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INDUSTRY X.0 FOR RENEWABLES

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FOREWORD

What is Industry X.0?

Industry X.0 is the digital reinvention of industry, where businesses use advanced digital technologies to transform their core operations, worker and customer experiences and, ultimately, their business models.

These days, it's not enough to digitize one part of the business and expect positive results for the entire organization. We are entering an Industry X.0 era, which has evolved over a period of time, converging information and operational technology.

Companies that are profitable deliver game-changing experiences or products, adopt and integrate digital technologies and leverage the appropriate combinations of technologies. These Industry X.0 businesses drive exceptional efficiency gains and enable new business models to promote growth. They know how to digitally reinvent their operating models, production and value chains to deliver meaningful worker and customer experiences, at speed and scale.

But identifying the ideal combination of rapidly evolving digital technologies to create such value isn't easy. As we discovered in our survey of more than 900 multibillion-dollar enterprises, only 13% of executives believe they are getting both top-line and bottom-line growth from their digital investments.[1]

How the industry benefits

- **New revenue streams** from as-a-service and smart connected products
- **New product innovation and design**
- **Personalized customer experiences** and better **worker experiences and productivity** for both B2C and B2B
- **Faster time to market** from smarter processes and leading technologies
- Increased **R&D efficiency** by lean, agile methodologies
- Greater **agility and responsiveness** to demand
- Dramatically **reduced cost** with data-driven insights

What is Industry X.O in renewables?

Digital is at the core of the current struggle for sustainable, competitive advantage in the renewables sector. The renewables industry has a limited legacy heritage and is highly innovative in both hardware and software. This allows for digitalization across every aspect of the life cycle.

Harnessing the power of digital

Most business leaders we work with understand the power of digital and see the potential to use digital technologies to bring about transformation and growth. Sometimes the journey is clear; however, this is not always the case.

Globally, we are experiencing a series of digital revolutions across all industries—and renewable energy is experiencing a transformation of its own, driven by what we call the "five Ds":

1. **Dispatchable.** Renewables will become more dispatchable with digital, storage and hybrid plants, offering access to new grid services value pools.

2. **Digital.** Digital is at the center of the current struggle for sustainable competitive advantage in the renewables sector.

3. **Divided.** The digital divide driving the operational performance gap between the large renewable operators and smaller renewable players will grow wider.

4. **Diverse.** Diverse players, including deep-pocketed new entrants such as oil companies, traders, automotive companies and possibly even technology players, will compete.

5. **Demand.** Consumer demand for renewables, particularly the increase in renewable power purchase agreements (PPAs) by commercial and industrial (C&I) entities and the aggregation of demand is changing the way renewable demand is met.

By the end of 2018, global renewable generation capacity reached 2,351 GW worldwide.[2] Many renewable energy sources now have a competitive average levelized cost of electricity (LCOE) compared to fossil fuels, partly due to a push from governments and environmental agencies. However, increased industry maturity brings growing pressure for the industry to stand on its own. 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.

Wind, solar, hydro and batteries all lend themselves to digital. Wind farms are fleets of rotating equipment and solar farms fleets of static equipment, both generating huge amounts of data that can be used to drive competitiveness. The high proportion of costs during the operations phase of offshore wind, which makes up about 40% of LCOE,[3] makes the case for autonomous, automated or remote inspections and maintenance. Hydro plants are comparable to large conventional plants with similar opportunities for digital modernization and digital workforce.

