One of a kind Service for all kinds of turbines

Multibrand Services Whitepaper

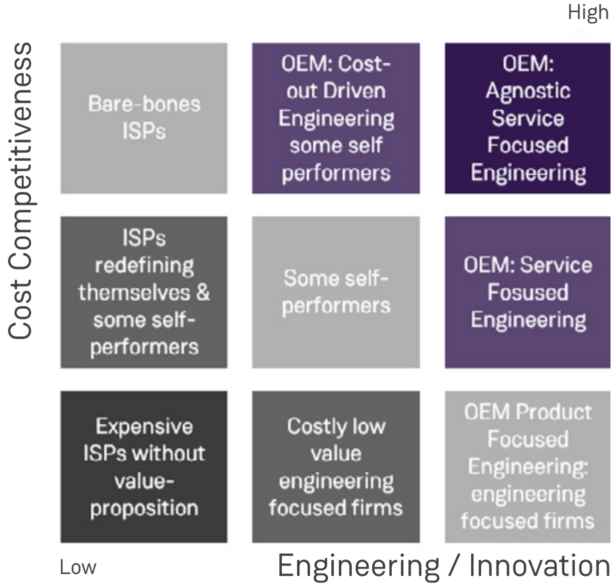
SIEMENS Gamesa
RENEWABLE ENERGY

Index

Structural notes

In the multibrand service market, the combination of cost efficiency and strong, innovative engineering is rare. But one provider delivers both: Siemens Gamesa.

What is our differentiator in the multibrand business? Look at the upper right corner:

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Introduction

The wind service market is experiencing a far-reaching shake-up, driven by the maturity level of the wind industry as a whole. Ultimately this must be celebrated, as it signals a normalization of the industry's technologies and solutions within the larger energy sector context. This shake-up, however, poses complexities that industry players and more specifically wind turbine service providers must address in order to remain both competitive and profitable.

Chief among these complexities is the relentless downward movement of price. Double-digit price declines have been observed in certain markets in just the last two years. Government-funded support schemes are in some cases declining or disappearing altogether, and energy owners and operators bid highly competitive rates to sustain or build their renewables portfolios. The effect is the downward pressure on both CAPEX and OPEX as owners seek paths to reduce cost and increase returns. Perhaps nowhere is the industry maturity impact proving as dramatic as for the market suppliers contributing to customer OPEX lines – turbine OEMs, component suppliers, and Independent Service Providers (ISPs). The pressure is on for suppliers to meet and exceed the needs of wind turbine owners, now more than ever.

But what are those needs? Further complicating the shake-up of the wind service market are rapidly evolving customer demands. Variations in business models, scope needs, and fleet compositions ensure that what customers require from the contributors to their OPEX always varies from customer to customer, from project to project, and from year to year.

First, business models are structured differently, depending on the agreements formulated between owners and the grid operators and off-takers. Some with a restricted interconnection agreement are exclusively focused on "cost out", since "power up" is not an option. Others with more flexibility seek out opportunities for additional power output. Further, some owners within low price/MWh markets require unique financing support mechanisms for these power upgrade solutions to meet payback period requirements.

Second, scope requirements depend on the composition of the customers' operational structures. Some large developers and investors are composed of a group of fewer than ten individuals sharing a small office, with little capability or interest in managing wind farm operations and maintenance. Others are large and established, with their own highly competent remote operations centers, repair facilities, and service teams.

Finally, demand is also driven by an increased diversity of fleet composition. As owners grow their fleet sizes, many expand their fleets beyond a single turbine manufacturer, either due to economics, performance, or through the integration of fleets from M&A activities. Indeed, very few owners today with more than ten wind farms have only one turbine make or brand.provider stakeholders and shareholders are also facts. The question then is not merely how a service provider can survive in this market complexity, but how it can thrive.


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Service providers must contend with these complexities head-on. The market price pressure and large variety in customer expectations, economics, and composition are facts. At the same time, high expectations among service provider stakeholders and shareholders are also facts. The question then is not merely how a service provider can survive in this market complexity, but how it can thrive.

