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ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Policy Insights:

Synthesis for Decision Makers

Trends of Digital Transformation of Utilities

Discussion Paper

ISGAN Annex 4

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iea Energy Technology Network

CLEAN ENERGY MINISTERIAL

About ISGAN Discussion Papers

ISGAN (Smart Grid Action Network) discussion papers are meant as input documents to the global discussion about smart grids. Each is a statement by the author(s) regarding a topic of international interest. They reflect works in progress in the development of smart grids in the different regions of the world. Their aim is not to communicate a final outcome or advise decision-makers but rather lay the groundwork for further research and analysis.

Disclaimer

Acknowledgments

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1. Background

Recently, the energy market is going through drastic changes with the launch of a new climate regime and the advent of the Fourth Industrial Revolution era. Amid these changes, many countries worldwide are strategically pushing for digital transformation to address various issues arising from the pursuit of energy conversion policies. As defined by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of Germany (BMU), energy transition refers to the shift to a sustainable economy through renewable energy, energy efficiency, and sustainable development, and its ultimate goal is replacing coal or other nonrenewable energy sources entirely with renewable ones. Thus, energy transition is the shifting of centralized nuclear and fossil-based energy systems into decentralized renewable energy-based systems. However, the critical issue behind it is to expand the use of renewable energy and reduce energy consumption through energy efficiency. As such, energy transition can be more efficient through digital transformation, which combines technology and ICT in the field of electrical energy. Therefore, the present publication examines the various cases of the digital transformation of utilities and identifies the implications of digital transformation in the transition to clean energy. Moreover, ISGAN Annex 4 aims to convey some messages, such as what the digital transformation means in terms of transition into smarter energy, its potentiality, and the most pressing challenges, to policymakers and related industries.

2. Background of Digital Transformation

The term “digital transformation” refers to the process of streamlining machine and system operations through the collection, sharing, and analysis of data by connecting devices through telecommunications, and it has recently spread beyond the collection, sharing, and analysis of data in industrial sites and work environments to the stage where such data is used in the establishment of management strategies and creation of new businesses (e.g., World Economic Forum, Digital Transformation of Industries 2016, and others). In addition, its concept has been developed as follows: the digitization that transforms analog information into a digital format, the digitalization that improves a value using digital information, and the digital transformation that develops a new business concept using digital information and technology. Thus, the digitalization not only affects the demand and supply of energy but also changes the energy system itself. In particular, the digitalization of an electric power industry could, at its best, break boundaries among energy sectors and integrate the whole energy system. Moreover, the digitalization creates an opportunity to directly interact in breaking boundaries among consumers and suppliers in an energy market and balancing the supply and the demand in real time. As such, businesses and governments shall respond to this digitalization quickly.

Utility enterprises that face various challenges encourage the digital transformation to cut costs by improving their efficiency and meeting customer satisfaction, as well as creating profits through a business model with a focus on customers.

2.1 Necessity for Digital Transformation

The interest in digital transformation has different drivers and different countries as utility enterprises faced various challenges, such as the slowdown in the increase of electric power demand, expansion of distributed generation, deterioration of grid, change of customer demand, etc.

<Challenges by the Value Chain of Utility>

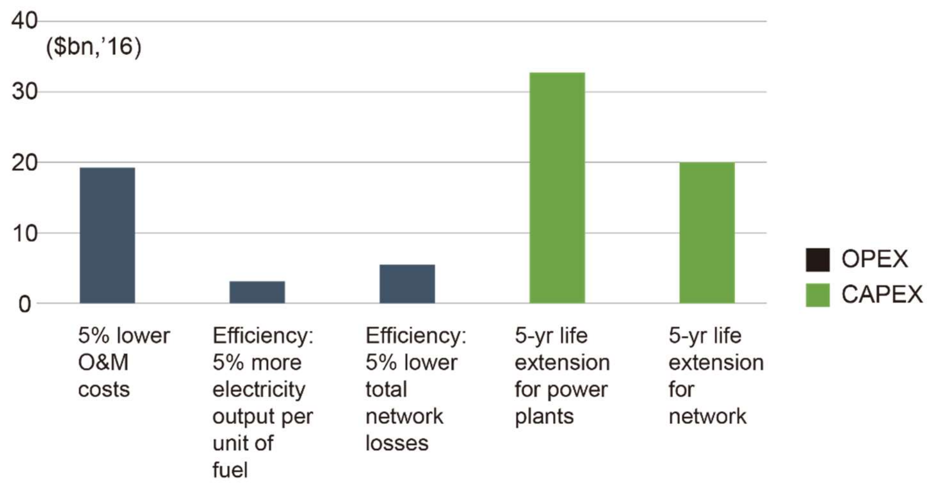
Generation	Transmission and Distribution	Energy Management	Sales
· Deterioration of the thermal power generation plant · Decrease in the utilization rate	· Increase of association with new renewable energy · Deterioration of power grid	· Intensification of imbalance between supply and demand · Expansion of distributed resources/EV → Necessity for the expansion of flexibility	· Decrease/stagnation of sales · Deterioration of the decrease in customers · Increase of demand for customer participation
→ Increase of necessity for cost-cutting			

* Source: Utility Digitalization: Tech, Strategies, and Progress, BNEF, April 2018

New profits can be created by improving efficiency and cutting costs through digital transformation in the whole field of the value chain and developing a business model with a focus on customers.

For example, in the fields of power generation, transmission, and distribution, it is possible to cut operating expenses and investment costs with predictive maintenance, remote control, property plan, etc. by analyzing in real time the data collected sensors in gas turbine, transmission and distribution network in wind power, etc.

<Potential cost savings from enhanced digitalization in power plants and electricity networks over 2016-40>



* Source: IEA, 2017

In addition, it is possible to cut costs and create profits through customer value–oriented business model that improves energy management platform and customer service by using a chatbot and e-billing system with digital technology.

<Main Fields in the Digital Transformation of Utility>

Efficiency Improvement / Cost Cutting		Biz Model / Profit Creation	
· Asset performance management · Digital field worker · Smart asset plan	· Real-time platform for the balance of supply and demand · Real-time network control · Energy integration platform	· Linkage of energy storage device · Digital customer model · Energy solution integration	· Energy management · Industrial service (B2B) · Local government service (B2T)

2.2 Obstacles to Digital Transformation

However, a utility industry faces a limitation of creating a tangible performance in digital transformation compared to other industries. The following factors would hinder the prompt digital transformation in a utility industry: inflexible organizational culture, outdated corporate image, and conditions to operate a large scale of the system.

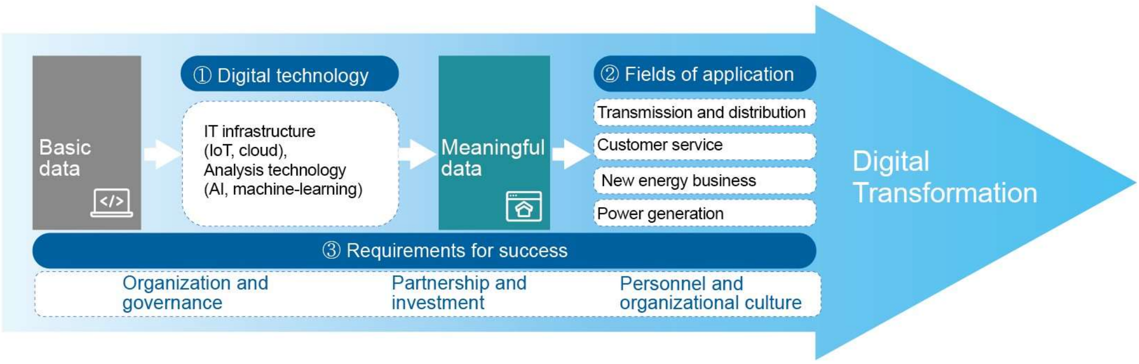
Organizational culture	It lacks agility and innovation because of the utility's traditional organization culture to minimize risks and changes with a focus on the stable power supply.
Digital talent	It is difficult to attract digital specialists, such as data scientists, because of its corporate image associated with analog generation.
IT system	Operate IT systems, such as SCADA, DAS, etc., on a large scale and on a mutually separate basis.

