their only source.

# Finding the Right Balance: Spare Parts Logistics

Determining the appropriate level of inventory to carry is one of the most important and challenging tasks related to optimizing O&M. Carrying too much inventory ties up capital, but insufficient inventory levels can result in stockouts and economic losses due to downtime.

The difficulty stems from the unpredictable demand pattern inherent to spare parts logistics. The complex world of spare parts logistics has evolved from the more straightforward production logistics used in the manufacturing industry, and differs in several important ways, as shown in Table 1.

## / Service Level /

The percentage of time a system is able to meet demand. A 98 percent service level for spare parts inventory means that 98 percent of the time a part is needed, it will be on hand. When combined with uncertainties in demand and lead times, high service levels necessitate larger safety stocks and thus overall inventory.

**Table 1. Production Logistics vs. Spare Parts Logistics**

| Parameter | Production Logistics | Spare Parts Logistics |
|---|---|---|
| **Objective** | Maximize turnover – achieve a service level close to 100% | Effective allocation of inventory (based on the desired service level) |
| **Strategy** | Just in time | Just in case |
| **Key performance indicator** | Stock availability | Uptime of the system being supported |
| **Stock turn** | 6 to 50 times per year | 1 to 4 times per year |
| **Demand pattern** | Predictable | Unpredictable |
| **Response** | Plannable | ASAP |
| **Total parts on hand** | Minimal – the goal is just in time delivery | Thousands |
| **Range of items on hand** | Uniform | Many different types of parts |
| **What is returned?** | Tooling, cores, customized shipping containers | Rotables (repairable items), defects and scrap |

# Spare Parts Inventory Management Strategies for Different Types of Maintenance

Different types of parts require different approaches to maintenance. These approaches can be categorized as follows, and the appropriate spare parts management strategy applied accordingly:

- **Preventative**: Maintenance that involves replacing consumable parts or materials; occurs on a predictable, regular schedule.
- **Corrective**: Maintenance that is necessary to correct an unexpected deterioration or failure; occurs on an as-needed basis.
- **Planned Corrective**: Maintenance that is necessary to address identified issues or risks and avoids future issues; once identified, work is scheduled at the project level and executed in a way that minimizes downtime and maximizes efficiency.

**Table 2. Maintenance Approaches & Spare Parts Management Strategies**

| Maintenance Approach | Spare Parts Management Strategy |
|---|---|
| **Preventive** | • Maintenance is performed on a set schedule<br>• Work is standardized as much as possible to maximize efficiency<br>• Parts ordering is driven by economics: items that are costly or needed infrequently are delivered to order, whereas it may make sense to purchase less expensive items in bulk |
| **Corrective** | • Lead times, usage history and engineering information are used to predict future needs and determine inventory levels<br>• Service levels are differentiated based on criticality and cost<br>• Deliver from stock |
| **Planned Corrective** | • Parts are delivered to order for a specific planned corrective scope<br>• A distinction is made between parts ordered for scheduled, project-wide maintenance work and parts that are available for unplanned maintenance – this ensures large-scale maintenance activities can proceed as planned |

# Fine-Tuning Demand Forecasts

Forecasting demand variability is a science unto itself, and relies on multiple inputs:

- **Demand history** (accurately reported in real time)
- **Demand forecasting based on engineering information** (including advanced analytics, condition-based monitoring, and predictive maintenance)
- **Demand forecasting based on planned maintenance and planned correctives** (deferred correctives and retrofits/upgrades)

Once the demand forecast for a part is understood, the appropriate inventory replenishment model can be applied.

## / Forecasting /

Forecasting demand variability is a science unto itself, and relies on multiple inputs.

# Inventory Replenishment: Categorization is Key

Different types of parts can be categorized based on their cost and the frequency with which they are needed. Applying different inventory replenishment models to each category makes it possible to optimize the amount of inventory that is carried so that high service levels can be achieved at the lowest cost, as illustrated in Table 3.