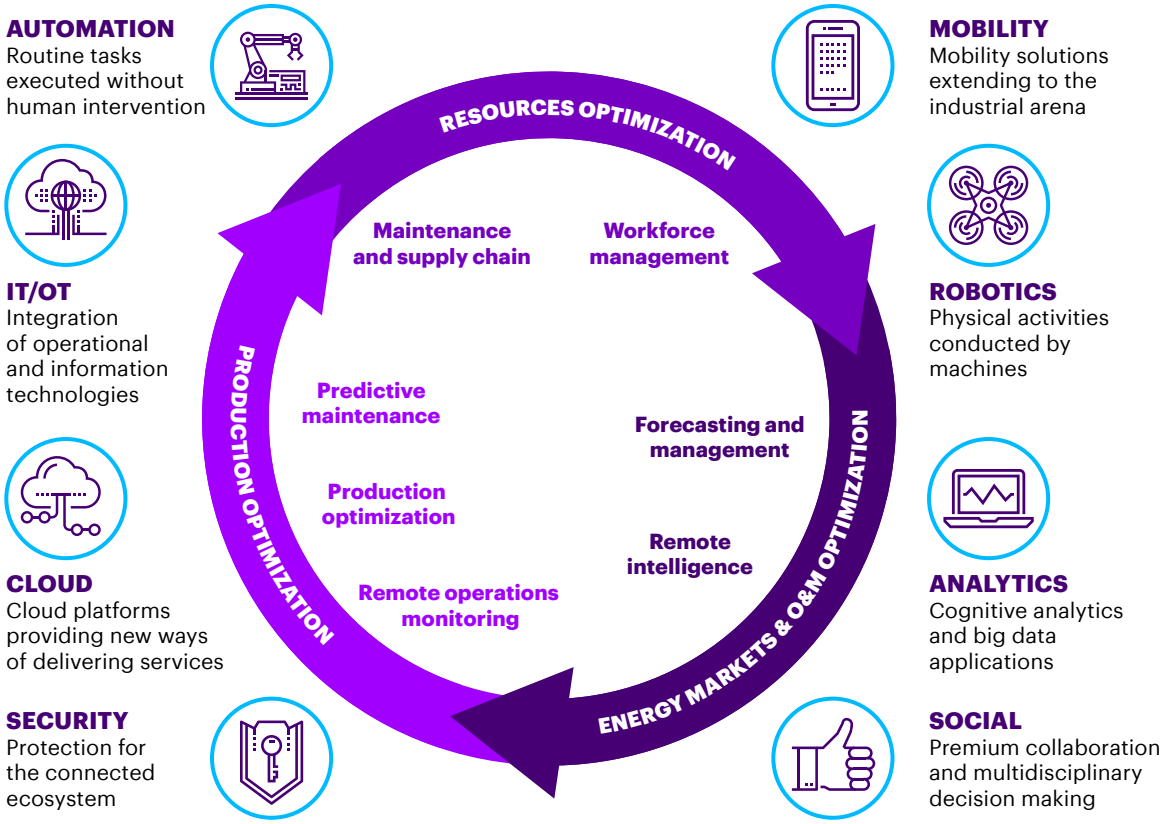
DIGITAL CAN UNLOCK VALUE ACROSS THE RENEWABLES LIFE CYCLE

Before formulating a digital strategy, there are three key value focus areas to be considered:

