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A Practical Guide to Digitalization for the Power Industry

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Introduction:
The Challenge of Digitalization

The energy industry is currently undergoing digital transformation which brings with it vast opportunities and additional challenges forcing the industry to change. There is an underlying uncertainty about the future and this has many CEOs expressing a somewhat pessimistic outlook about what lies ahead[1].

However, great change can mean even greater opportunity. This is the time to embrace the change and reshape your business to create a more sustainable and efficient footprint while enhancing customer experience. In order to remain viable long enough to see what the future holds, critical business challenges must be addressed.

These include:

1. Incorporating Renewables and Distributed Generation
2. Regulatory and Policy Uncertainty
3. Low Energy Prices Bringing Greater Cost Pressure
4. Overwhelming Capital Demands
5. Cybersecurity Risk
6. The Search for Talent
7. Market Disruption

While these challenges aren't new, technology has evolved enough to allow us to address them with the use of data-driven approaches that will propel the energy industry into the future.

This white paper offers an overview of the pain-points in the energy sector. It also provides a few practical suggestions to start harnessing the power of this digital transformation. The digital transformation is unique to each organization based on their individual requirements and business objectives. In every case, the digital transformation, termed as "digitalization" at Siemens, offers the means to navigate the difficult waters that lie ahead. It achieves this by making it possible to not only survive ongoing market upheavals, but to strengthen the business by operating more efficiently and reliably while maintaining profitability. Digitalization, then, is a critical enabler of positive change – allowing operators to chart a path through ongoing challenges and emerge better and stronger.

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1. Incorporating Renewables and Distributed Generation

There has been a shift in the power generation mix with a rise of renewable energy sources and distributed generation. New renewable installations are expected to more than double to 191 GW from 2010 to 2020 and projected to reach 300 GW by 2030[2]. Through the combination of regulatory mandate and more attractive renewable economics, power generators are being compelled to rapidly transform their energy portfolios. Additionally, coal-fired and nuclear plants are being shuttered decades earlier than anticipated. Meanwhile, gas-fired plants are struggling to remain viable as they are dispatched behind wind and solar plants.

The fossil facilities that continue to operate in today's environment find that traditional roles have been turned transformed, and the old days of operating for years as a base-load or peaking facility are gone. Instead, power plants in some areas are evolving into renewable load following units: when the wind stops or the sun fades, they are called upon to bring large amounts of energy onto the grid in short order. The unintended consequence can be unplanned downtime.

Additionally, the spike of starts and stops of the turbines is wreaking havoc on maintenance best practices.

Renewable availability also remains problematic. Wind in France, for example, has 60% availability at best, but that can sink as low as 1%[3]. Solar, too, is known for its wild fluctuations. Places like California may lose up to 15,000 MW of renewable power within a couple of hours – right at the time when consumption peaks as commuters return home from work.

Of course, the challenge isn't limited to renewable generation. Great strides have been made in energy storage, resulting in utilizing renewable energy during peak demands again further delaying the need for fossil fired generation. The annual U.S. energy storage market is projected to reach 1.7 gigawatts (GW) by 2020—with a value of $2.5 billion. According to IHS, the energy storage market is set to "explode" to an annual installation size of 6 gigawatts (GW) in 2017 and over 40 GW by 2022 — from an initial base of only 0.34 GW installed in 2012 and 2013.[13]

Additionally, the rise of distributed generation (DG), wider adoption of Combined Heat and Power (CHP), and the growth of micro-grids are posing additional challenges in grid predictability. Renewable energy provided an estimated 19.2% of global final energy consumption in 2014, and growth in capacity and generation continued in 2015. An estimated 147 GW of renewable power capacity was added in 2015, the largest annual increase ever. Renewable heat capacity increased by around 38 GWth, and total biofuels production also rose. This growth occurred despite tumbling global prices for all fossil fuels, ongoing fossil fuel subsidies and the many challenges facing renewables. These challenges include how to integrate the rising share of renewable generation, policy and political instability, regulatory barriers and fiscal constraints.[14]

No one can predict market conditions a year or two from now with any level of conviction. A good example is the nuclear disaster in Japan a few years ago.