* Source: Accelerating digital transformations: A playbook for utilities, McKinsey, 2018

3. Cases of the Promotion of Digital Transformation

In all business areas of power generation, transmission, distribution, and customer solutions, costs can be cut, and profits can be created through data-based digital transformation in which unique competencies are combined with digital technologies, such as AI, IoT, etc. The digital transformation has proceeded in various forms through the following: establishing an organization exclusively for digital-related matters, conducting M&A using external competence, cultivating startups, encouraging internal digital training and culture, etc.

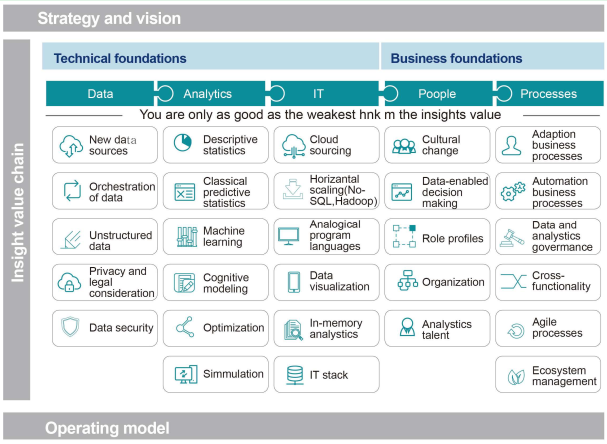
Framework of Digital Transformation



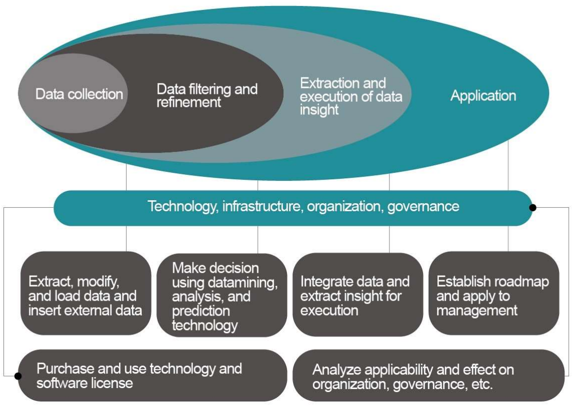
3.1 Digital Technology

The concept of digitalization has continued to evolve as data processing and transmission technologies advance. In the past, digitalization meant to convert analog signals into the binary system. However, digitalization has evolved to developing an environment to improve connectivity and share data. This change promotes the development of the components of digital technology, such as communication networks, IoT platforms, robotics, etc. Thus, it is important to develop a data-driven management environment that combines unique business competence with digital technologies, such as data utilization, IT infrastructure, and analysis algorithm, for the value creation process that contains data collection, insight extraction, and business application.

<Components of Data-Driven Management Environment>



<Data-Based Value Creation Process>



* Source: Achieving business impact with data, McKinsey, April 2018

As it is emphasized to use data insight in a power generation field, it became more important to secure digital technology capabilities. The data-driven business environment is realized by combining the following technologies closely: IT infrastructures, such as IoT and cloud; analysis technology using AI and machine learning; and technology such as AR, VR, and robot. Moreover, it is required to understand all functions and requirements for software and hardware to use these technologies.

Classification	Digital technology	Technical features	
		Hardware	Software
	Communication network	· (Requirement) Wired and wireless communication system · (Function) Collect data and transmit them using communication network	· (Requirement) Standardized communication protocol · (Function) Guarantee interoperability among devices
	Cloud computing	· (Requirement) Large-capacity remote server · (Function) Provide fee-based large-capacity data storage and processing service	· (Requirement) Sophisticated support service · (Function) Support data processing, security, etc. · (Representative companies) Amazon, Microsoft
	IoT platform	· (Requirement) Digital sensor and computer chip	· (Requirement) Data management platform

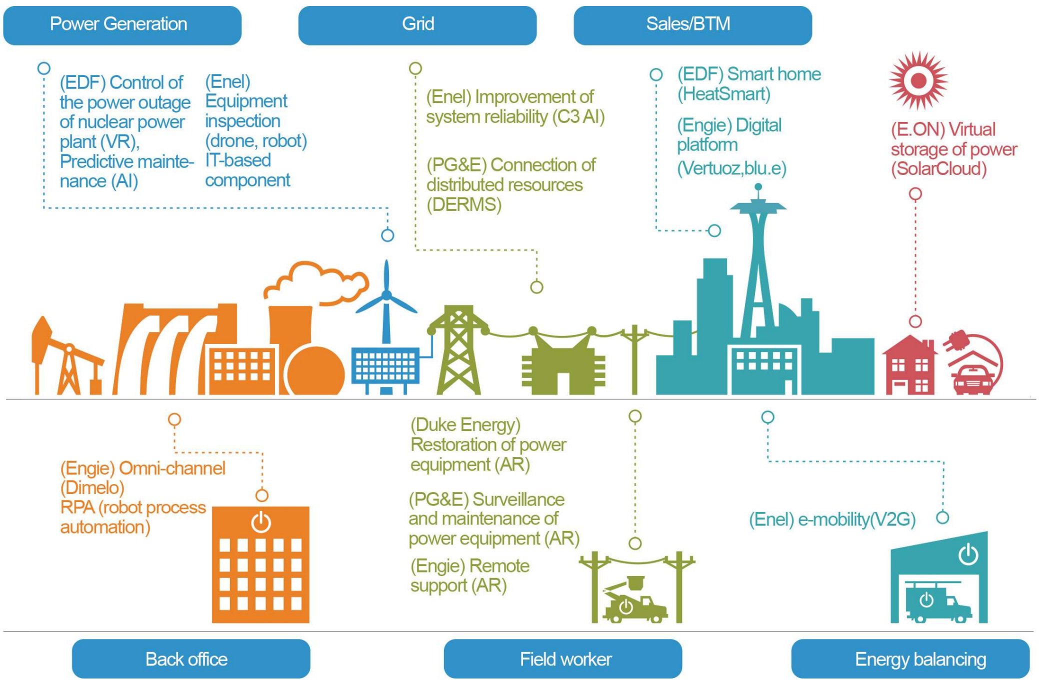
IT Infra-structure		· (Function) Obtain information on internal and external environments, such as temperature, light, vibration, etc. · (Representative companies) Infineon, Bosch	· (Function) Collect various forms of data and convert them in analyzed forms · (Representative companies) GE, Siemens
	Blockchain	· (Requirement) Distributed ledger-sharing network · (Function) Apply to the data processing of IoT infrastructure facilities, such as power network, EMS, etc.	· (Requirement) Distributed dealing system · (Function) Realize distributed energy transaction based on the local community · (Representative companies) LO3 Energy, Slock.it
Data insight	Data analytics	· (Requirement) Computer chip exclusively for AI · (Function) Manage complex and repetitive operation processing · (Representative companies) Google, Nvidia	· (Requirement) Analysis algorithm (AI, machine learning) · (Function) Analyze big data pattern and improve operational efficiency · (Representative companies) Google, IBM
	Digital twin	· (Requirement) Sensor within physical assets · (Function) Use communication network and transmit operational information of assets regularly	· (Requirement) Physical asset virtualization S/W · (Function) Provide real-time operational information in real time and predict its future performance · (Representative companies) GE, Siemens, Hitachi
	Augmented reality, virtual reality	· (Requirement) Portable smart device · (Function) Provide training and information for field workers and engineers	· (Requirement) Contents development S/W · (Function) Project working information (augmented) and realize the training environment (virtual) · (Representative companies) Vuziz, DAQRI, Scope
Creation of new value	Robotics	· (Requirement) Controllable machine equipment · (Function) Perform an operation repetitively (robot) and provide remote information (drone)	· (Requirement) Machine equipment control S/W · (Function) Construe instructions of human and computer, induce machine movement · (Representative companies) Fanuc, ABB, Kuka

* Source: Utility digitalization: Tech, strategies, and progress, BNEF, April 2018

3.2 Applicable Field and Case

Global utility enterprises apply digital transformation as their core business strategies to the whole field of the value chain in an electric power industry from power generation to electric power sales.