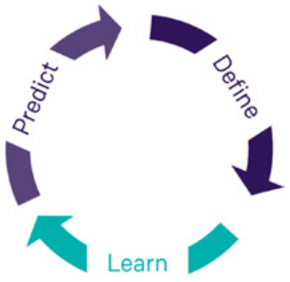
To truly thrive in this market environment, wind service providers must do what wind turbine manufacturers have done over the last 30 years to drive the industry from nothing to where it is today – they must unleash their innovative engineering talents. Only through engineering-driven leadership will service providers continue to drive down cost and increase value through new upgrades, all for a large and growing mix of customer requirements. While significant innovation will come from outside the wind power industry and indeed outside the energy sector, the industry's experience and know-how must lead the way. Siemens Gamesa's 400+ service engineers, over 40 of whom are dedicated to service-market solutions, are developing these innovations, as well as ensuring that they are not solely for Siemens Gamesa turbine owners.

Example 1

Introduction
The service market is not only challenging service providers, but owners as well. From inefficient repair loops, to unexpected and unbudgeted failures well outside of the warranty period, to older equipment with limited attention or supply chain, or even to turbine manufacturers shifting focus and leaving markets, the areas where owners require innovative engineering approaches are numerous. Service providers will thrive if and when they are able to address these owner challenges with the creativity and ingenuity characteristic of strong engineering-led companies. Let's review a few concrete examples.

As the markets evolve, different suppliers of both turbines and turbine services will make decisions about increasing or decreasing their market presence. Exiting a market to consolidate focus may be a good for the party doing the leaving, but by leaving the market the company may be leaving customers behind. One such example happened recently in Brazil. An OEM decided to leave the market, and several owners who had purchased turbines from them and had them serviced by the OEM were now on their own. With the OEM gone, who could service these turbines? Who could gain access to the turbine software? Who could ensure proper documentation and execution for troubleshooting? And who could ensure a constant supply of spare parts? Multiple customers had to grapple with these questions, and we leveraged our engineering organization in order to solve them.

1.
Our goal is that our services will always be provided in a matter that is safe, financially sound, and highly valued among customer stakeholders, SGRE took the following steps to ensure that we were well attuned to how these turbines would behave. 1. Define what we expect, 2. Learn from what we see, and 3. Predict what will come. Importantly, applying our predictions to refining our expectations makes this not only a cyclical process, but also a never-ending one.



We were able to define what we would expect by leveraging the fact that we have technicians and experience with the oOEM SCADA and diagnostics within both the operational and leadership aspects of our business. With a dedicated set of engineers developing the necessary documentation based on experience in SGRE turbines, we could reduce the expected processes and operational requirements of the OEM turbines. Our procurement organizations, functioning as one global organization, were able to capitalize on their fundamental knowledge on parts consumption and availability, coupled with leveraging Siemens Gamesa relationships with parts suppliers, to define expectations before ever approaching the wind farms.

By working with both the OEM and the owners, we were able to take the next step and combine our expectations with what we could learn. We were able to gather large troves of valuable information about site performance, parts consumption history, major events, warranty issues, and turbine site conditions and inventories. Access to the turbine SCADA systems was crucial in order to take control of and plan for day-to-day troubleshooting and remote diagnostics. Finally, and crucially, turbine inspections on a large percentage of the population helped us correct some of our assumptions, understand the fleet's maintenance history beyond what was written down, and ensure that our team was fully ready to take over when the project kicked off (more on training, further down).

Coming up with what we could predict was based on the historical performance of the turbines, our initial assumptions, and our understanding of component failure expectations looking at similar-conditioned sites in similar climactic conditions across the globe, across a multitude of technologies. Our engineers told us and showed us which and where turbine characteristics mimicked or were close to mimicking the performance of these oOEM turbines, and where there were deviations in the norm of the population of relevant turbines. Ultimately, we were able to compile a model in which we could tell with relative certainty what sort of failures we should be on the lookout for, and what factors are likely to contribute to those failures. In doing so, we were able to devise a proactive maintenance plan tailor-made to fit these turbines, but based on a collection of historic site information and statistically relevant fleet-wide data.

