HITACHI ABB

Digital transformation of the distribution grid

Solutions from the field to the boardroom for distribution utilities

- Increase visibility into your distribution network
- Enable advanced distribution management applications
- Increase grid's hosting capacity.

HITACHI ABB POWER GRIDS

Summary

Electricity systems around the world are undergoing fundamental changes. Driven by three key megatrends – decarbonisation, decentralisation and digitalisation – utilities are changing faster and more profoundly than they have in decades.

The power system is no longer founded on unidirectional energy flows and traditional centralised generation, but rapidly evolving into a cohesive system that embraces both the prevailing and emerging technologies. This new, integrated system is being shaped by digital tools that enable data-driven decision making across the organisation and allow a range of technologies to coexist.

However, key technical challenges and regulatory headwinds brought on by the growing threat of climate change represent significant barriers to successful transformation. This paper describes how taking a layered approach to achieving digital transformation can help overcome the technical challenges, allowing distribution utilities to improve operations and achieve significant organisational benefits. When digitalisation is applied to distribution utilities, they are also much better prepared to comply with the rapidly changing regulatory environment.

By adopting Hitachi ABB Power Grids' 'from the field to the boardroom' roadmap, distribution utilities will accelerate the integration of cutting-edge technologies with existing systems whilst successfully addressing the challenges along their digital transformation journey.

Introduction

An accelerating pace of innovation led by key technology advancements is laying the foundation for the digital transformation of the power industry. Driving this change are certain significant and inexorable trends that have re-defined the distribution grid. At the same time, there are a multitude of challenges and changes faced by distribution utilities that need to be overcome.

There are five key drivers of grid modernisation that push the utility to overcome the challenges and achieve this transformation: reliability/resiliency, efficiency, sustainability, operational effectiveness and customer engagement.

To achieve digital maturity, utilities must pass through three stages of progression – digitisation, digitalisation and enterprise integration – before they can effectively meet evolving regulatory and business challenges.

The key megatrends that re-define the grid

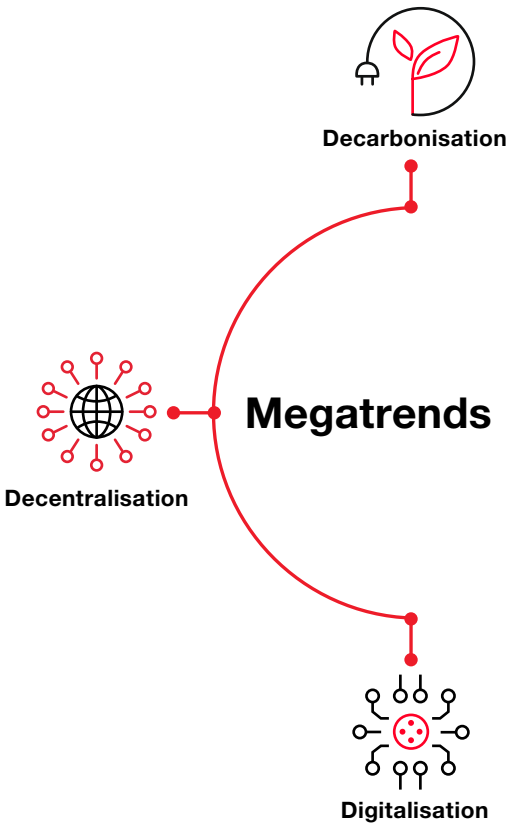
The transformation of the electricity system is buoyed by three key megatrends: decarbonisation, decentralisation and digitalisation.

01 Key megatrends effecting distribution utilities.

Together, these primary trends, the so-called '3Ds', are ushering in a new era of the electricity system by converging to produce game-changing disruptions and fundamentally reshaping the electricity system.

Decarbonisation: The notion of decarbonisation pertains to the reduction of carbon dioxide (CO_2) being released into the atmosphere.

Support for decarbonisation as a means to combat climate change has gained traction in recent years in response to shifts in public opinion combined with regional, national and international policy actions and key technological advances in areas such as renewable energy, electric vehicles and battery storage.



The energy and transport sector accounts for the largest share of global CO_2 emissions and plays a pivotal role in reducing carbon intensity. Therefore, one of the most efficient pathways toward decarbonising is the integration of low-carbon technologies into the electricity generation mix and the electrification of transportation.