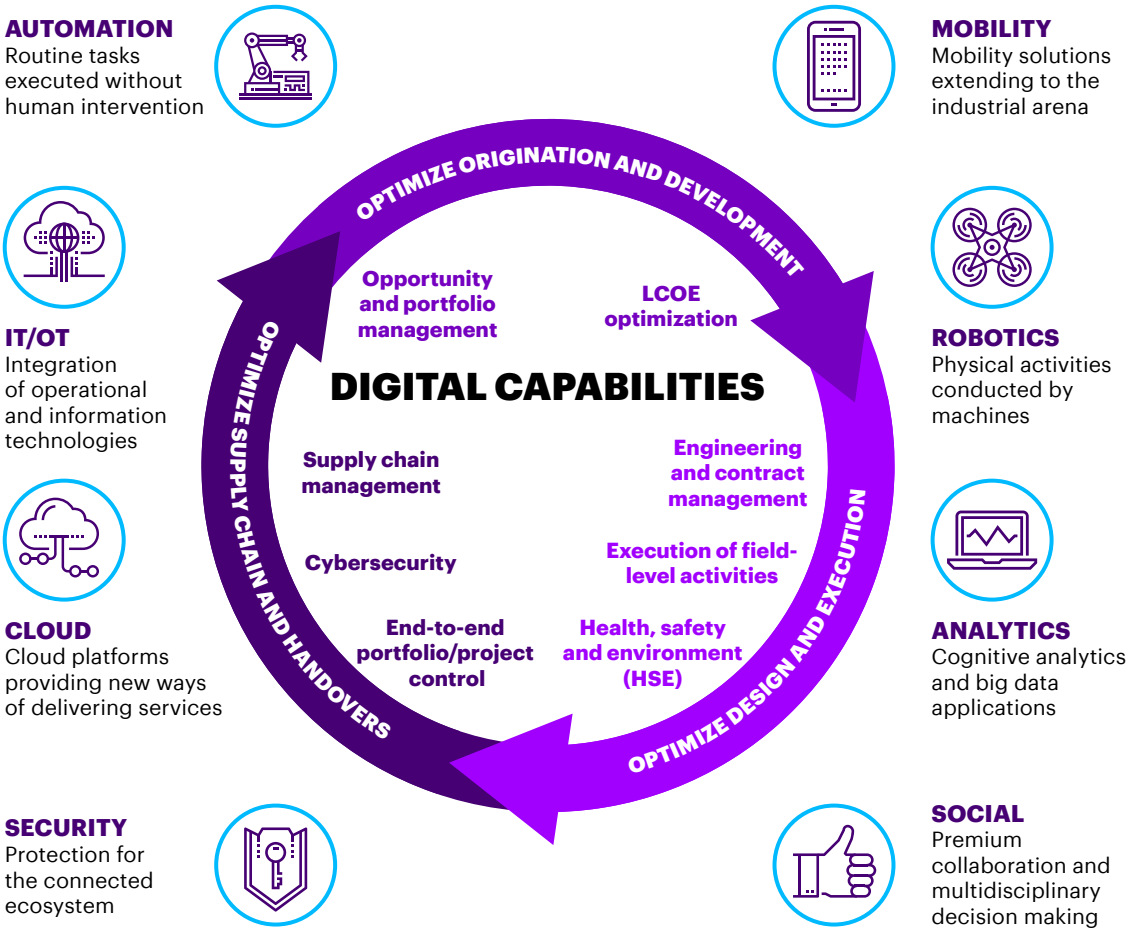
VALUE FOCUS

- **Origination and LCOE optimized designs**
- **Maintain the plan in construction and project delivery**
- **Maximize production and performance**

Wind operations and maintenance (O&M)



Solar project development and construction



APPLYING DIGITAL TO RENEWABLES

Example digital use cases to drive value in your business (non exhaustive)

Safety

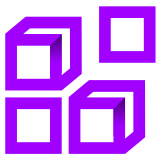
- Analyze safety performance and formulate predictions from historic trends using **machine learning**
- Track and report fatigue management, lone-worker alerts and safety red flags with **analytics and The Internet of Things (IoT)**
- Harness existing surveillance cameras to monitor health and safety compliance using **video analytics**

Program management

- Monitor live feeds from equipment via the **construction site control center**
- View real-time data and insights, gain early warnings and re-plan options on **leadership dashboards**
- Monitor productivity of people, equipment and processes through **zone-management analytics**

Design

- Apply virtual design and construction concepts, allowing test plant/site/project design, constructability and user experience prior to construction by building a **digital twin**
- Take virtual plant designs through to the operational environment by maintaining a **digital thread**
- Integrate multiple designs in a x-dimensional common data environment and facilitate cross-supply chain working through **collaborative design**



Quality

- Create a permanent electronic audit trail for equipment supply and validation records using **blockchain**
- Protect high-value equipment in transit/storage by tracking progress/handling with a **connected package**
- Commission solutions virtually throughout all stages of the life cycle in virtual **design environments**

Asset management and operations

- Reduce routine maintenance times through connected worker technologies by deploying **wearables**
- Use senior resource time more effectively through over-the-shoulder support and **remote guidance**
- Improve predictive risk-based maintenance through **unmanned surveillance, artificial intelligence (AI) and analytics**

People

- Improve safety and operational costs for repetitive or remote tasks through deployment of **cobots**
- Transform the design, commission, maintain and operate experience through **extended reality (XR)**
- Enhance access to the appropriate data, people, time and place in collaborative **knowledge environments**

Recognize that technology adds value when people are clear why they need to work differently.

SELECT VALUE QUESTIONS AND DIGITAL TECHNOLOGY RESPONSES

We have selected five digital technologies to consider against **four questions** applicable to the renewables industry today. These technologies provide the potential for value creation throughout the project life cycle.

1	**Can intelligent analytics enable a step change in performance?**	**APPLIED INTELLIGENCE**
2	**How can we better use scarce resources and reduce error rates in operations and program delivery?**	**CONNECTED WORKER**
3	**How can we harness data to control remote and unmanned operations?**	**DIGITAL PLANT**
4	**How can we improve the productivity of people, plant and materials in capital projects?**	**DIGITAL PROJECT CONTROLS**

DIGITAL TWIN/THREAD

In the following pages we outline technologies selected to respond to these four questions. They represent varying levels of maturity and ease of application. While those represented here are a conversation starter, many more possibilities exist.

1

APPLIED INTELLIGENCE

Can intelligent analytics enable a step change in performance?

Timely, relevant actionable insight

- Barriers to accessing high-quality data are lower than ever for mid to large players.
- Combining existing feeds from multiple sources is possible without expensive migration to common systems and platform.
- Manageable volumes of real-time, daily and weekly reports can be combined to create valuable insights.

Predict and protect

- AI "machine learning" can be used to analyze operational time series data and provide predictions, scenario analysis and issue detection.
- Applying machine learning informs management's responses to site conflicts and optimizes the impacts of change.