2.

There was, among all parties, an understanding that there were conditions that predated the entry of SGRE into the equation, and that those conditions needed to be addressed without putting SGRE as the new services provider in harm's way. However, this sort of approach had to be framed so that the owners were not exposed to undue financial risk themselves. Charging a customer extra to clean up an oil smear on day one of a capital-intensive relationship is hardly starting things off on a good foot. We needed to create an execution line in the sand, and do it before Day 1. Over 30% of the turbines were inspected for serious issues that might jeopardize the performance of the assets or the safety of crews. These issues were noted and then taken back to both the owner and to the OEM to come up with what we call a "Recovery Plan" that established joint responsibility by outlining what needed to get done, by who, by when, and what SGRE would take on in order to get things up and running again.

The inspection resulted in a number of findings that led to repairs or exchanges in over 70 WTGs. Components inspected and discovered to have issues that needed resolving in the form of repair or replacement included:

- IMS Shaft
- Generator
- HSS & IMS
- Gearbox
- Blade Bearing
- Blade Repair

Specific work instructions were developed for every repair noted on the recovery plan, including technical description, H&S measures, list of components and tools required for the operation, as well as the necessary qualifications of the technicians to be involved in the operation. The recovery plan also included the commissioning of the turbine and checking working parameters again to ensure that the turbines were back to a nominal working level.

The works were planned for 24 months with a clear schedule leading to “back into service”, as well as availability increase targets for every turbine included in the recovery plan. The plan is now being implemented and it is on schedule. Both parties, via this plan, have clear expectations on what needs to be resolved, the cost effectiveness of the resolution, as well as the outcome and guarantees available as a direct result of the execution of the plan.

3.

Now that we had a good understanding how the turbines were likely to behave and knew what sorts of things would need to get resolved on Day 1, we wanted to make sure we had the ability to determine whether our new expectations were in line with reality, and, most importantly, whether we could proactively improve on our assumptions. Enter remote diagnostics. SGRE has a long history of vibration diagnostics, as it comes standard in 100% of our current fleet, dating back over 10 years. Combine with that our SCADA diagnostics, which capitalizes on our historical data to not only flag that there is a problem, but also what is causing that problem and the likeliest solution, and the question becomes if these techniques would also be applicable to non-SGRE turbines. Long story short – yes. The ability to do this arises from a combination of legacy-SGRE engineering competence, coupled with the latest algothithm-based SCADA analytics from NEM Solutions, and a long-term standing relationship with Gram & Juhl, the leading condition monitoring system (CMS) supplier in the wind industry. We’re currently developing the following remote capabilities to support the oOEM turbine fleet:

- 24/7 remote monitoring of the turbines
- Remote control to increase availability
- Collection and analysis of historical data from turbine controllers
- Condition monitoring system testing, validation, and eventual full implementation

The development for these capabilities is ongoing, and we’re partnering with an experienced team who is familiar with the control system platform for the OEM turbines. We have just received confirmation that we are able to read variables from the turbine control system, and this was the first and very important milestone. We now have remote monitoring capabilities integrated into our remote operation centers and will soon be remotely managing OEM turbines just as though they were our own manufactured WTGs.