The drive towards decarbonisation could entail significant challenges for distribution grids due to the anticipated uptake of distributed, variable renewable energy sources (V-RES) and electric vehicles (EVs) connecting and disconnecting to the grid at random hours during a day.

Decentralisation: Traditional electric utility models are based on centralised power generation with a unidirectional flow of electricity from plant to user. Modern utilities are increasingly adopting decentralised models that allow power to flow on to the grid from many points or nodes, mainly from V-RES sources such as wind and solar, battery energy storage systems (BESSs) and microgrids. These models require the grid to be capable of accommodating multi-directional, unpredictable electricity flows, which adds to the complexity of grid management.

With the relatively newfound ability to generate power on-site, commercial, industrial and residential electricity consumers are considered prosumers (a combination of the terms 'producers' and 'consumers') that contribute further to multi-directional power flow.

The rapid improvement rates and a sharp decrease in the costs of the underlying technologies such as photovoltaic (PV) are accelerating decentralisation and changing the way energy is being generated, transported and consumed.

Utility- and smaller-scale BESSs connected to the distribution grid make the grid more efficient by discharging at times of high demand and charging at times of over-supply

Digitalisation: Thanks to the confluence of favorable technological advancements and market developments, utilities can now transform their business processes by an end-to-end sharing of information across the entire enterprise, improving operations and effectiveness of customer delivery.

In a quest to remain competitive in a rapidly changing environment, utilities are increasingly adopting digital technologies like machine learning (ML), artificial intelligence (AI) and virtual or augmented reality (VR/AR), cloud and analytics, 5G and blockchain. Once integrated, these technologies can provide a host of new insights that can help utilities sharpen their competitive edge.

These new digital technologies allow data from sensors at substations, smart metering systems and other connected devices to be collected and delivered to the control room via wired and wireless broadband communication networks. The data can then be processed by software applications powered by AI that provide operators with detailed views of their grid and enables fast, accurate decision making.

And when the field workforce is equipped with digital devices that provide mobile access to maps, data, work-management tools and real-time expertise, this results in increased workforce productivity, which in turn can aid utilities to better serve their customers.

The application of digital productivity tools and automation of the various processes ultimately translate into immediate and substantial improvements of the bottom line of the utility company. For example, digital tools that enable sophisticated workforce management can streamline operations and substantially reduce opex.

Utilities are faced with an increasing number of challenges and changes

The energy world is evolving rapidly. With sweeping transformations in the way electricity is produced, stored, managed and consumed, grid operations must be adapted to perform in a constantly shifting environment.

To address the breadth of these challenges, distribution grid owners and operators must embrace digital transformation solutions and become customer-centric, resilient, automated and hyperconnected with collaboration between AI and human processes.

A 20th-century analog business needs to be transformed to an enterprise that can communicate, monitor, compute and control grid and customer operations with real-time intelligence and situational awareness, whilst maintaining reliability, improving resiliency, integrating renewable generation, enhancing customer options and services and ensuring sound financial performance – all at the same time!

Among the multitude of challenges and changes that distribution utilities face today, some of the most significant include:

Aging infrastructure: Many substations and other power grid assets are already operating beyond their design life, causing utilities to seek a better balance between maintenance, life extension and replacement.

Rise of non-utility players: It has been forecast that by 2022, non-utility players will seize 20% of the retail energy market. Many Fortune 500 companies either plan to develop or already have the capability to self-generate energy mainly from distributed energy resources. Part of the appeal of self-generating power is to wholesale excess through utility-independent subsidiaries.

Changing role of the DSO: The traditional responsibility of distribution system operators (DSOs) was limited to developing, operating and maintaining power distribution systems. But with the evolving energy market, DSOs are now expected to provide a wide range of support functions to the grid.

Additional roles include procuring flexibility services like peak load management through distributed energy resources (DERs), network congestion management and voltage support from the assets that are already connected to their distribution network.

Other services expected from DSOs include providing reactive power support to transmission system operators (TSOs), load-balancing, using distributed energy resources to avoid or reduce network investments and supervising advanced networks. Some of the expectations, such as supplying data in a non-discriminatory manner to third party for them to offer innovative services to consumers and providing technical validation for the power market may require rapidly developing or maturing new skill sets within DSO organisations.