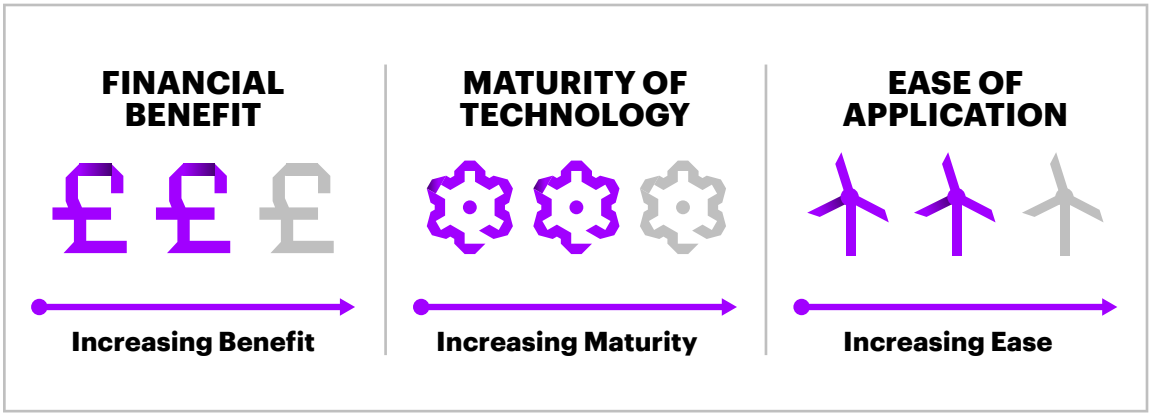
Visualization and dashboards

- Display key operational and commercial information for leadership with the ability to drill down into red flags, specific supply chain partners or site zones.
- View progress in an interactive, engaging format.
- View the physical asset as it is constructed or decommissioned.

Control center

- Production data hub displaying live project production data.
- Provides live updates from various sources and creates instantaneous data insights.
- Recommends actions and impact of actions.
- Delivers live updates of tasks completed against plan on the site.

Applied Intelligence identifies risk and predicts performance—supporting faster decision and actions



Example use cases

- **Wind power curves:** Applied Intelligence algorithms can offer early-warning recommendations to correct the deviation and improve load factor and energy production.
- **Predictive maintenance:** Predictive models for key components and subsystems of renewable assets. Models can detect deviations from the expected operating conditions and predict expected time to failure (TTF).
- **Hydro revenue maximization:** Inflow forecasting models are a key starting point to predict future availability of water resources and allow optimized planning and management of energy production.
- **Continuous improvement:** Benchmark and compare the performance of supply chain partners, site zones and sub-projects. Identify opportunities to transfer leading practice.

Case studies: Making advanced analytics a reality

Predictive maintenance: Wind operator and MIT

- Client wanted to maximize operating time while also avoiding catastrophic failures.
- Statistical model for reliability analysis was developed to distinguish between the latent internal vulnerability of the equipment from that caused by temporary external sources.
- Resulted in increased plant availability and a reduction in unplanned maintenance costs.

Global mining business: Pit-to-port overview

- Client lacked a complete view of its business from the mine to shipping and was limited to unconnected third-party data insights from each process stage.
- We developed a "pit-to-port" analytics overview to unify various data streams in a single system for improved visibility and support instant and optimal decision making.

Accenture strategic alliance: Maana

- We have formed an alliance with Maana, a digital knowledge technology company, to support our clients in accelerating their digital transformation.
- This alliance combines deep industry knowledge with Applied Intelligence.
- Maana's Knowledge Platform turns human expertise and data into digital knowledge for better employee decision making.

Benefits

- Estimated reduction in project spend by delivering continuous improvement throughout build from benchmarking.
- Estimated reduction in execution duration by optimizing a delivery plan and enabling efficient re-phase of work.
- Estimated reduction in lost production through intercepting and preventing critical fault conditions.

2

CONNECTED WORKER

How can we better use scarce resources and reduce error rates in operations and program delivery?

Wearable technology

- Connect workers to plans, tasks, records, instructions and expert support.
- Support task execution and over-the-shoulder coaching.
- Provide detailed advice on demand.
- Monitor workforce safety.
- Support workers in diagnosing and repairing issues in real time.

Movement tracking

- Use digital worker technology during lone working.
- Analyze fatigue management and prevent incidents.
- Analyze risk factors through congestion area alerts.
- Integrate worker panic alarms and area breach.
- Access worker location quickly.