In parallel to the development of remote monitoring capabilities, we have two strategies to capture historical data from the turbine controllers. In the first option, data is sourced from a web-service provided by the turbine OEM, and in the second, we partner with a supplier familiar with the data interfaces to capture data directly from the site. Having this historical data will allow us to apply advanced analytics for detecting outliers in the operational

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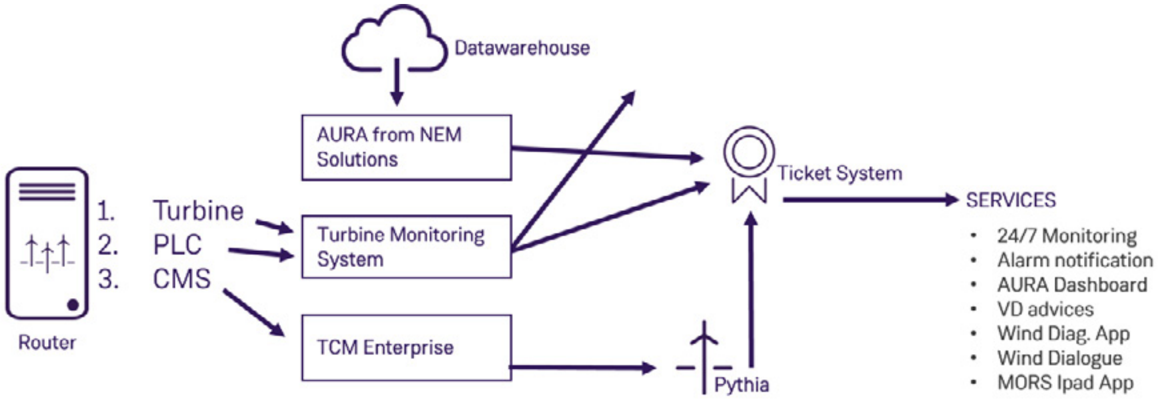
With condition monitoring installed, the focus shifts to building vibration diagnostics models for the turbines and to planning for additional installations once we have conceptual validations. In addition to this, we intend to introduce advanced analytics by enabling the SGRE Pythia engine, which uses machine learning and advanced data analytics to train new models for detections. Pythia is also used on Siemens wind turbines.

By applying condition monitoring systems, we target detection of failures on the drive train and the main components of the turbine with a very high level of certainty and long lead times, enabling us to reduce the downtime in case any failures are detected. Knowledge of early indicators of failures allows better planning, logistics, and the sourcing of parts and planning for replacements.

Communication flow

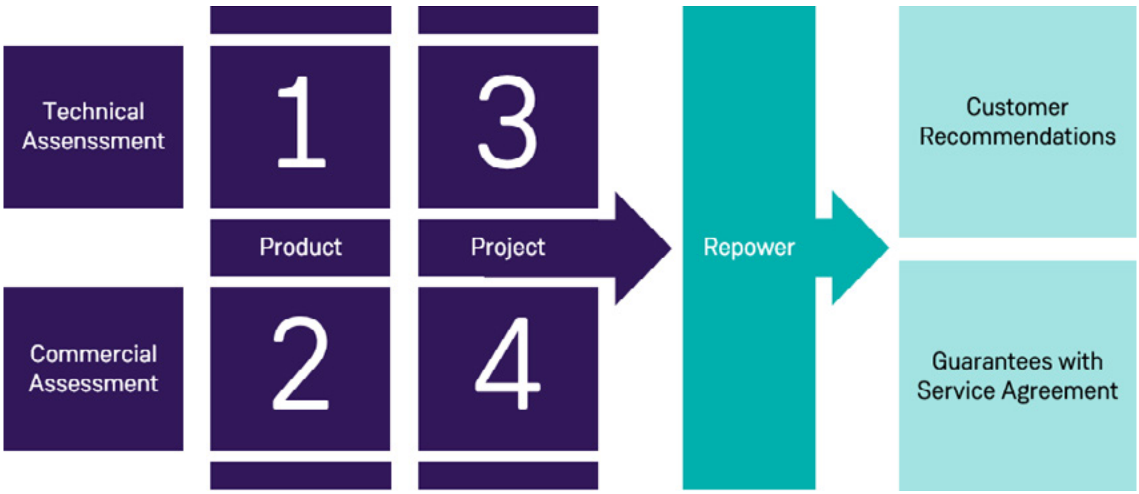


Conclusion

In short, why did a Latin American power company feel confident in SGRE as a supplier of services for their oOEM fleet? We had a process by which we could simultaneously ensure profitable customer outcomes as well as sound cost management. Following the process, regardless of the circumstance, technology, climate, turbine age, or other complicating factors was, is, and will always be the most valuable aspect of what owners should expect service providers to bring to the market.