The broadening role of DSOs and increased interaction with TSOs could lead to an overlap of many services. DSOs are also expected to start financing, operating and maintaining energy storage systems.

Shrinking workforce: It is estimated that nearly 40%[1] of the workforce at America's electric and natural gas utilities will be eligible for retirement in the next few years and similar scenarios are playing out around the world. This will result in a shortage of qualified utility workers and place a greater emphasis on the systems that can provide knowledge resources and support to the next generation of workers.

IT/OT convergence: The convergence of information technology (IT) and operations technology (OT) brings both challenges and opportunities to utilities. A fundamental challenge is the need to integrate new types of assets to the electric network such as electric vehicles, demand response programs, home area networks, and distributed, large-scale renewable generation systems. Another major challenge brought on by digitisation is the need to manage very large quantities of 'new' data in near real time that will be generated by new devices and sensors spread across transmission and distribution networks, metering devices, EV recharging stations and home area networks.

Many of the opportunities from this convergence will centre on the new ways that utilities will be able to view their operations. The same influx of data that will pose a management challenge will yield a wide range of possibilities for providing wholly new insights that will help improve safety, increase workforce efficiency and enable better decision making.

Increasing cyberattacks: The increasing rate of cyberattacks on critical infrastructure is troublesome. The severity of the attacks, in terms of both regularity and sophistication, poses real challenges to the viability of cloud-based solutions.

Regulatory compliance: The regulatory system in most countries is currently in flux. Driven by the concern for global warming and uncertainties of fuel supplies, regulators are imposing more stringent policies and tighter deadlines for compliance. These tougher policy mandates will likely require increased capital investment, which could lead to more contentious utility rates and increased customer apprehension.

[1]https://www.power-eng.com/2014/12/03/who-will-replace-powers-aging-workforce/#gref

Grid modernisation drivers from the utility perspective

The general trend toward grid modernisation is driven largely by new digital capabilities and the promise of automation that will enhance grid control and stability and improve decision-making, safety, security, sustainability and reliability.

02 The five main drivers of grid modernisation.

Digital technologies can also be used to meet rapidly evolving customer expectations, enhance reliability and security and enable broad integration of DERs.

Whilst all of these elements of grid modernisation are attractive, the main drivers for grid modernisation from a utility's point of view include reliability/resiliency, efficiency, sustainability, operational effectiveness and customer engagement.

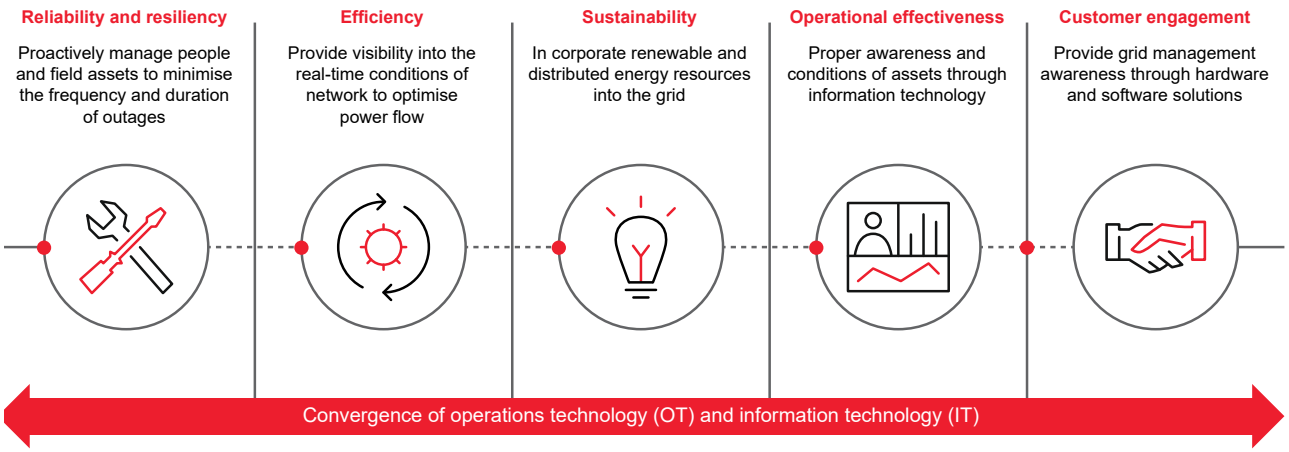
Reliability and resiliency: Grid modernisation is chiefly about ensuring that utility companies will be able to deliver the energy that customers need when they need it. With electricity permeating every corner of our lives, expectations for minimal service interruptions are high, even during major weather or security events.