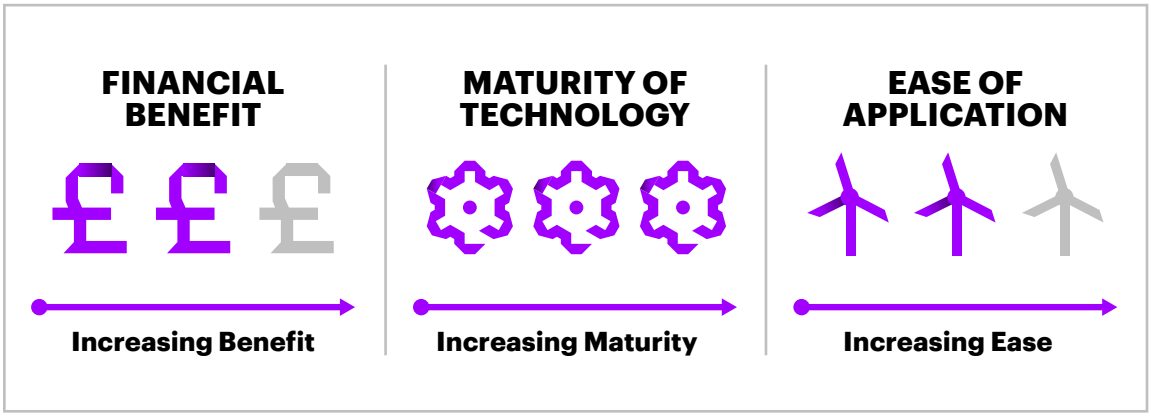
Connected kitbag

- Monitor the condition of kitbag assets in real time.
- Assess kitbag inventory before departing to complete a work order.
- Improve job completion rate and efficiency.
- Monitor tool performance in the work environment.
- Track asset location.

Virtual reality training

- Provide a 360-degree immersive video experience to learn in real-world conditions.
- Utilize augmented reality to provide virtual overlays on real-world assets.
- Provide enhanced information to users or a personal viewpoint to remote experts.

Connected worker technology improves productivity, reduces risk, improves safety and optimizes costs



Example use cases

- **Continuous improvement:** Delivering O&M activities digitally provides a wealth of data that can be used to increase task efficiency and worker productivity and inform future scheduling.
- **Better use of scarce resources:** Over-the-shoulder coaching enables experienced advice and support to be provided flexibly, reducing unproductive travel time to remote sites.
- **Improved accuracy and defect reduction:** For precise yet routine tasks, augmented reality can significantly improve right-first-time results through a virtual check and sign-off.
- **Training:** XR can enable offline experiential training in clean, low-risk, safe environments or provide critical information in the field.

Case studies: Making connected worker a reality

International nuclear power: Electronic work packages

- Templated work, PDF mark-up and reference docs within electric work packages (EWPs) reduced prep effort and improved standardized work productivity.
- Delivered 25% operational efficiencies and productivity uplift.
- Reduced time for work package-related activities by 75%.
- Increased planner productivity by 10% to 30%.

Hydro operator: Equipping our workers

- We are working with a large hydro operator to leverage digital to equip the workforce with tools that allow workers to focus on core functions and reduce administrative tasks and worker frustrations.
- Early projects include digital security logbooks and digital worker documents, with 3D scanning and dashboards.
- Testing underway on AR helmets, SmartUse on iPads.

European network: Over-the-shoulder coaching

- Taking support for non-routine work to the next level by providing coaching from centralized advisers using wearables, ad-hoc mark-up and download of reference documents.
- Sharing of leading practice works both ways, as experienced field workers record leading practices to upload into a shared knowledge portal.

Benefits

- Estimated increase in maintenance flexibility due to mobility solutions that improve planning and work execution.
- Estimated reduction in asset downtime from improved worker productivity, collaboration and automation of data sharing.
- Estimated increase in maintenance productivity as a result of improved supplier management and enhanced operational efficiency.

3

DIGITAL PLANT

How does digital design provide real benefits to power generation projects?

The digital twin comprises multiple elements that, combined with advanced analytics and other digital plant enablers, are critical to planning, preparation, prediction and performance.

Physical twin

- Maintain pre-construction reference models and designs throughout build and into operations.
- Integrate with as-built photometry and scans.
- Provide access across the organization through smart plant portals.

Operations twin

- Provides the data context for real-time data systems analogous to the role of the general ledger in finance and the asset register.
- Establish this early in the facility life cycle to maintain alignment of critical metadata and calculations.