Recommendations:

As these challenges continue to increase in scale, some simple changes can be made to prepare for the future. Sensors and networking infrastructure are becoming more readily available and cheaper, enabling asset connectivity. For example, an interconnected control center can be built to manage the entire fleet to monitor asset operations, and deploy resources optimally.

Informed decision making depends on a robust and reliable data management and analytical foundation. Conclusions drawn from the analysis of key data sources must be integrated with deep domain knowledge. Data analytical capabilities such as predictive analytics, machine learning, AI, etc. provide actionable insights to increase system transparency and make informed decisions. Scenario planning, for example, offers visibility into the impact of renewables to ensure that required dispatch is available whenever the need arises.

Data management and analysis play a key role in the optimization of processes in operations, planning and maintenance on a unit- and site-specific basis. A data-driven approach analyzes patterns and trends in operations, planning and maintenance, enabling tailored recommendations to the customer focused on maximizing their profitability By digitally connecting key assets across the value chain of the power industry, data is collected securely and analyzed using the appropriate context and algorithms to optimize operations, planning and maintenance.

2. Regulatory and Policy Uncertainty

29 of 50 states in the U.S. have adopted mandatory Renewable Portfolio Standards (RPS)[4]. This is just one part of the ever-growing landscape of federal and local regulations that operators must now contend with - from rates, to competition regulations, environmental impact, fuel efficiency, infrastructure security, and more. Managing compliance involves greater operational complexity, and introduces uncertainty into any assessment of risk.

There are also supra-national forces at play. For example, Utilities and Independent Power Producers (IPPs) have to anticipate how climate change policy may evolve, whether carbon offsets and taxes will gain traction, and how their decisions will be viewed in the court of public opinion. All it takes to derail years of planning is one simple change in the direction of the political winds.

No one can predict market conditions a year or two from now with any level of conviction. A good example is the nuclear disaster in Japan a few years ago. This event had repercussions around the world. Japan took its entire nuclear fleet offline. Germany mandated a phased closure of its nuclear facilities. And a large number of nuclear projects globally suddenly fell off the table. However, this is just one instance of how an unexpected event catapults an issue into public consciousness. There are many other forces at play that can bring years of careful planning to a crashing halt. These can destroy the value of stranded assets overnight, and put capital investments at grave risk.

Clearly, a need to hedge against uncertainties around fuel prices, political and environmental regulations, emissions control, climate change, and other potential disruptors. However too much hedging could cripple profitability. Every organization must find the right balance between boosting profitability when the market is ripe and curtailing losses when the unexpected descends suddenly.

To stay ahead of curve, it is a good idea to engage in scenario planning based on real-time digital data-feeds. This enables a thorough view of best, worst and other cases to aid in decision making, and to test strategies. It is also important to pay close attention to varying environmental and political regulations in different regions and incorporate these factors into strategies.

3. Low Energy Prices Bringing Greater Cost Pressure

Energy prices have fallen in many markets. As supply has grown. it has created an imbalance with demand, fuel price volatility and long-term price declines. In the U.S., for example, natural gas prices are a fraction of what they were 10 years ago and most projections expect the trend of low gas price to continue for several years to come.

Conversely, the cost of non-fuel operations and maintenance has grown every year since 2011.[4B] This brought tremendous pressure on controlling costs and maintaining profitability, at a time when operators are being challenged to invest strategically to remain viable.

Strategic direction remains cloudy for many as disparate conditions prevail around the world. Electricity demand in the U.S. has remained flat for several years. That trend is expected to continue. Asia and the developing world show soaring demand. Coal is virtually outlawed in many countries yet worldwide consumption continues to grow.

Just look at forecasts from the early years of the millennium: we were set to have a nuclear renaissance, and coal would continue to be king.