<Case of the Application of Digital Transformation to the Whole Value Chain>



* Source: McKinsey & Company, Reorganized by adding utility cases

3.2.1 Transmission and Distribution

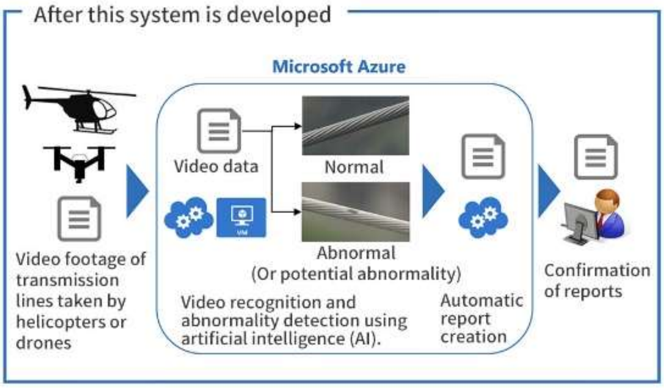
The power transmission and distribution fields utilize big data from the power grid to improve the O&M (operation and maintenance) process and grid reliability. In addition, the digital transformation is applied to maintain a power network, optimize investments, and increase the receptivity of new renewable energy but the motive to do so can change depending on a jurisdiction's requirements. For instance, in the United States to better manage the transmission network stably and efficiently, there is an increased effort to manage the efficiency of transmission lines and the decentralization of distribution systems given the need for investments in overhead electric lines. On the other hand, Europe prioritizes digital transformation related to increased penetration of renewable resources into grids and disseminating of smart meters.

Application	Expected Effect		Digital Technology		Application Case
Predictive maintenance	·Cut operating expenses ·Prevent facility malfunction		·Sensor, cloud computing ·Data analytics		**[PG&E, US]** ·Predict facility failure in advance
Monitoring	·Understand the current state of power flow and congestion in real time	→	·Sensor, digital twin ·Power distribution control system	→	**[Terna, Italy]** ·Increase of available capacity of electric network
Power Failure control	·Cut operating expenses and customer service costs		·Sensor, smart meter ·Data analytics		**[Iberdrola, Spain]** ·Control breakdown and power failure in the distribution network

Personnel operation	·Improve operation productivity ·Improve operation stability	·Sensor, drone ·Augmented reality, data analytics	**[TEPCO, Japan]** ·Automate the reading of the power transmission line

※(TEPCO) Automation of the process to diagnose power transmission lines

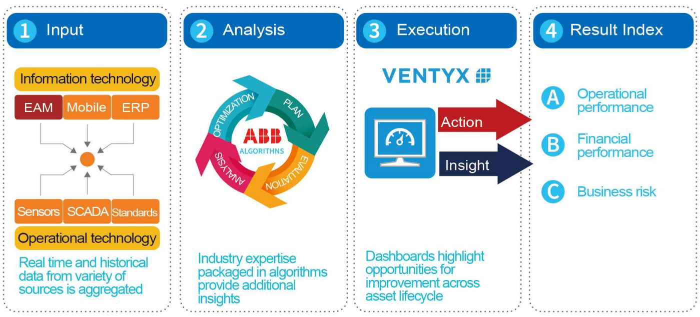
In collaboration with Tecnos Data Science Engine ering, Inc. (TDSE), TEPCO developed a system that utilizes artificial intelligence (AI) to automatically detect transmission line faults from video footage captured by helicopters flying over power transmission lines in mountainous areas that have limited access for maintenance workers. Through the development of this system, it is able to automatically detect faults from video footage taken by drones for transmission line inspection work..



*source: TEPCO website

※(AEP, US) S/W-based asset management system of transformation facility

In cooperation with ABB, AEP has developed and applied VENTYX, a transmission facility asset management system, which collects data through various monitoring systems, such as sensors, etc., analyzes such data in Asset Health Center (AHC), and provides the owner or manager (utility) of an asset with information regarding facility maintenance to be used in an operation instruction to field workers.

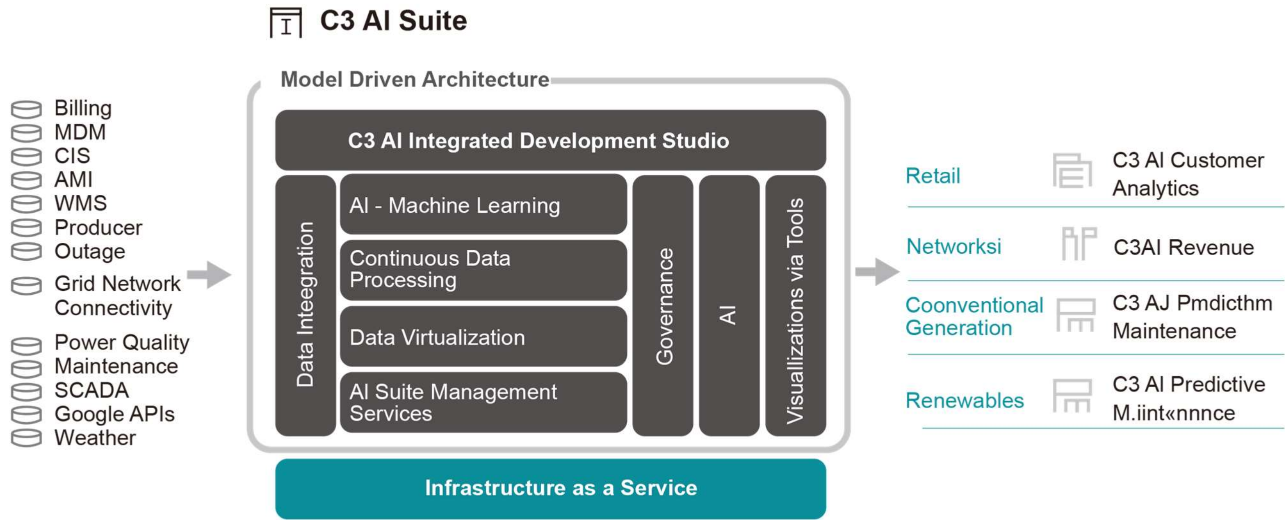


* Source: VENTYX AN ABB COMPANY

※ (ENEL, Italy) C3 AI Fraud detection and power distribution predictive maintenance

In cooperation with C3 AI, ENEL developed the C3 AI Fraud Detection application. It uses advanced AI capabilities to prioritize potential cases of non-technical loss at service points, based on a blend of the magnitude of energy recovery and likelihood of fraud. The system integrates and correlates 8 trillion rows of data from 83 Enel source systems and 218 data integrations into a unified, federated cloud image in near-real-time, running on Amazon Web Services. Using analytics and more than 300 machine learning models with thousands of machine learning features, it continuously updates probability of fraud for each customer meter.

To improve grid reliability and reduce the occurrence of faults, E deployed the C3 AI Predictive Maintenance application for f control centers. The application uses AI to analyze real-ti network sensor data, smart meter data, asset maintenance recor and weather data to predict feeder failure.
The system provides a holistic view of Enel's operating assets integrating data from eight disparate systems (SCADA, G Topology, Weather, Power Quality, Maintenance, Workforce, W Management, and Inventory) and presents relevant, actiona insights.