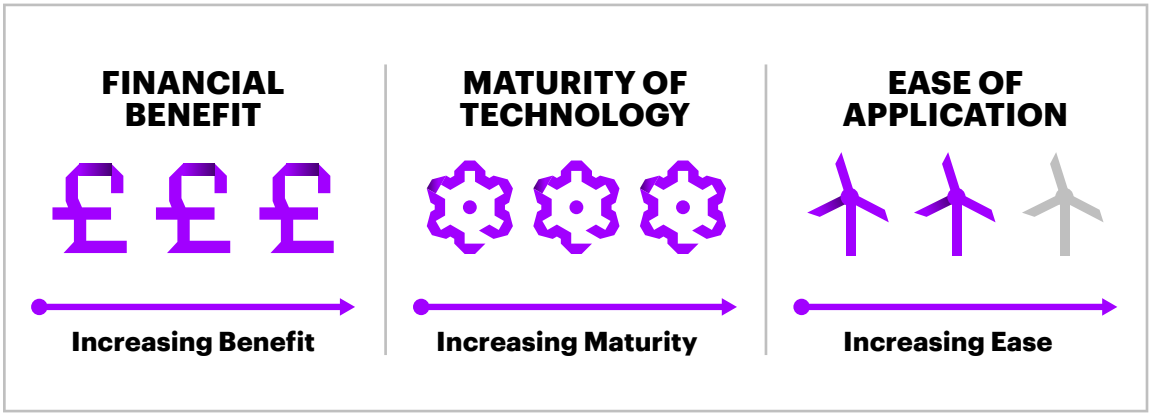
Models and methods

- LCOE optimization.
- AI and machine learning are organized within an analytics model framework.
- Combine these alongside station operating instructions and other procedures within a common framework.
- Governance of change and management of data chains.

Applied Intelligence

- Exploit the digital representation in combination with advanced analytics and knowledge systems to identify emerging risk and inform decisions on next best actions.
- Combine with connected worker and other collaborative solutions to provide key reference solutions for one version of the truth across the plant.

Digital plant is a solution to provide optimized and integrated O&M



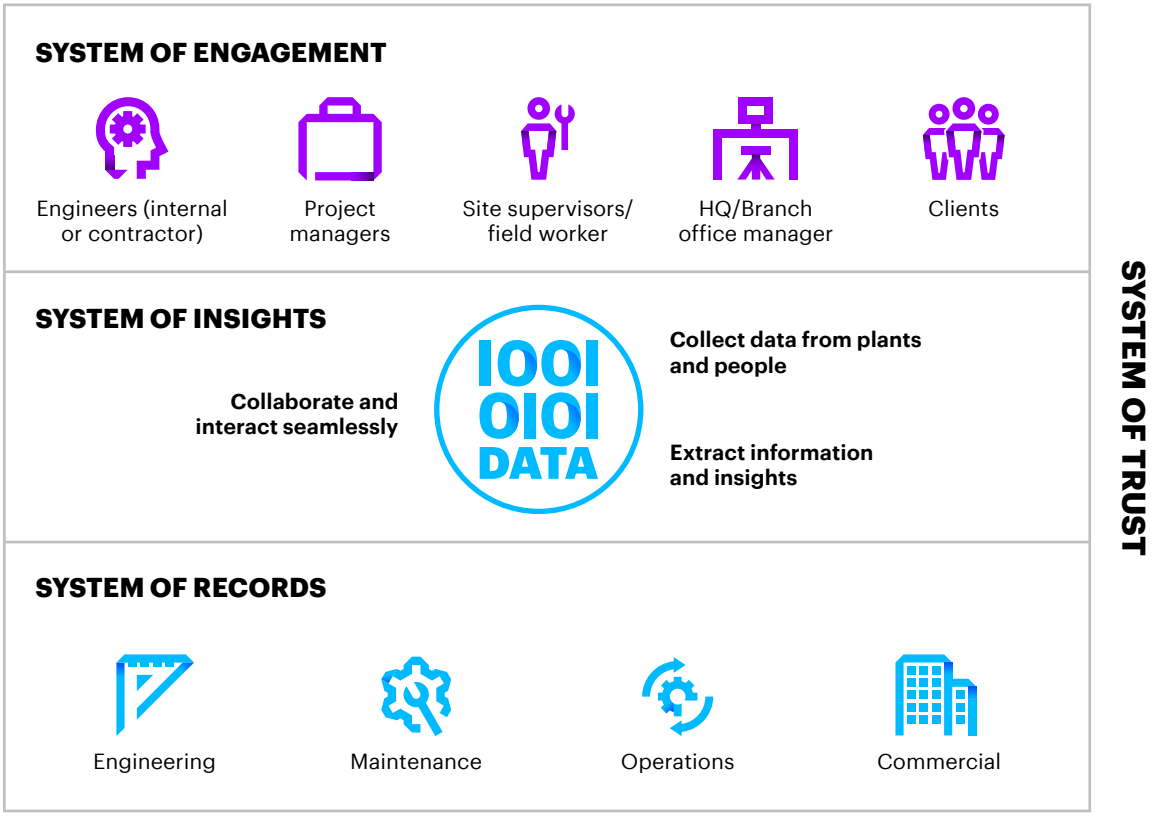
Case study: Making digital plant a reality

The potential for O&M to impact the bottom line is underestimated, with O&M often not sufficiently factored into decision making. The key to unlocking additional value is the seamless integration of all commercial and operational data sets that could truly enhance the bottom-line impact. This integration includes all data from the SCADA systems, external market and weather forecasts, work management and the supply chain, through investments in big data and analytics.