The U.S. was gearing up to become a massive importer of LNG. Yet today, the U.S. leads the world in natural gas production and is poised to become a leader in LNG exports. It is likely that today's expert predictions will look just as silly a decade from now. The only guarantee is ever-more stringent pressure on cost control.

There are, however, sensible cost-saving actions that can be instituted today regardless of the eventual market destination. Maintenance can account for as much as 40% of operating costs[11]. Added to direct maintenance expenses are the costs associated with unplanned downtime and funds tied up in carrying replacement parts. By leveraging the power of the digital transformation, you can identify areas to reduce unplanned downtime and heighten predictive maintenance accuracy through transparency and advanced analytics. By knowing and understanding the exact condition of your operating assets, it is possible to reduce the need for inventory by ordering a part and conducting maintenance only when necessary.

The total O&M cost is generally divided into three components:

- Non-fuel and non-capital costs or briefly O&M costs
- Fuel costs
- Capital costs or capital additions (costs that have to be depreciated or are eligible for depreciation)

While maintenance accounts for approximately 40% of the operating costs, fuel accounts between the range of 47% to 64% depending[15] on the type of fuel and condition of the plant. By far the largest cost associated with a plant. Operations optimization and performance improvement results in 2-5% output improvement, 3% fuel efficiency and about $2M reduction per day in outage reduction. Fuel management is based on the principles of operations optimization and performance improvement, and there are certain areas such as operations benchmarking, power-plant optimization, outage planning and regulatory compliance, which play a key role.

Monitoring and benchmarking of operations is done using KPIs and key metrics to define the health of operations. Power-plant optimization introduces flexibility in operations in terms of length of run and load, and dispatch optimization. The approach of predicting impending events directly impacts the outage decision analysis, outage event management, and system commissioning, and decommissioning. This is a paradigm shift from reactive and preventive maintenance strategy to a more proactive and predictive maintenance. All these approaches around operations play an important role in optimum asset utilization to achieve high performance and reduced fuel consumption.

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4. Overwhelming Capital Demands

Over the next 25 years, capital expenditures for power generation are expected to total more than $11 trillion[5], which is the equivalent of China's annual GDP[6]. Where does such a staggering figure come from? In Western markets, aging power generation infrastructure in some areas has exceeded its planned operational life - not by years but by decades. Long overdue capital improvements come at a time when power demand in many markets has entered a period of long-term slow growth. This adds up to a severe mismatch between capex and cash flow.

The opposite situation is apparent in emerging markets where high demand growth is creating a scramble for capital to fund supply. China is erecting coal, nuclear, wind and solar power plants in great numbers as it copes with rampant demand. Many areas of the developing world are following suit as their booming populations demand reliable power – and they are not prepared to wait.

Regardless of geography, all markets are struggling with capital requirements. India, for example, has a relatively poor distribution network. Yet the volume of renewables is high and it is saddled with an aging fleet of fossil assets.

Every region is attempting to create a portfolio of energy sources that can help smooth the impact of price volatility across fuel types. But the scale of capital needs is making it increasingly difficult for operators to secure the needed funding.

The inhibition of cash flow and a reticence toward taking more debt on the balance sheet has led many to rethink their approach to capital allocation. The trend is to expense projects, thus by transforming them from CAPEX to OPEX; many power producers are adjusting their business model for greater operational flexibility. Financial arrangements are also more readily available to translate CAPEX into a recurring monthly payment.

We recommend turning to digital technologies to find the right balance between CAPEX and OPEX. It is critical to study risk profiles and run scenarios before setting strategic direction. Wherever possible, it is encouraged to move large CAPEX investments into more manageable monthly OPEX payments. This requires looking at new business models and finding the right partners to co-develop the right solutions aligned to your business objectives.

5. Cyber Security Risk

Once upon a time, power plants existed as islands – connected to the grid, but otherwise impervious to the perils of Internet connectivity. But in the past few decades, more and more assets have become automated and connected to vendor systems. They have the ability to tap into plants to monitor the health of turbomachinery assets and manage fleets remotely. Within the plant, control systems are no longer concerned with one system or one piece of equipment. Their reach is continually being expanded with the eventual goal being the development of one system to manage an entire plant or fleet.