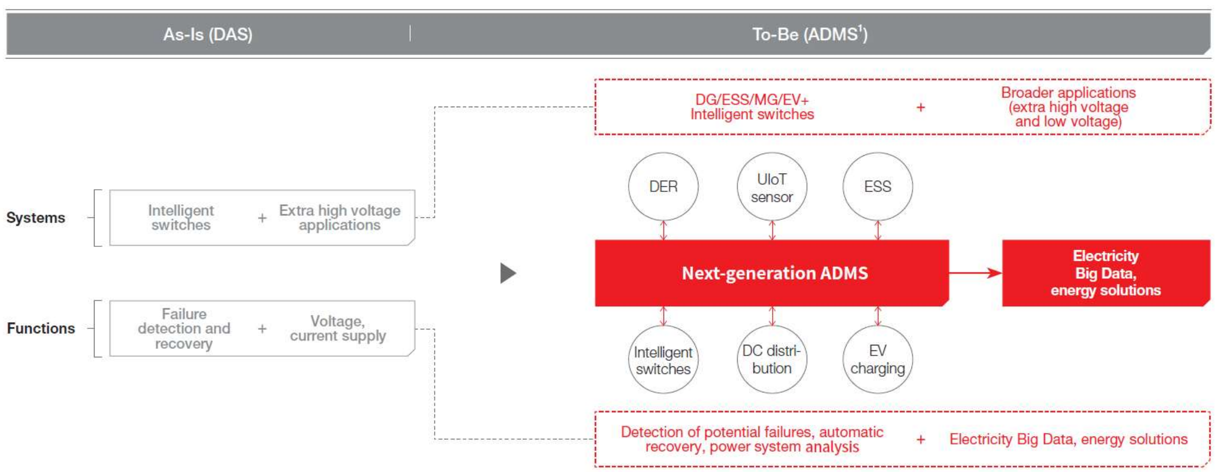
*source: C3 AI website

※(KEPCO, Korea) Development of the next-generation distribution automation system

As a comprehensive control system using IT and power operational technology, DAS (Distribution Automation System) monitors and controls remotely scattered distribution switches and collects operational information, such as voltage and current automatically, as well as identifies a breakdown section. In 1998, KEPCO adopted the automation system and, in 2017, installed 110,295 intelligent switches, accounting for 62.6% of the whole distribution line switches. Moreover, utilizing the DAS system, KEPCO can optimally operate the distribution system by monitoring the line information and controlling the intelligent switches in 41 distribution centers. Thus, power transmission became possible within 3 min in the case of a failure in the distribution line, and the outages per household became the shortest in the world

Furthermore, KEPCO is developing the advar distribution management system (ADMS), which will the Fourth Industrial Revolution in the distribution spending research budgets of about USD 28 million 2020. ADMS, to which the ICT convergence technol such as AI, VR, AR are applied, provides integrated en solutions with big data of power grid and controls energy business. To prepare for future distribu environment, including the expansion of dispe generation and smart grid, KEPCO has developi new conceptual grid operational technology, “Self-Hea DAS,” which enables automatic identification malfunctioning section and noninterruption of pc supply. KEPCO is planning to improve its distribu automation rate from 50% as of today to 90% by 203 satisfy customers’ need for high-quality electric power

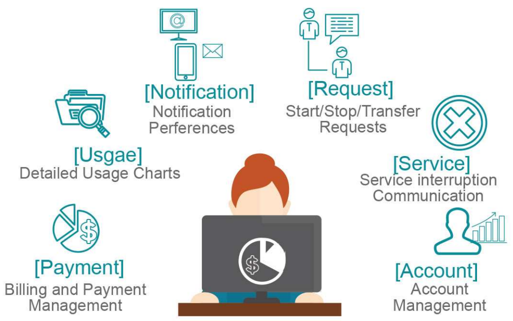
<Distribution automation system>



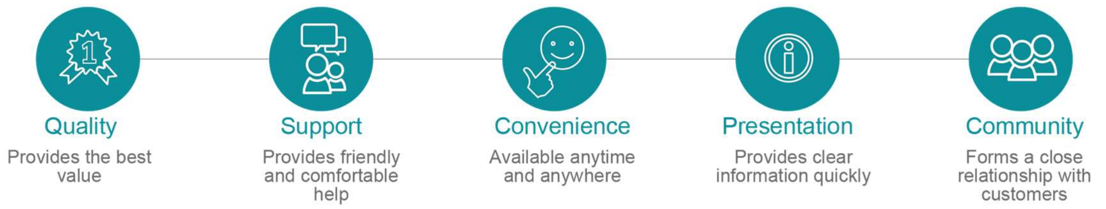
3.2.2 Customer Service

In the field of customer service, the digital transformation can live up to the expectation of customers by providing a differentiated service through various channels and improving customer satisfaction by responding to customer complaints in real time. In particular, the following services can be provided: acceptance and response to complaints using a chatbot and mobile app, energy-saving consultation, advice on rates, etc. Using the Digital Self Service stated above, customers can immediately report a failure and a blackout and request to restore the service or be provided with a rate plan customized based on the breakdown of his/her electric charges. Utility enterprises collect meaningful data and analyze spending patterns by integrating data from each channel. Based on such collection and analysis, utility enterprises can understand the needs of customers and develop successful customer experiences (CX).

<Overview, Features, and Merits of Digital Self Service>



- Software-based, flexible, and cost-efficient software as a service (SaaS)
- A high-performance digital application that customers can use anywhere and anytime easily and conveniently
- Provides customers with a real-time amount to be paid and a proper rate plan by analyzing data on past rates
- Provides methodology and insight for improving energy efficiency
- Updates failure information and restores system swiftly
- Cuts expenses for operating off-line service centers (personnel, facilities, etc.)



※ (Iberdrola) Energy Wallet

The energy wallet is a customized energy rate package that allows customers to manage their own energy consumption by selecting rate plans and payment methods. By charging one's Energy wallet for six months, one year, or two years in advance, customers can receive a discount at the end of every month when their bills are confirmed. It is also referred to as the "green energy package" because a new renewable energy certificate is issued for electricity consumed through the energy wallet. Moreover, it is an all-digital solution in which customers monitor their energy costs in real time through the app and website and predict their future consumption. Moreover, the energy wallet provides integrated energy management for a customer who retains multiple houses, allowing the one to add the buildings into the existing package.

※ (Engie) Digital Customer Service

Customers can report their complaints in real time 24/7 with the mobile app, website, or Facebook messenger and immediately receive a response thereto. Responding to customer needs or providing the related service within 60 min is the major principle of the Digital Customer Service. In addition, customers whose monthly energy costs are USD 300 or more are provided with intensive management services, such as pattern analysis, consultation, etc..

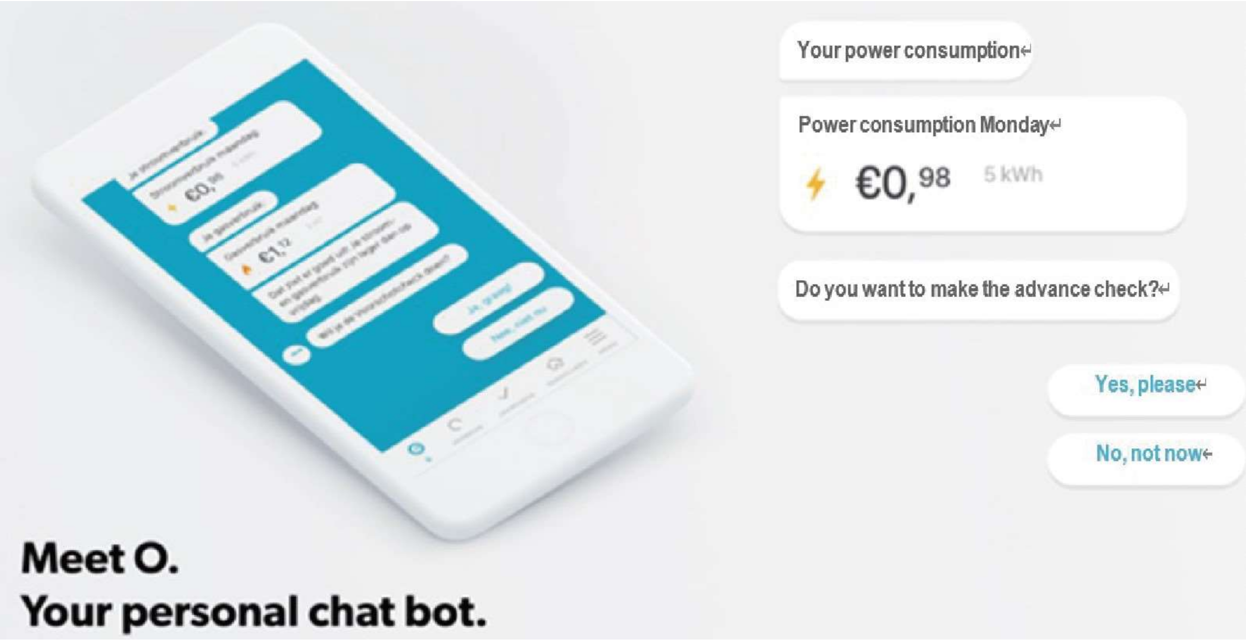
※(KEPCO) An energy marketplace where customers and enterprises in an energy field participate together

The energy marketplace is a platform where various goods and services are traded between energy suppliers and consumers, and an application utilizing power data is provided. At present, services in the field of Energy Service Company (ESCO), Demand Response (DR), and Electricity Data Service (EDS) are being provided. Moreover, the following services are scheduled to be provided additionally: open market for energy data, Energy Efficiency Resource Standards (EERS), and a fund service for the new energy industry.
By developing a platform that intermediates and supports the transactions of energy goods and services, KEPCO contributes to the mutual development of suppliers and consumers. In addition, the energy marketplace improves consumers' access to the energy market and provides small businesses and startups with a new channel for public relations.