- Expect, Learn, Predict
- Develop an execution line in the sand
- Improve on our assumptions

Example 2



Introduction

As turbines age, multiple owners have taken decisions to both extend the life of their assets while also upgrading the total potential output of those assets (where the grid permits). The question is, what solutions are available in order to both upgrade and extend life, while keeping capital expenditure for these otherwise potentially lower revenue-generating assets to a minimum? Siemens Gamesa has successfully implemented an overhaul, power output upgrade, and service lifetime extension solution not only for its Siemens and Gamesa turbines, but also for Vestas assets. The successes of these solutions are reflected in multiple certifications, awards, and contracts.

1.

Regardless of turbine make, model, or experience, wind assets require thorough front-end due diligence from four angles in all repower cases. First, the repower solution needs to first fit the structural constraints of the turbine design, in what we call a Technical Product Assessment. Second, an initial commercial viability needs to be assessed. As an example, if the only way of repowering a particular technology is to replace the entire tower due to constraints identified in the technical product assessment, this may quickly remove this solution as a viable candidate, given the market movements of power purchase agreements and phase of production tax credits in some markets. We call this the Commercial Product Assessment. Third, introducing the project-specific conditions into the equation is critical to determine if the models hold, and account for any unique aspects. These unique aspects may include unusually high turbulence, high humidity, unusual foundations, etc.

This is called the Technical Project Assessment, and will identify the site-specific “world of the possible”. Finally, the Commercial Project Assessment takes into the account each of the preceding three steps to determine the “world of the viable” from an ROIC perspective. Significantly, this step is done in conjunction with the owners: ultimately, an owner decision and strategy is implemented to realize the potential that these analytical stages spell out, but these steps arm owners or their service with the requisite knowledge to execute on a profitable strategy.

2.

Let’s look at a concrete example of “lightly repowering” non-SGRE turbines, and how it was possible. The origins of this optimization go back to the year 2000, when the old Gamesa received a technology transfer from Vestas, a partner at the time. The transfer involved the V47 turbine, which had been classified by the Gamesa engineers as having room for improvement in terms of its electrical and electronic configuration. In the early 2000s it was thought that generation and control through the VRCC system wasted part of the energy produced, so engineers went to work on adapting a double feed and converter solution to the turbine, so that the energy output would keep system loads under control.

This configuration was certified according to contemporary requirements. A few months later, Gamesa was manufacturing and offering to customers the G47 machine, structurally identical to the V47, but with an important upgrade in its electrical and electronic configuration. This was the origin of the upgrade that SGRE was able to offer to customers with V47 fleets years later, now as a field-based Service modification.

	Current V47 / V42 & 44	Overhaul V47
Nominal Power	660kw / 600kw	710kw
Grid Code dip compliance	✗	✓
Active Power regulation	✗	✓
Reactive Power ability	✗	✓
RCC technology (90´s)		DFM technology Cost maintenance reduction

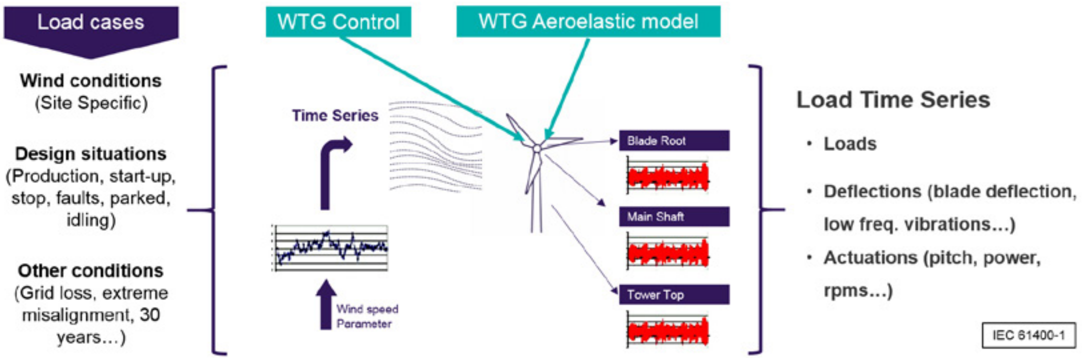
3.