Accenture has defined the concept of a "**digital renewables 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**. This step change would require a transformation away from the use of local control rooms, enterprise resource planning and legacy systems toward a new digital multi-speed architecture that integrates a variety of external and internal factors to drive asset value maximization.

DIGITAL PLANT

Our approach separates the system of engagement from the systems of insight and record. This allows for the front line to have an integrated, end-to-end view of the most relevant data, enabling an open environment where multiple personas can exploit data and insights, operate and collaborate, being engaged in the integrated business process. Therefore, this data centricity approach relies on a system of trust, and cybersecurity is a key part of this architecture.



Benefits

- Reduction in overall maintenance cost through the availability of intelligent asset information that also drives improved planning and decision making.
- Maximizing asset value, increasing production through integration of operations and energy management data.

4

DIGITAL PROJECT CONTROLS

How can we improve the productivity of people, plant and materials in capital projects?

Location tracking

- Use of RFID trackers to identify logistics/planning improvement opportunities.
- Review excess supply (people/plant/materials) and evaluate options for better use of the available resources to accelerate tasks/activities.
- Benchmark supply chain partner performance.
- Identify leading practices and issues contributing to more/less time on tools.

Unlock data to optimize plans

- Monitor plant, machinery and people productivity performance in real time.
- Evaluate work zone inefficiencies (congestion, queues) and optimize site design.
- Use captured data to inform future productivity and planning improvements.

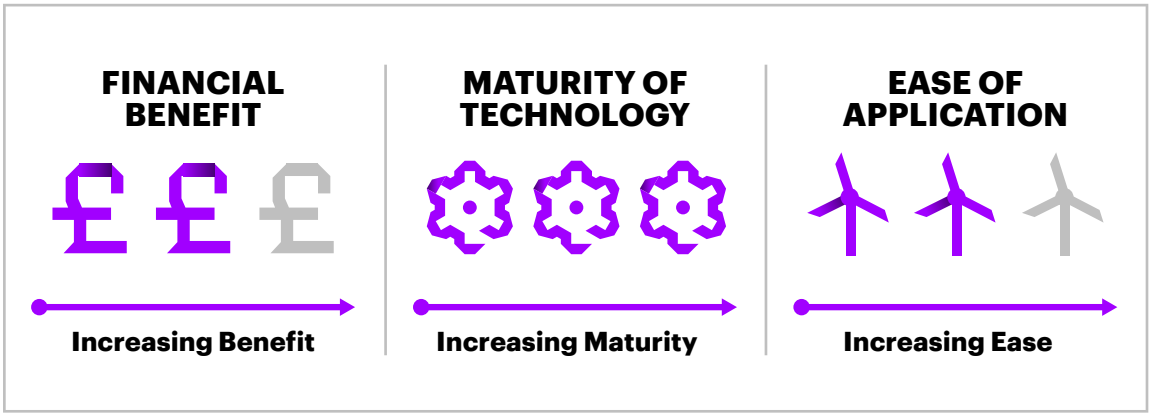
Enhanced safety

- Analyze fatigue versus incidents, identify individuals at high risk of fatigue, and assess associated scheduling impacts.
- Receive congestion alerts, optimize vehicle traffic and manage hazardous working through real-time monitoring of high-risk locations.
- Implement worker panic alarms, with incident investigation and notifications of breach issues.

Cost management

- Link data sources to validate costs, for example timesheet versus gate data.
- Identify costs of unproductive time, plant and materials usage.
- Provide real-time data on estimated hours while waiting for timesheet entry.
- Analyze and optimize worker/manager ratios.
- Inform change processes.

Digital controls take live site feeds and allow companies to optimize plans and continously improve work practices, site designs, time on tools and safety performance



Example use cases

- **Maintenance:** Optimize plans, reduce safety risk, and monitor and optimize logistics. Feed the resulting insights back into plans.
- **Construction zone management:** Optimize site design to maximize time on tools, manage bottlenecks, manage access and mitigate traffic and safety risk.
- **Permissions and permits:** Analyze lost-time causes to identify permit and permission delays. Improve client-owned processes to optimize time on tools.
- **Benchmarking:** Compare data across suppliers on a site or across operations. Set benchmarks using historic data and identify ways to improve delivery. Build data and associated learning into future plans.