- **(OXXIO, the Netherlands) Information on energy usage provided to consumers with a chatbot, "O"**

It provides customers with information on individual energy consumption and prior advice to save money through chatbot "O." The chatbot (text-based) is available using the Oxxio app and can be expanded and developed based on platforms, such as Apple (Siri, Voice Intelligence) or Facebook (Messenger).

※ Oxxio's chatbot, "O"



* Oxxio is a Dutch power and gas company (a subsidiary of Eneco Energie).

3.2.3 Energy Sales and New Energy Business

Digital business models can be developed for customers segmented into B2C, B2B, and B2T sections. The following relates to the field of energy new business: energy efficiency, distributed generation, smart home, e-Mobility, smart city, etc. In addition, customer value can be improved through the optimization of energy consumption (expense reduction), enhanced convenience, increased use of new renewable energy, and creation of additional revenue by market participation. Moreover, new revenue models, such as new service fares, platform utilization fees, and ancillary service fees, can be developed.

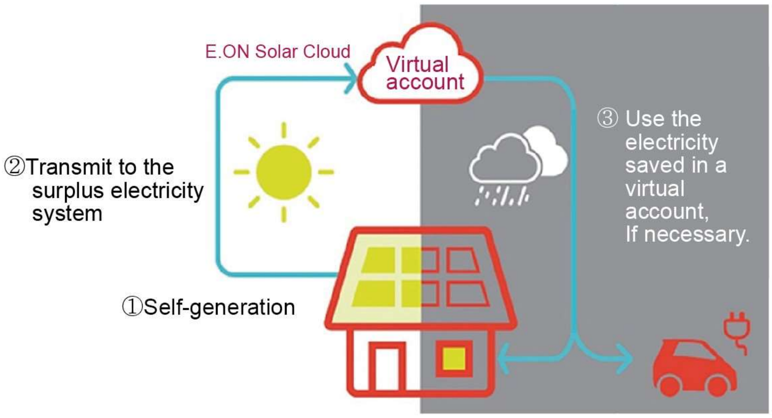
<Main Digital Business Model of Utilities (refer to [Attachment])>

Digital Technology		Business Model				Suggestion for Customer Value
Cloud Mobile App SW Platform AI IoT 3D Modeling ...	→	B2C	(E.ON) SolarCloud (EDF) Mon Soleil et Moi (E.ON) Plus, (EDF) HeatSmart (ENEL) e-Mobility Solution	- Electricity virtual storage - PV self-consumption - Electricity + Smart - Home - V2G platform	→	Cut energy costs Improve convenience Optimize EV charging Create revenues from electricity sales Participate in balancing service Construct an eco-friendly ecosystem
		B2B	(ENGIE) Vertuoz, blu.e (ENEL) DEN.OS	Digital platform		
		B2T	(ENGIE) Ohio State University (US) Energy Service, TFL Solution (England)	Smart city solution		

※ (E.ON, Germany, SolarCloud) Battery-free solar light storage solution (B2C)

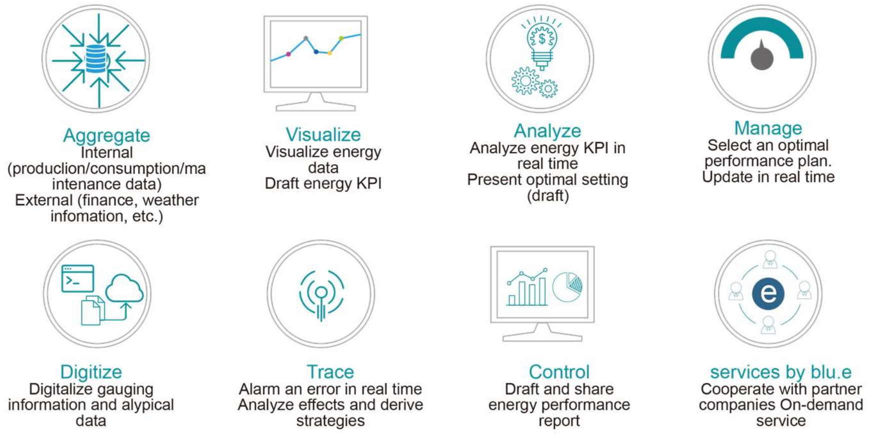
<Conceptual Diagram of SolarCloud>

Using this solution, customers can transmit self-generated surplus electricity to the system through a "virtual account," without installing a separate storage unit, and use the stored power whenever necessary. With the E.ON Manager app, customers can monitor energy consumption and charging, and utility enterprises can create revenues through service fees (about EUR 20–30 a month) and secure customers with distributed resources.



※ (ENGIE, France, blu.e solution) Energy management platform (B2B)

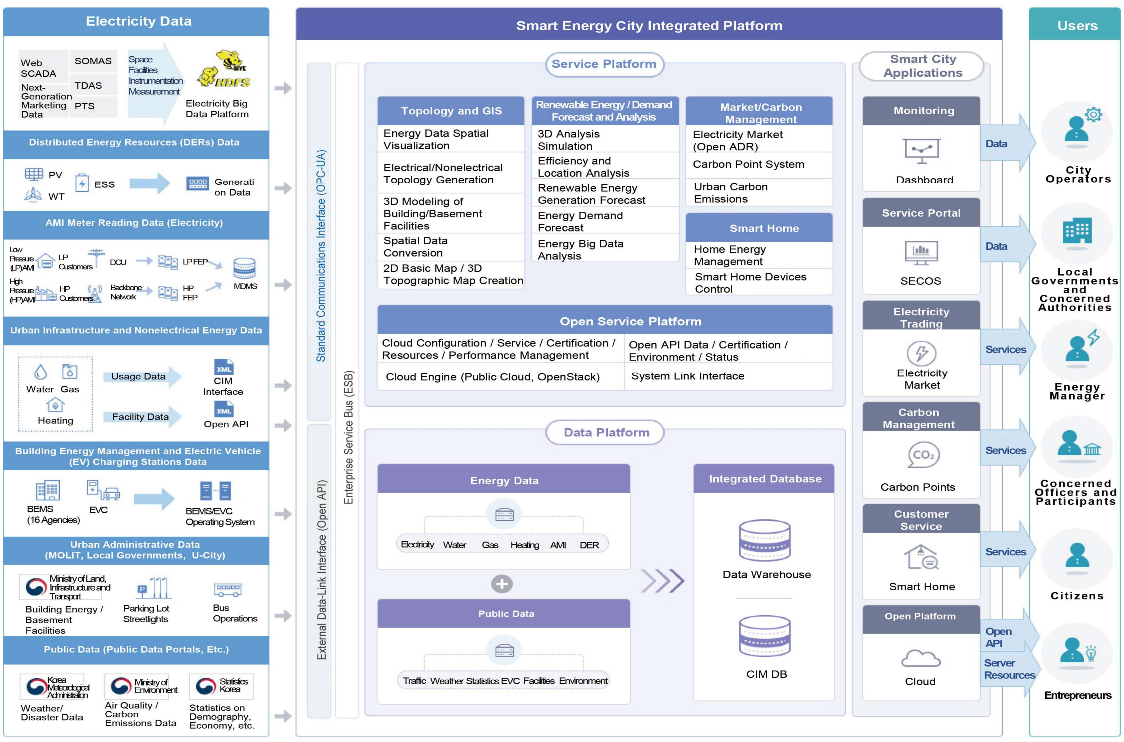
ENGIE came up with a plan for energy optimization by making an energy performance index with industrial process data. The PSA Group (automobile company in France) adopted the blu.e solution for energy optimization in the workplace (April 2017).