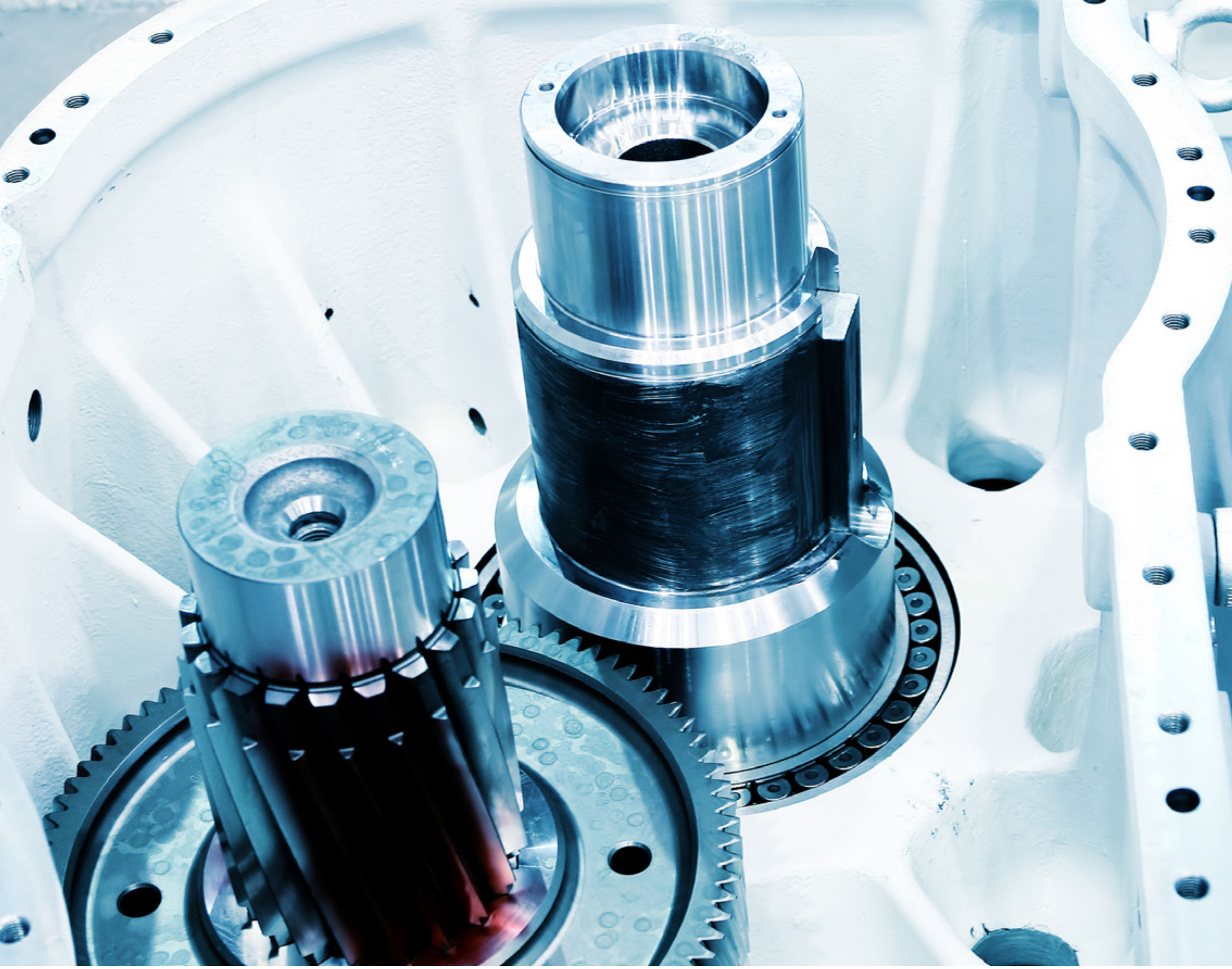
Further modeling is required to generate recommendations for customers or service plans that take advantage of the repower initiative. Just as with the implementation of a sound strategy for the Suzlon fleet in Brazil, the success or failure of creating a lifetime assessment and extension program comes down not to turbine experience or the volume of turbines under service, but on adaptable and consistently proven engineering processes. Our methodology for creating a service plan for repowered assets is proven and clear.