To meet these expectations and guard against the increased frequency and magnitude of outages, utilities are making investments in automation and communications (A&C) systems to harden the grid and improve resiliency. Many of these systems are aimed at proactively managing people and field assets for this purpose.

Efficiency: Electrical system efficiencies result in many benefits including reduced demand during peak loads, improved service quality, reduced losses, efficient integration of DERs and lower energy consumption through methods like feeder voltage optimisation, where automation provides visibility into the real-time conditions of the network to improve power flow.

Sustainability: Utilities are now aiming for a sustainable energy future through the integration of DERs. Production of energy from more sustainable sources can be realised at both utility scale and distributed resources connected at the residential level.

Sustainability can be achieved by focusing on various aspects like monitoring grid health by deploying low-cost sensors, isolating grid failures and performing quick restoration of power using visualisations and data analysis, strengthening cybersecurity, deploying advanced technologies for power flow control and real-time validation of electric system restoration activities.



Operational effectiveness: Utilities aim to make use of information technology to arrive at improved situational awareness of grid disturbances, workforce management and the latest asset conditions. By sharing data and information across the enterprise, utilities can dramatically improve asset performance management and make faster, more accurate decisions.

Customer engagement: Overall, renewable generation and automation are driving us to a new grid paradigm – instead of dispatch generation to match the load, utilities need to be able to manage the load to match renewable generation availability to avoid curtailment. As a result, utilities are moving away from the 'ratepayer' mindset, where their customers are strictly consumers and are seeking new ways to become more customer centric as they modernise grid operations.

Customer engagement includes not only aspects like providing outage notifications with an estimated time for restoration, allowing access to energy usage data and expanding the options for energy management, but also providing grid management awareness through hardware and software solutions.

The three major stages on the path to becoming a truly digital utility

One of the tenets of grid modernisation is creating a pathway to becoming a fully digital enterprise.

03 The three digital maturity stages for the distribution utility.

To effectively modernise to meet regulatory and business challenges and become more resilient, customer-focused and automated, utilities must progress through three distinct and stages: digitisation, digitalisation and enterprise integration.

Digitisation: Digitisation refers to the process of converting analog data into digital formats that can be gathered, stored and processed by a computer. For example, a physical photograph would be considered digitised if it were scanned and converted into a digital file.

Once digitisation occurs, data can be accessed and used in a multitude of new ways and can be combined with other data that can help businesses of all kinds gain new perspectives on their operations. In the energy sector, the data not only becomes more accessible and moves faster but can also work synergistically to provide optimal plant and grid output.

Digitisation can be done by the addition of certain control systems and internet-enabled software, or even by doing something as simple as replacing the copper cables with fiber optics and thus substituting analog with digital signals.

Digitisation is a pre-condition for the next stage, digitalisation to happen.

Digitalisation: This stage shares its name with the megatrend because they both refer to the transformation of business processes by end-to-end sharing of digitised information across the entire enterprise improving operations and effectiveness of customer delivery.

A utility may be considered ‘digitalised’ when data can be captured and communicated autonomously throughout a distributed network. Once digitalised, business velocity can accelerate because systems are more efficient and responsive, which allows innovation to occur more rapidly.

Enterprise integration: The third and final maturity level is enterprise integration. In this level, the optimisation of strategic, data-driven decision-making and digital processes are applied to solve business challenges.

Since the integrated analytics and optimised process and systems across the enterprise have been already established in stage 2, the utility will now have an holistic, 360-degree view of the customer that helps in improving delivery, digital communication and customer experience.