※ (KEPCO, Korea) Naju Smart City Project

Through the Naju Smart City Project, conducted for Gwangju-Jeonnam Innovation City, KEPCO has developed an integrated smart city operation platform to collect and utilize electricity and nonelectricity data. This platform enables comprehensive management of distributed urban energy resources, achieving better energy efficiency, self-reliance, and augmentation of renewable energy. It also helps consumers to cut energy costs and respond to climate change by reducing carbon emissions. Moreover, it can diminish grid extension expenses and unnecessary enlargement of capacity by providing energy near consumers and saving renewable energy in ESS.

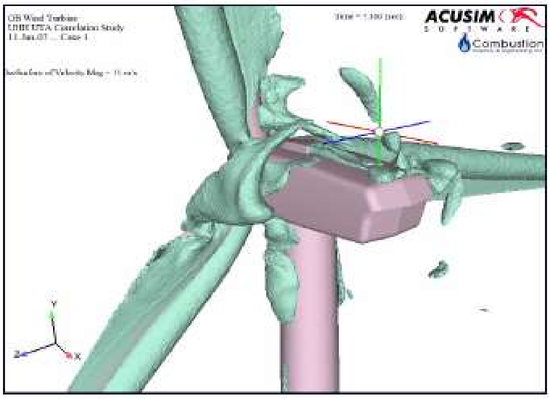
<Architecture of the Smart City Energy Integrated Operation Platform>

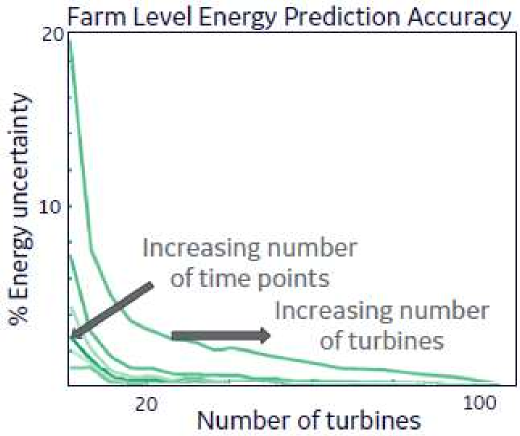


※(GE Energy, USA) An AI-applied service to improve the utilization rate of wind turbines

The sensor data and past weather data of wind power generation facilities are studied to predict the amount of power generation in 5 min – 1 hr cycles. As such, the precise prediction of the power generation amount enables efficient inspection maintenance, for example, on days when the amount of power generation is low and improves the efficiency of wind turbines (the annual power generation up by 5%; the maintenance cost down by 20%).

<Prediction of Wind Power Generation Using Data and Machine Learning>





* Source: Industrial Machine Learning, GE Global Research, 2017

Energy prediction accuracy improves as the number of turbines and data increases.

※(Upside Energy, UK) Developed a virtual energy store (platform)

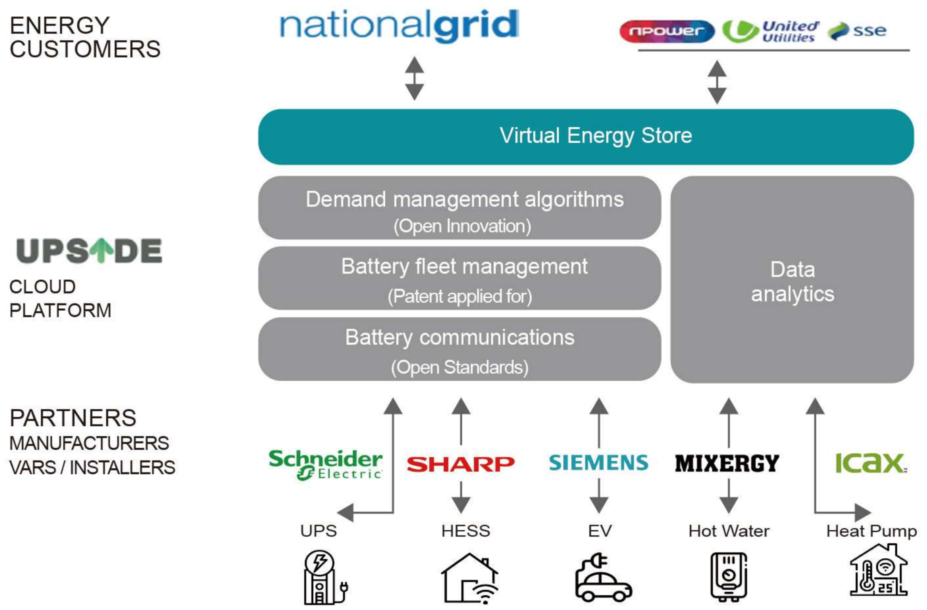
By applying AI, a virtual energy store (platform) that integrates existing small decentralized energy storage devices* and supplies reserve power to real-time systems is developed.

* UPS (uninterruptible power supply), batteries for PV for homes and EVs, water heaters, heat pumps, etc.
At present, Upside Energy's cloud-based platform connects various storage devices in more than 40 regions in the United Kingdom and is working with Heriot-Watt University to optimize the energy storage portfolio with machine learning and prognosis algorithms.

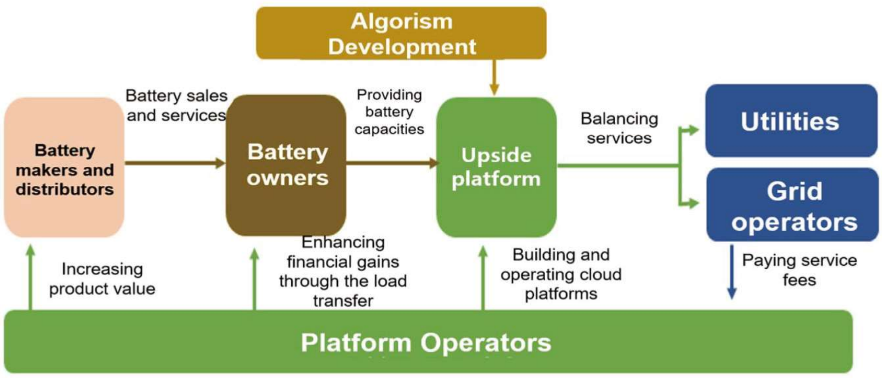
- (Machine learning) Analyzing data of smart meters and sensors to design control algorithms for individual storage devices and combine scenario-specific storage devices
- (Prognosis algorithms) Predicting the life span of a storage device through real-time monitoring

※ Virtual Energy Store of Upside Energy

Overview



Customer Benefit



※(Drift, USA) AI-based, saving on energy bills

It improves the accuracy of predicting power demand through AI-based SW and provides consumers with lower-cost power compared to conventional utilities through direct transactions. In addition, it can reduce peak load generation through the combination of machine learning, prognosis, and high-frequency trading technology and help users save energy costs by 10%–20% through peer-to-peer (P2P) trades. Moreover, it serves as a mini ISO for decentralized energy platforms in the region.

● Business Overview of Drift (a P2P energy service startup in the United States)

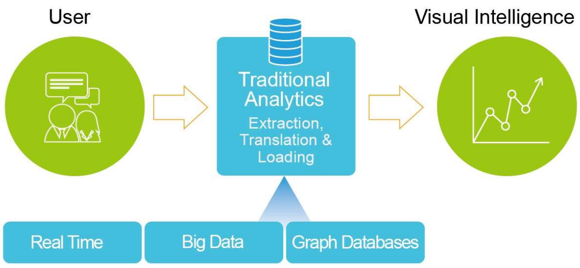
- Drift sells surplus electricity of 3,000 suppliers, including solar/battery, wind power, and large commercial buildings in the subscribed area, to home consumers at low rates.

* Facility operation is suspended because of the participation in DR during peak hours.
-Drift's revenue comes from the fixed fees (approximately USD 1/week for homes) from its users.

- It bills weekly.
- The company started the energy service in New York in 2017 and plans to expand the service area.

※(ENERGINET, Denmark) In partnership with App Orchid (an AI startup), the company is developing an AI-based grid analysis solution.