**Table 3. Inventory Replenishment Categories and Their Characteristics**

| UNIT PRICE | DEMAND FREQUENCY: High | DEMAND FREQUENCY: Low |
|---|---|---|
| High | **LEAN**<br>• Predictable demand means reduced variation in lead times<br>• Stocks of these items are maintained at medium to high levels<br>**Examples: solar panels and tracker motors, control boards, pitch and yaw motors and gears, generator bearings** | **JUST IN CASE**<br>• Accurate demand forecasting is critical<br>• Seek opportunities to leverage scale<br>• Risk management protocols should be used<br>• Stocks of these items are maintained at low levels except for critical parts<br>**Examples: IGBT modules, structural components, blade and yaw bearings, blades** |
| Low | **WHOLESALE (High Demand)**<br>• Fully automated process unless circumstances warrant intervention<br>• Stocks of these items are maintained at very high levels<br>**Examples: fuses, relays, circuit breakers** | **WHOLESALE (Low Demand)**<br>• The ability to use standard or easy to find items can reduce risk; seek to accelerate the phase out of obsolete or hard to find items<br>• Stocks of these items are maintained at high levels<br>**Examples: cabling, low pressure valves, buttons and connectors** |

## "Just in Case" Inventory: A Sunk Cost That Can Sink a Project's Profitability

Proactively maintaining generation equipment is important for both wind and solar facilities, although given that a single wind turbine is comprised of roughly 10,000 individual parts, wind projects typically present a greater challenge in terms of demand for spare parts.

Parts like control boards, circuit breakers or relays can be thought of as "consumables" and typically need to be replaced frequently. Other parts are designed to last the life of the turbine – these rarely fail but can require weeks or months to replace if they do.

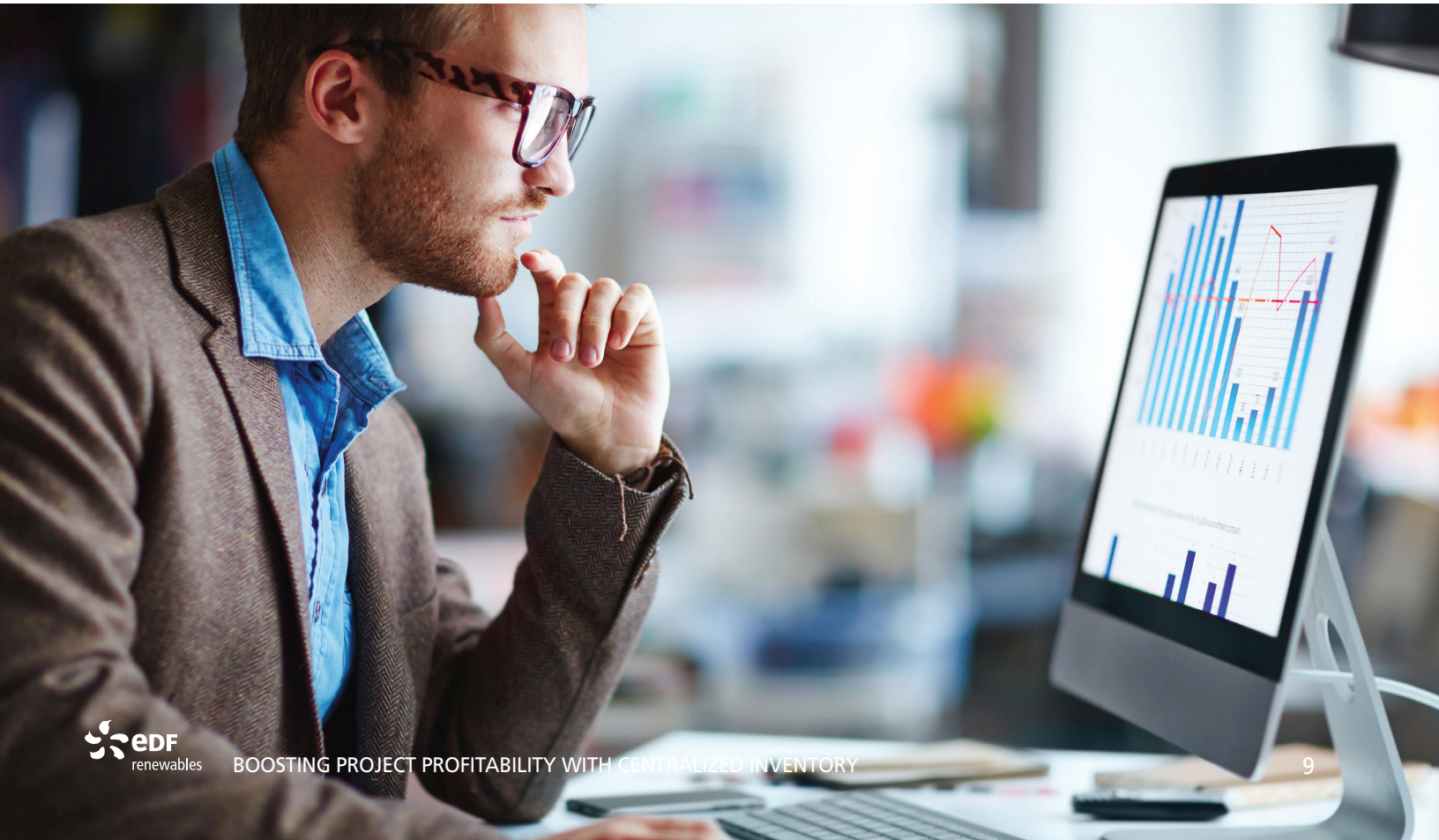
Downtime results in direct economic losses and can potentially result in penalties if a facility is unable to meet its contractual requirements. As such, project owners and asset managers are keenly attuned to the need to optimize O&M and be able to rapidly replace parts.