This requires upgrading controls and retrofitting assets with smart sensors to inter-connect assets and provide data to operators. These connected systems, in turn, will form a part of the Industrial Internet of Things (IIoT) – where analytical systems seek to detect potential causes of downtime long before the moment of failure, and direct effective remedial action. These same analytical systems also unearth zones of potential competitive advantage. But the exponential growth in data, this has opened many "windows" and "back doors" into plant systems.

A few have attempted to turn back the clock as a solution to a seemingly endless parade of cyber security incidents; however there is no going back. Power generation facilities are now reliant on the two-way exchange of data with other networks. This makes them susceptible to hackers and

cyber-criminals. Already, malware has shut down an Iranian nuclear facility and brought about major blackouts in the Ukraine in 2016. The Distributed Denial of Service (DDoS) malware behind these attacks, which was once only in the hands of a few military powers, is now available on the Dark Web to anyone[7]. Ransomware can shut all plant personnel out of critical systems if one gullible user clicks on the infected link or attachment.

Not all cyberattacks are so sophisticated and can stem from something as simple as an employee using an infected USB device in a computer. Therefore, it is necessary to ensure proper policies are in place internally to prevent simple mistakes from causing a major issue.

All of this raises cyber security beyond the level of corporate risk. It has now become a matter of national security bringing with it yet another wave of regulation, inspection, technology, complexity and cost. These factors can cloud perception when it comes to digitalization. Fear of an attack can cause some companies to delay execution of important digital initiatives. However, failure to keep up with the pace of digitalization could rapidly lead to competitive disadvantage and loss of market share. The correct strategy toward cyber security is to raise its profile in the organization and appoint a C-level executive to deal with it and safeguard the organization from attack while rolling out digitalization efforts.

Fortunately there are ways to safeguard your operations. It is important to evaluate your current situation to identify areas of concern for all systems relating to Operational Technology (OT) and Information Technology (IT). Once the entire landscape is understood, deal with high priority issues first, and develop a roadmap that reflects your priorities and overall strategy. From there, test, monitor and maintain your defenses for a long-term and systematic approach that involves continuous updates as cyber threats evolve.

6. The Search for Talent

Even the "softer" elements like talent management are creating difficulties for the field of power generation. The never-ending search for talent has moved beyond Human Resources (HR) to become a board-level problem. Utilities and IPPs are struggling to keep up with the demand for skilled resources. Heavy attrition is being experienced everywhere in the form of retirements, headhunting and cost-cutting layoffs.

According to some estimates, 50% of utilities face more than 50% of their professionals retiring over the next few years[16]. That's a lot of hard-won know-how walking out the door never to return. New personnel coming into the industry may be tech savvy and bring new skills however they are missing the reality of plant operations and lack experience.

Now take into account the fact that the industry must compete for skilled workers with newer industries perceived by younger people as more "hip" or having greater career potential. Power generators must assess their image in the modern world and find a way to attract workers. Recruits must be provided with the skills they need to be ready for a future filled with change.

The good news for the "changing of the guard" is that new people entering the workforce are attuned to digital tools. They are ready to embrace digitalization, but that willingness to adopt new approaches must be balanced with knowledge capture. Valuable know-how is disappearing fast.

For the 50% of professionals that are not retiring, it is important to acquire the skills necessary to be fully prepared for the digital transformation. At the same time, domain knowledge must be captured from veteran plant and turbomachinery specialists, and compiled into a digital format for future access. In some instances, it makes sense to automate processes that are redundant in nature or consolidate operations to a central location requiring fewer experts to operate the fleet.

When assessing the skills necessary to enter the digital age, start to recruit from a different talent pool such as cyber security and IT experts or data scientist who will be able to help make sense of the data that is being collected.

7. Market Disruption

The six factors above are more than enough for any executive to contend with over the course of an entire career. But top management is being assailed by all of them simultaneously. These huge forces of market disruption are steering the industry towards an inevitable conclusion: the wholesale replacement of the existing business model with a fundamentally new and better model[8].