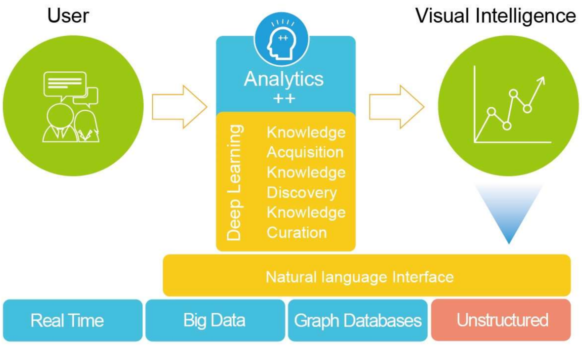
App Orchid's deep learning and natural language processing (NLP) technologies allow an analysis of power management systems and weather data, as well as unstructured data (such as stability guides and operational logs) in the forms of text (email, social media, reports, maintenance records, memos, etc.), images, and voice. Moreover, the methods of system operation are optimized for various operating conditions, such as uncertainties in the development of renewable energy because of weather (wind) volatility.



<Traditional Analytics>

· Machine learning not applied

· Impossible to process unstructured (natural language) data



<App Orchid's Analytics>

· Continuous learning and improvement; automated knowledge acquisition

· Structuring unstructured data; natural language processing

Source: Artificial Intelligence for the Utility of the Future, App Orchid, 2016

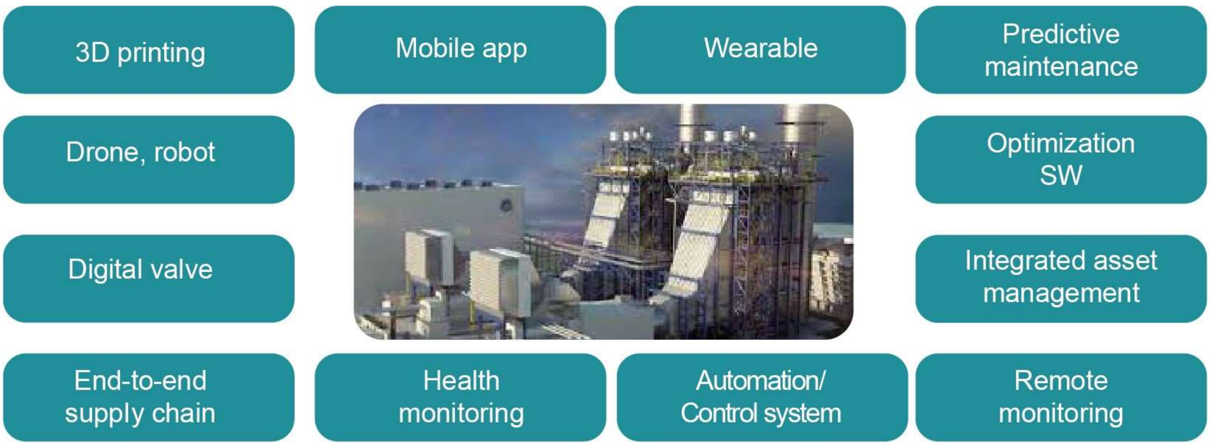
3.2.4 Power Generation

In terms of power generation, core technology and working environment can be transformed using a sensor, communication technology, software platform, etc. Digitalization is differentiated based on the characteristics of power generation sources, such as coal, gas, and wind power, with the aim of cutting O&M costs and improving the working environment. For example, the following are possible in the power generation using coals: shortening a downtime, reducing the number of failures, improving the working environment, and improving efficiency. The gas power generation can contribute to the flexibility of the system and expand the use of the reserve. Moreover, the wind power generation can improve the reliability of output prediction and develop failure response and protection system.

Application	Expected Effect	Used Technology	Application Case
Predictive maintenance	·Cut the operating expense ·Prevent facility malfunction	·Sensor, cloud computing ·Data analytics	**[Enel, Italy]** ·Thermal/new renewable facility O&M
Facility operation	·Improve power generation efficiency ·Extend facility life	·Digital twin, cloud computing ·Data analytics	**[Datang Power, China]** ·Operate gas power generation facility on an optimal basis
Weather analysis	·Predict the new renewable output ·Protect new renewable facility	·Cloud computing ·Data analytics	**[Vermont Power, US]** ·Predict wind power generation
Personnel operation	·Improve work productivity ·Improve work safety	·Sensor, drone ·Data analytics, augmented reality	**[Enel, Italy]** ·Read thermal power generator ·Educate and train workers

● **(ENEL) Digital transformation project of thermal power generation**

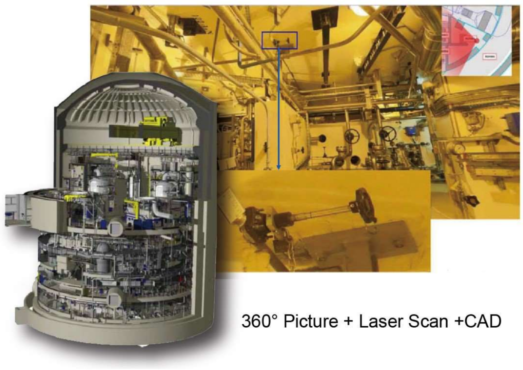
ENEL plans to achieve the digital transformation of thermal power plants by 31GW, accounting for 90% of the total thermal power generation, in 2020. This project is applied to the following: predictive maintenance planning/management, maintenance, power plant contract management, field workers, etc.



● **(EDF) Nuclear power generation**

EDF develops the automation of control through the following: VT, blackout management using 3D visualization, machine learning–based predictive maintenance, operational efficiency using mobile and augmented reality, and integrated simulation platform.

<Failure Prevention using VR>

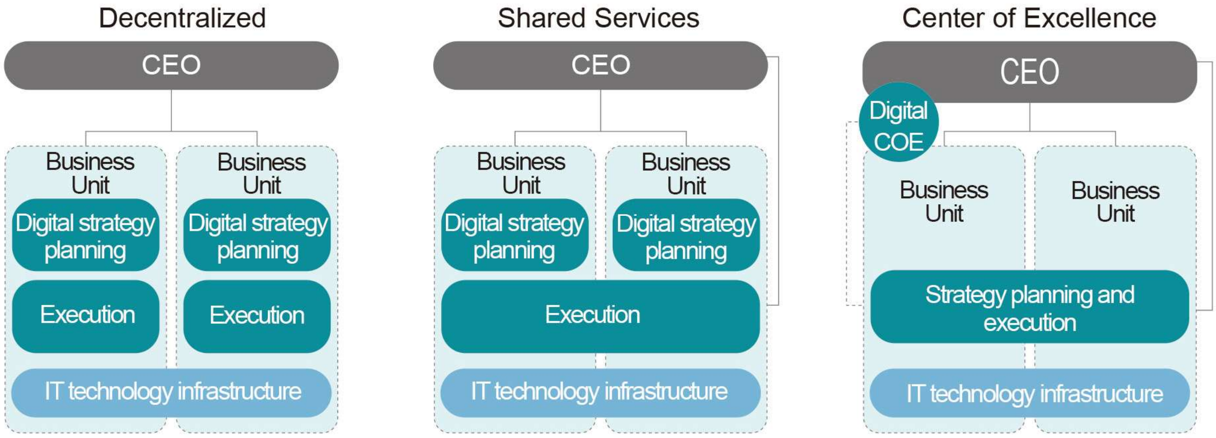


4. Enabler

4.1 Business Organization/Governance

Changing organization and governance is often required for a successful digital transformation. For example, a new organization under the direct control of the CEO can be established, which is exclusively responsible for digital transformation. As such, the organization performs the following on an integrated basis: establishing strategies, implementing projects, developing IT technology, operating system, developing R&D, etc. Thus, a decision can be made promptly and efficiently (for example, the CoE concentration model).

<Digital Transformation Model>



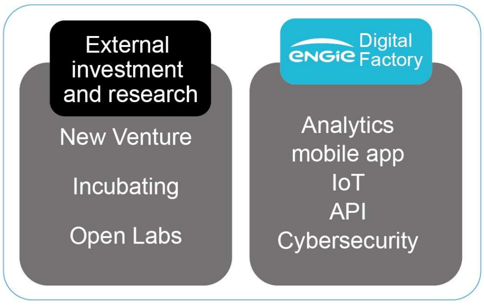
- Each department promotes digital strategy planning, execution, technology infrastructure, etc. separately.
- It is very slow in making decisions.