Input conditions that have changed

- Assess Current site
- Determine Loads
- Define the Plan

The assessment of the current site conditions was completed as part of the Technical Project Assessment, as described above. To determine the initial loads in Step Two, certain design parameters must be known, but these can either be provided by customers who have these documents on hand, by third parties, by collaborative OEMs, or by a reverse engineering organization focused on these sorts of tasks.





After the loads assessment is completed, we develop a plan for the customer that outlines what they should be on the lookout for to ensure the longevity of their turbines. Alternatively, SGRE creates a site-specific service structure whereby we provide annual services to guarantee certain outcomes that are based on the results of our analysis, including things like lifetime guarantee, power production guarantees, or even ROIC guarantees. In any case, the approach is built around site repower and site-specific aspects and their impact on specific components. Recommendations or service plans are built around component-specific findings in the models, not just turbine-wide considerations

Conclusion

Repower is complicated, to say the least. But it's not magic. Diligent product design, evaluation of site specifics, and consistent process control with advanced modeling all combine to define the opportunity landscape for owners' turbines – no matter the make. .

Example 3

What about smaller challenges?

Not taking over whole fleets on a subcontinent, not shifting design elements and lifetimes, but ones more specific to daily issues? Let's look at one of the industry's core challenges: major component integrity and reliability. In July 2017 we received a request for a quotation to repair a group of Vestas gearboxes. The client from Northern Europe was looking for a supplier to repair its park of V80 gearboxes located off the coast of the Netherlands – yes, offshore. The agreement had some very strict requirements: removing major components offshore can easily become an expensive endeavor, and that's just for the lifting crane, or jackup vessel, to show up at site. Providing major components in time was key for the customer, as was our ability to repair these models of gearboxes with better performance than the original manufacturer, at a cost already set by the customer in their RFQ.

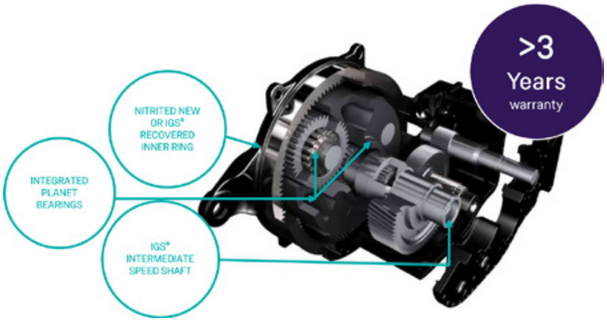
How could we affordably do this better than the OEM, especially considering all the risks associated with expensive major component exchanges? To better understand this model, SGRE used a gearbox for reengineering, and we performed up-tower inspections.

Luckily, Siemens Gamesa created a Gearbox Repair Center in 2010 dedicated not only to repairs of gearboxes from our fleet, but also specializing in the repair of other OEM gearboxes. The repair center currently manages more than 400 repairs per year, with about 50 products around gearbox repairs and/or refurbishments. The capacity and experience of the repair center allow us to offer our customers differential solutions to reduce failure rates and improve LCoE.