Case studies: Making digital controls a reality

Global mining company: Connected Mine solution

- We helped a global mining company gain better data visibility through digital controls.
- Our Connected Mine solution was deployed and increased total material moved by 9,000 tonnes per shift per supervisor, which could potentially unlock value of US$14 million per year per supervisor.

National network infrastructure: Portfolio management

- Providing a single view of the plan across all capex projects and opex maintenance to enable better portfolio balancing.
- Optimize decisions across multiple dimensions (including risk, schedule, cost and resources) through exploring the impact of multiple “what-if” delivery scenarios.

Digital platform for engineering and construction process integration

- Implementing digital platform at a major multinational renewables operator to support adoption of a truly end-to-end project approach.
- Platform is tailored to the differing needs of the project phases.

Benefits

- Estimated increase in schedule attainment as a result of increased worker productivity and more effective project execution.
- Increase in productivity from the use of location data to optimize plans successfully and improve the ability to predict safety events.
- Increase in billing accuracy from the use of accurate real-time data that is assessed against multiple sources and validated before billing.

WHERE TO START?

Bringing "the New" to renewables is essential to building our low-carbon future.

We have demonstrated a small number of technologies to bring to life just a few of the digital use cases in renewables. There are many more technologies with wide applicability for the industry today, not to mention the seeds of ideas being considered right now—those big, yet-to-be-developed ideas that will ultimately generate huge business value.

Imagining the digital future is exciting, but it is not without its challenges. Often, leaders may see the potential value and benefits a technology can bring, but the barriers seem high, and the journey to realizing the opportunities appears expensive, lengthy and difficult. In response to this concern, we believe is it best to follow an agile approach.

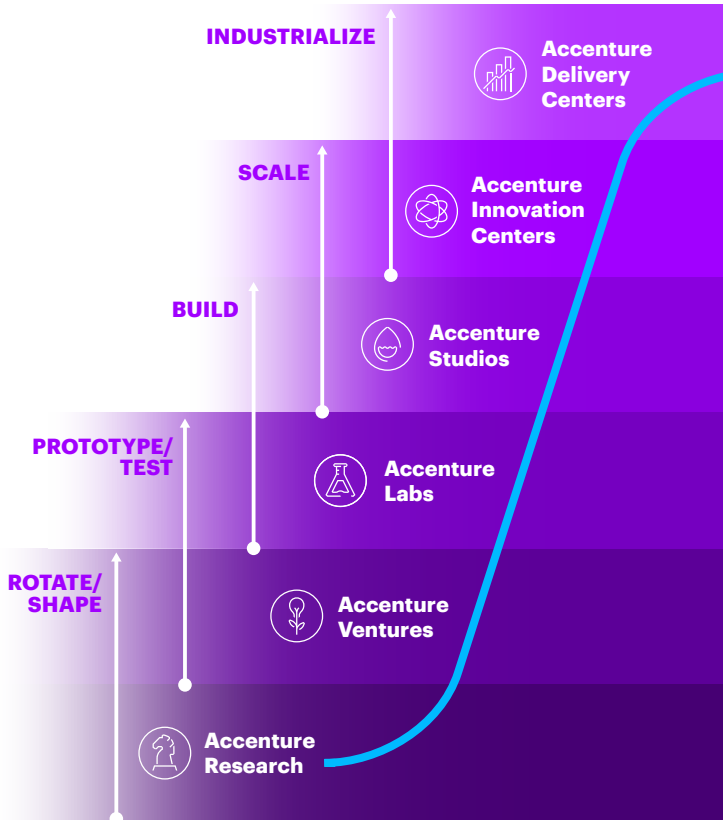
This means setting your digital strategy for the value areas you wish to focus on, and then executing a small number of flagship implementations for high-maturity technologies that have already delivered proven business results in other industries. These projects should have a maximum duration of 12 weeks and be run in "sprints and scrums" to confirm progress is visible.

Our innovation architecture

Accenture's innovation architecture provides clients with a proven method to innovate. We have developed our innovation architecture to provide valuable results from digital, at pace.

Utilizing our innovation architecture means companies can bring "the New" to their renewables business using tried and tested tools, approaches and methods while accessing some of the brightest digital minds.

One of our newest centers, the Accenture Intelligent & Secure Industry Center in Bilbao, focuses on showcasing the latest innovations within the renewables industry across wind, solar and hydro. Another newly opened Innovation Hub in Shenzhen, China, focuses on applied R&D. Additionally, our renewables content is available to all of our innovation centers around the world.



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