Digitalisation and distribution utilities

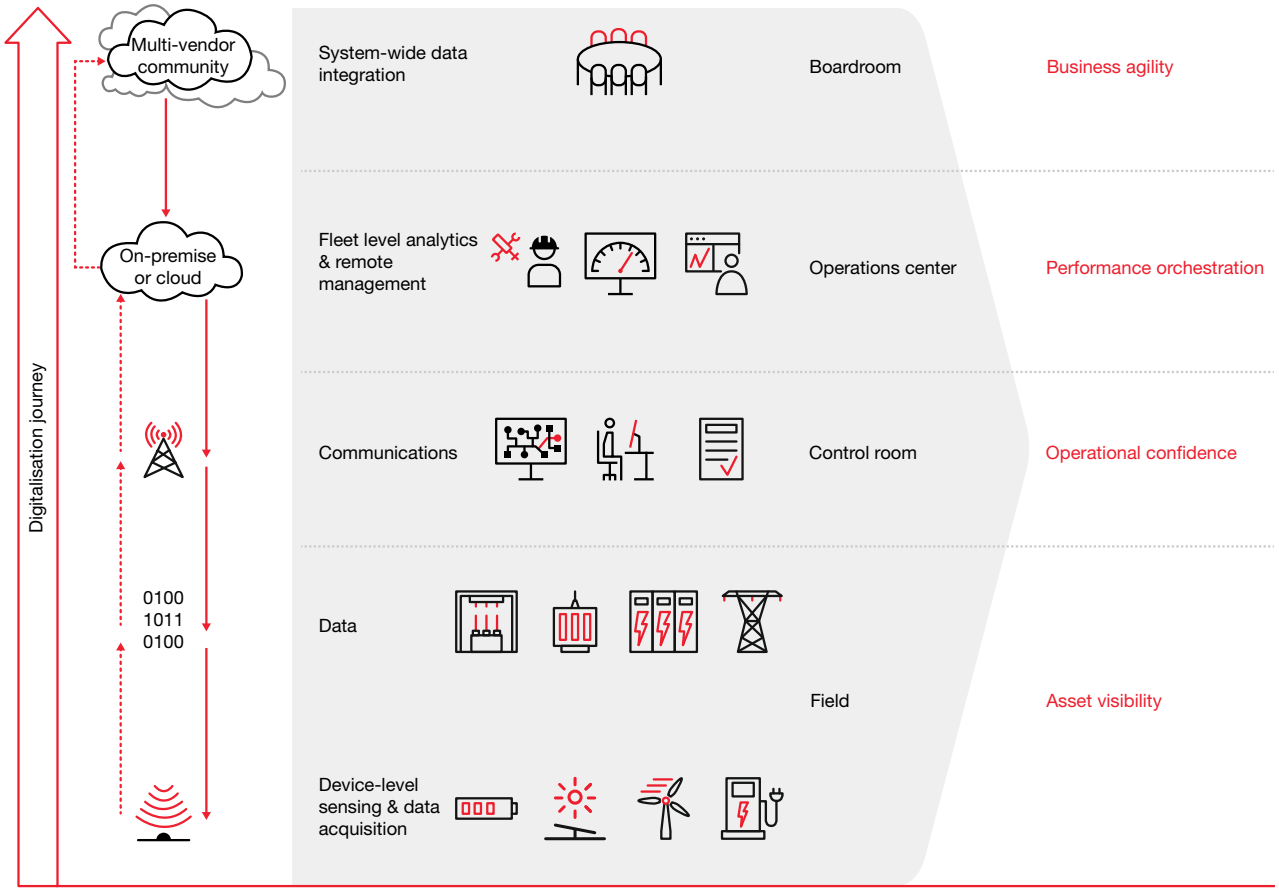
Along its digitalisation journey, the main goal of a utility is to achieve an increased visibility of their physical assets, which in turn enables the migration from asset focus to system-level analysis.

04 Digitalisation enables data from sensors to be used to enhance decision-making throughout the utility.

For instance, instead of the typical whiteboard and spreadsheet-driven data capture process, if smart devices (IEDs, sensors, etc.) are deployed in the field, the data can be quickly captured and transformed via device level sensing and data acquisition.