During the initial years of a wind project's operations, the OEM typically provides parts and services under the turbine's warranty. However, once the warranty period has ended, owners must determine the most profitable way to manage their asset – and maintaining an expensive inventory of spare parts for each project, some of which may become obsolete and/or never be needed – is a sure way to hamstring a project's finances.

# Dialing in the Savings with Dashboards

EDF Renewables uses specialized supply chain dashboards to track performance and quantify the cost savings achieved through the utilization of a centralized inventory program. Key Performance Indicators (KPIs) we share with our O&M clients may include:

- Production based availability losses attributed to parts ($)
- Lead times (days)
- Savings vs. previous year moving average ($)
- Warranty recovery (%, $)
- Transportation spend ($)
- Expedited transportation spend ($/MW)
- On time in full (OTIF) delivery (%)
- Fill rate / Service level (%)
- Inventory accuracy (%)



# Designed to Succeed

Maximizing the return on investment for a renewable energy project depends on intelligent asset management, which in turn relies on optimized O&M to maximize production and minimize costs. Using a centralized spare parts inventory program is critical to optimizing O&M, because it improves efficiency and leverages economies of scale. Importantly, centralizing spare parts inventory for an entire fleet in a single location removes lead time uncertainty, making it possible to focus on demand variability.

A successful centralized spare parts inventory program is carefully designed around several elements:

- Strategy & Policy
- Organization & Control
- Processes
- Operating Standards & Systems
- Performance Management

Each of these elements will help ensure that spare parts procurement and management of inventory levels are standardized, making it possible to streamline and optimize O&M and boost profitability.

Dirk Ruitenberg is leading the Supply Chain function of EDF Renewables' Asset Optimization business unit in North America. In this position he is responsible for developing and implementing the overall supply chain management strategy including procurement, fulfillment, logistics, warehousing and quality control of goods and services.

Prior to joining EDFR in 2019, Dirk held various global supply chain roles for Acciona Energy since 2007. In his last role he led Acciona Energy North America's Supply Chain department in support of development and construction of new utility-scale wind, solar and battery storage projects, as well as ongoing maintenance activities for >1,000 MW of operating renewable energy facilities across the US and Canada.

Dirk holds a Bachelor of Engineering in European Logistics Management from Niederrhein University of Applied Sciences in Germany and Fontys University of Applied Sciences in the Netherlands, as well as an MSc in International Logistics from University of Plymouth Business School in the United Kingdom.

Nicolas Rossel is Senior Business Development Manager - Asset Optimization for EDF Renewables North America. He has worked for EDFR since 2016 and has negotiated over 900 MW of O&M and Asset Management agreements. Prior to arriving in EDFR NA's San Diego headquarters, Nicolas worked for EDFR Mexico and EDFR Chile where, in addition to Asset Optimization business development, he led both country units' ERP, Supply Chain and CMMS implementations.

Before EDF, Nicolas headed Sunspot Services, a business consulting firm dedicated to supporting international renewable energy companies in Chile.

Nicolas holds a BA from the University of British Columbia in Canada and an MBA from the Universidad Adolfo Ibáñez in Chile.

## ABOUT EDF RENEWABLES

EDF Renewables North America is a market leading independent power producer and service provider with over 35 years of expertise in renewable energy. The Company delivers **grid-scale power**: wind (onshore and offshore), solar photovoltaic, and storage projects; **distributed solutions**: solar, solar+storage, EV charging and energy management; and **asset optimization**: technical, operational, and commercial skills to maximize performance of generating projects. EDF Renewables' North American portfolio consists of 16 GW of developed projects and 11 GW under service contracts. EDF Renewables North America is a subsidiary of EDF Renewables, the dedicated renewable energy affiliate of the EDF Group.

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