The specifics of what this model will be are still evolving. We can look to other verticals to illuminate how diverse new models can be – and how difficult they can be to predict. Amazon and eBay, for example, have revolutionized the retail sector. Similarly, Uber and Airbnb turned entire industries on their heads.

Many power executives are worried that a revolution is soon to befall their industry. 82% believe that they must rapidly evolve or reinvent themselves under the threat of such disruption[9].

Whether it originates within power generation, or flows upstream from the new expectations that consumers have for all aspects of their lives, there is concern that fundamental disruption is coming – and soon. This change could originate from an innovative incumbent, from proven disruptors like Tesla or Google, or from technologies and start-ups that are not even on the radar. Apprehensiveness about what's next can have a chilling effect on strategic planning and tactical execution. In some cases, it may engender a wait-and-see attitude that if carried on too long, such a stance will bring about stagnation and decline.

The truth is, the digital transformation is upon us and this means that in order to remain relevant we need to change as well. However, it might not be as dramatic as it might appear. Power producers can harness digitalization to facilitate decision making accuracy by incorporating incremental changes that over time will add up to major changes. First start with data collection and analysis to enable more informed decision making that can help you hone your strategy and minimize risk. Import digital data feeds from all areas of the business to provide management with a deeper understanding of what is happening in real-time. This enables them to adjust accordingly to maximize revenue and minimize losses.

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Making Digitalization Real

When examining the pain points impacting power generation today, it becomes clear that these challenges don't fall neatly within a single organizational silo or C-suite role. They are cross-functional issues that demand an enterprise-wide collaboration to solve and ncreasingly demand active participation of the CEO and the board. Digitalization offers a roadmap for future success. To fulfill its potential, however, it must be grounded in real business pain points and not just noise for the sake of noise. Instead of speculating about the trillions in value that digitalization may be able to unlock at some undefined point in the future, you focus on immediate and tangible gains.

The fact is few power generation executives need convincing about the potential of digitalization. This is a journey that most operators have begun. Some are already reaping benefits from early-stage initiatives around installing sensors and controls, or the implementation of predictive data analytics. This is highlighted by a 2016 survey of industry executives: 39% said their companies had realized more than 16% in cost savings through digital automation in just the past two years[9B].

Where power generators may need assistance from partners is in determining what's next. Prioritization is required among the many competing business cases to plot out the next step in the digital journey.

McKinsey analysis of real digital use cases suggests that energy producers can conservatively improve their profitability by 20-30%[10]. Up to a third of this improvement can come from power generation alone, through optimized fuel management, plant maintenance, and spare-parts management. The size and composition of each operator's digitalization prize will of course depend upon where they are starting from and the nature of their operations.

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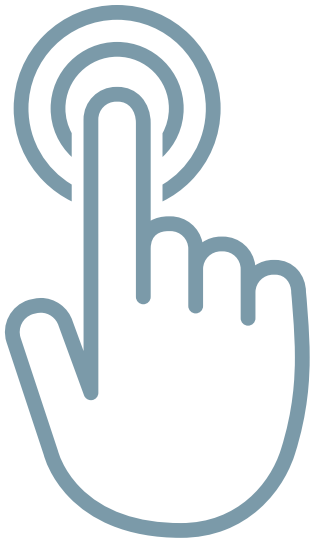

Conclusion

Digital-led maintenance protocols can extend the operating life of equipment. In turn, this will help to lower the pressure on capital expenditures can potentially reduce the need for highly skilled workers, while enriching the work experience of those that remain.

This paper has touched upon a few areas for power generation executives to consider as a way to harness digitalization to tackle ongoing challenges. By concentrating digital transformation efforts upon specific pain points, targeted implementation will enhance efficiency and profitability.

For more information on how Siemens has helped power producers incorporate digitalization for competitive advantage visit: www.siemens.com/digital-services-energy

Footnotes:

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