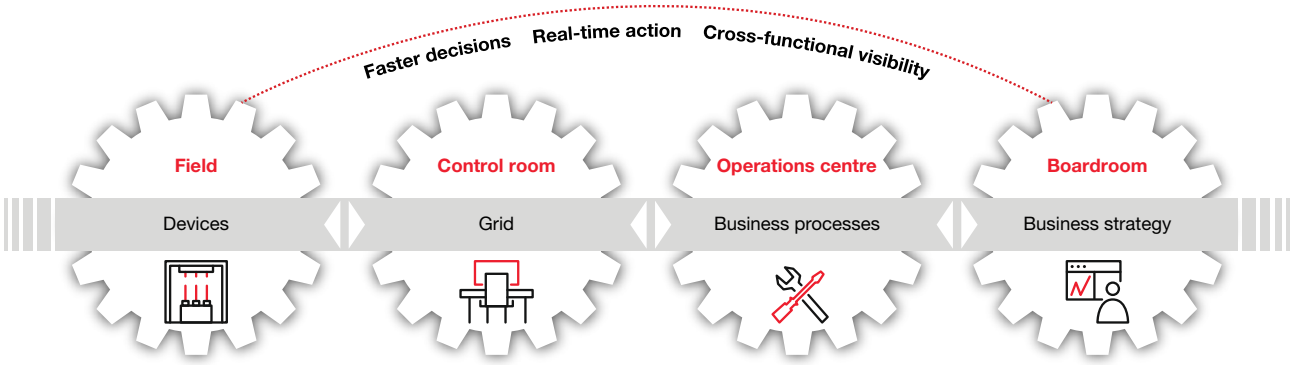
As shown in the graphic below, operational data would then be transferred to higher levels like the cloud, substation, or the control centre via a cost-effective communication architecture where it can be used in new ways.

To enable a higher degree of business agility necessary to optimise asset management, the installed base would be made remote-manageable. As a next step of the utilities, system-wide data integration would offer broad visibility and historical analysis across the fleet, leading to better risk management.



Digital transformation from the field to the boardroom

Digitalisation and the resulting transformation of operations affects all components and aspects of a distribution utility. Hitachi ABB Power Grids' has a broad portfolio of distribution products, services and solutions that can help utilities navigate their digital transformation journey – from the field to the boardroom.



05 Digitalisation affects all components and aspects of a distribution utility.

A real-life scenario of a utility's digital transformation journey encompasses the application of automation at the field level, control room, operations centre and boardroom.

Hitachi ABB Power Grids' suggested roadmap pertains to an incremental approach to infrastructure investments, adoption of advanced technologies into the grid, the inclusion of smarter distributed system designs, seamless integration of DERs to improve overall efficiency, comprehensive access across disparate IT/OT systems and collaboration across data and system silos, converging together to create a resilient and efficient system that also accomplishes economic and environmental objectives.

For example, monitoring equipment can translate information in milliseconds and can automatically communicate that information to decision-making systems at higher levels. This type of comprehensive architecture results in an interconnected, data-driven environment, that enables utilities to make faster decisions, allows for dynamic, real-time grid management and provides cross-functional visibility. With these enhancements, utilities can improve asset management, reduce maintenance costs and can integrate new data streams in their strategic planning.

The utilities that adopt an agile, thoughtfully designed digital approach will be better placed to deliver an improved customer experience, enabling them to thrive in this transformative age of digital energy.

The ideal business partner to accelerate your digital transformation journey

We have entered an era of digital transformation of the distribution grid that is shaping up to be a defining moment for electricity systems everywhere. This transition is expected to fundamentally change how electricity is produced, transmitted and consumed.

A utility's digital transformation journey is filled with challenges that must be overcome before the full benefits of the various digital technologies can be unlocked.

With customer preferences and expectations shifting towards lesser carbon emissions, more choices, uninterrupted connection and higher transparency, a smarter, decentralised and yet, connected electricity system is now the need of the hour.

Hitachi ABB Power Grids is the ideal business partner to help you achieve your transformation goals and become a digital utility. With more than 100 years of expertise and an industry-leading portfolio of products, solutions and services of expertise, our depth of knowledge and breadth of portfolio are second to none. Hitachi ABB Power Grids contributes to a stronger, smarter, greener and more economical approach to operating the distribution grid.

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