Unfortunately for us, the SGRE repair center was located more than 2,000 kilometers away from the project site, while the OEM's repair shop was around the corner. An additional challenge: the specific gearbox mentioned in the customer's tender was not part of our product catalogue. Both of these hurdles had to be overcome and be reflected in our competitive proposal.

Our Premium Service:

LIFEX



Our in-house knowledge and experience, however, allowed us to assemble a competitive proposal, not only considering the requested repairs, but reducing the failure rates significantly on that gearbox type going hand-in-hand with a LCoE reduction.

Conclusion

SGRE won the five-year repair contract, with the first four gearboxes repaired in 2017 and the next four corrected in 2018.

Example 4

Introduction
Digital Remote Diagnosis has become an important strategic focus area for major operators and utilities as they look to maximize the full potential of their turbines' data and provide better support to their Operation & Maintenance (O&M) teams. Specifically, customers want to centralize all the real-time information for their assets in order to gain operational efficiencies, and embed analytics-based predictive capabilities into operational processes to better manage O&M costs.

Major customers today expect that their advanced analytics provider should be able to deal with a diverse range of operational data coming from a "multitech" portfolio and be able to detect relevant operational failures in their turbines.

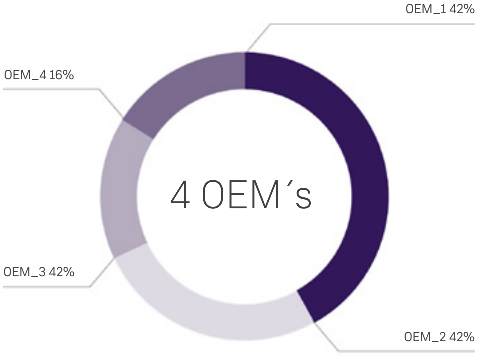
1.
One of (SGRE strategic partner) NEM Solutions' customers, a northern European utility with a +2 GW portfolio in wind energy assets, developed an internal solution for the centralization of their fleet asset management and operations information in order to avoid predictable main component failures.

To augment their solution, the customer was on the lookout for partners to help them achieve four specific objectives:

- Improve their predictive maintenance solution with early failure detections.
- Improve failure detection accuracy for the main turbine components.
- Integrate analytics services into their solution.
- Transform performance analysis issues into real savings.

2.
As part of their request, the customer wanted to evaluate the potential of NEM Solutions' advanced analytics capabilities for the main technologies and markets of a representative onshore fleet, in real time.

Wind technologies (MW)



Markets (MW)

Based on NEM Solutions' internal assessment of the relevant SCADA signals from the fleet, they designed an advanced analytics proposal to maximize detections and improve the customer's data quality. Specifically, the proposal provided solutions for six main wind turbine subsystems (including the generator and gearbox) and used three different analytic techniques based on unique methods of failure detection. In addition, NEM designed over 33 analytic solutions at asset level.

	3 Techniques	Analytics on asset level
Generator		
Gearbox	Normality Model	15
Rotor	Operational Ruels	4
Transformer	Data Acquisition	14
Nacelle		

3.

Following the project definition, the advanced analytics design, and the customer's online integration, results measured after a period of six weeks showed that the main project goals had been met. Flagged detections at the selected failure modes saw a 56% increase, and the number of detectable failures rose by 12%.

In order to ensure the best advanced analytics results, NEM Solutions performed a data quality audit, allowing the customer to improve data acquisition and increase the wind turbine performance issues from the SCADA.

Conclusion

You can survive without a sophisticated engineering backbone, but you'll underwhelm customers and eventually your own shareholders, losing confidence from owners along the way. To truly thrive in the market, you have to double down on your engineering talents. That talent elevated this industry to where it is today, and it will carry the industry forward into its next phase of challenges and opportunities. Do you, or does your partner, have what it takes?

TURN TO ONE-OF-A-KIND SERVICE, FOR ALL KINDS OF TURBINES.

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