- The digital strategy execution and IT technology infrastructure function by the department is integrated with the CEO's authority.
- It is rather quick in making decisions than the decentralized model.

- CoE (exclusively responsible organization) supervises the whole process from strategy planning to execution.
- It is very quick in making decisions.

● (EDF) Nuclear power generation

In October 2016, the Engie Digital was established for the efficient execution of a digital project. It is composed of 50 staff from Engie (25 staff) and its partner company (25 staff). Moreover, it operates the Digital Factory, which develops IT systems and platforms, with a focus on mobility, big data, and IoT core technology SW. Engie Digital also supervises the following: establishing strategies for digital business, developing IT using internal and external R&D technology, and executing businesses.



Furthermore, it is advised to appoint a Chief Digital Officer (CDO) who should be ensured to have an authority to develop strategies and technologies based on respective businesses and spread internal digital culture. He/she shall act as a digital front officer who has the ability to establish and design digital-related business strategies and understand new technologies. To carry out efficient digital transformation and spread digital culture, the CDO can be appointed by turns in the CDO pool.

<Roles and Domains of the CDO>

♦The CDO focuses on seizing a new digital business opportunity and create values	
Roles and responsibilities (R&R)	• Establish digital strategies and plan businesses (analyze the trend of new technologies and reflect the same in businesses) • Select digital channels • Manage digital agency • Plan and execute digital programs: public relation (SNS), sales (e-commerce), services • Manage the life cycle of digital contents and assets • Manage database (analyze big data) • Manage digital experience with a focus on customers • Develop technology (develop a mobile app) • Manage digital brand image
Required abilities	• Understanding of the relevant industry • Ability to establish and plan business strategies • Ability to perform marketing works • Understanding of new technology

● (E.ON) Scouting digital sales manager from the external organization for appointment as the CDO

In August 2016, E.ON scouted an external expert as a CDO who had fulfilled various digital transformation projects, such as e-commerce, mobile digitalization, and market segmentation, in a multinational bank, General Motors, SAP, etc. Then, the CDO established the Digital Business Unit and promoted the following: developing big data solutions, providing service customized for the digital market, digitalizing process, etc.

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- **(ENGIE) Operating Engie Digital with the internal HR pool**

A total of 24 Chief Information Officers (CIOs) acted as CDOs in turn. Then, the CDOs operated the Customer Hub Team composed of customer experience specialists and strategy planning experts, as well as the Factory House Team composed of technical experts, architects, and cybersecurity experts.

- **(EDF, France) Nurturing internal experts as the CDO**

Since 2015, the EDF Group has appointed 12 CDOs by major business units, such as nuclear, water, and new renewable power generation. With the core competence in the respective business areas, the internal experts have fulfilled digital transformation tasks and become CDOs in the field.
(Example) A digital talent who majored in mathematics and computer application in college joined a company as a data analyst, after five years from his/her joining, as a system operation manager (four years in this office), policy advisor (two years in this office), and then an e-commerce CDO.

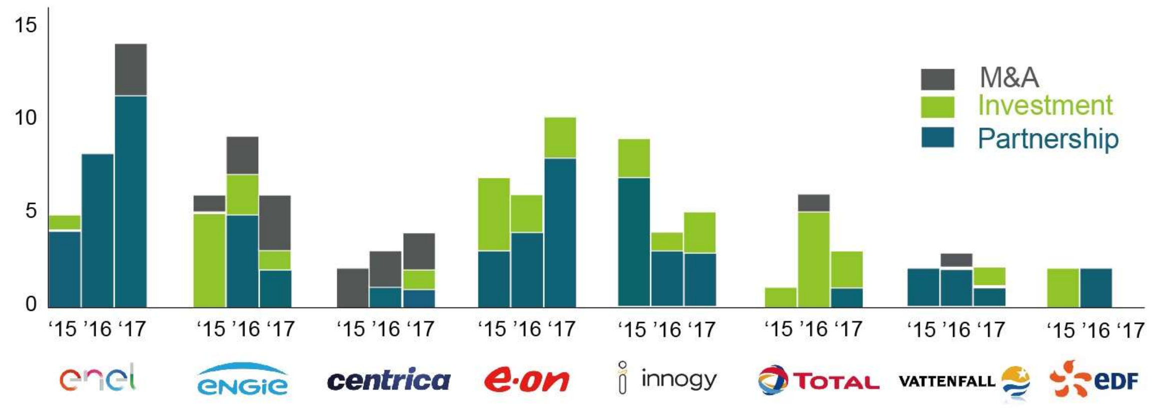
- **(KEPCO) Establishment of the Digital Transformation Office to leap forward as an energy platform supplier**

KEPCO established the “Digital Transformation Office” to respond to the change of industrial paradigm led by ICT technology. The Digital Transformation Office is composed of 38 staff and is responsible for the following: planning digital and platform policies and developing big data and solutions. At present, such office performs the following roles: developing a data integration platform; collecting and analyzing internal and external data generated from the existing power generation facilities and system; analyzing big data and providing a development solution based on AI; and supporting the creation of new data value, such as the development of an app, S/W, etc. Moreover, the Digital Transformation Office provides a function to analyze big data by linking 261 systems and 36 agencies and AI development tools for deriving data insight, such as deep learning, natural language processing, image recognition, etc.

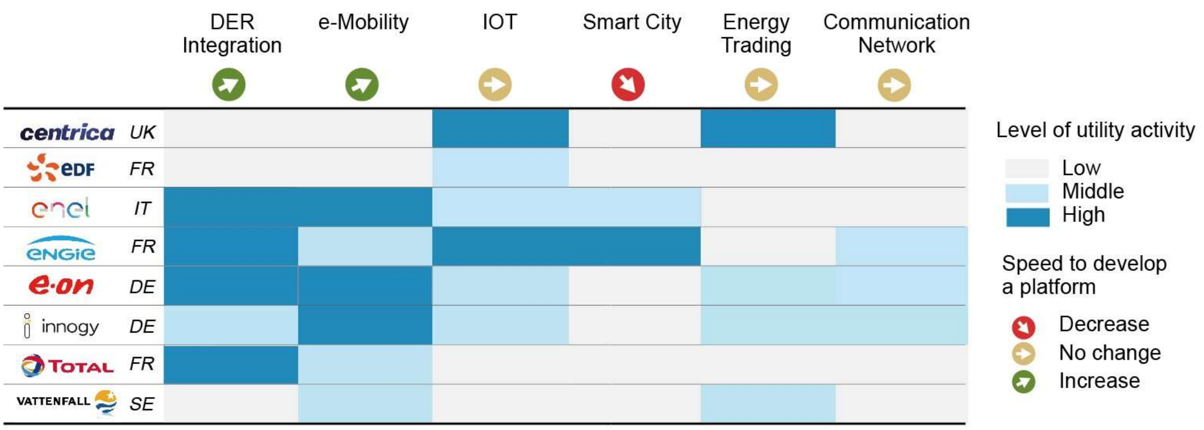
4.2 Partnership/Investment

Another enabler relates to digital transformation is to take advantage of external expertice. This means using external competence in areas, such as venture capital investment, M&A, or partnership among specialized companies, other utility enterprises, universities, and research institutes. From 2015 to 2017, ENEL, ENGIE, and Centrica had actively implemented the corporate takeover. In addition, E.ON and Innogy had utilized external competence by developing partnerships. In particular, they are focusing on establishing partnerships with enterprises that have technology specialized in integrating decentralized resources and developing e-Mobility (electric vehicle) platforms.

<Current State of Partnership and Investment of Utilities in Europe(2015–2017)>



<Current State of the Promotion of Digital Transformation by Sector (2015–2017)>



● (ENGIE) Nurturing and takeover of startups through incubation platforms

ENGIE develops startups using its 14 incubation platforms in 5 countries. Among them, Engie New Ventures is nurturing startups for digital transformation solution in an energy sector with EUR 115 million. In addition to support startups, ENGIE is also taking over the related technology by merging and acquiring startups that develop the SW platform or solution.

● (ENEL) Support for startups by investing in VC and establishing partnerships with research institutes

ENEL has supported 2,300 startups by establishing Accelerator* and investing in IoT, big data, and security technology. Moreover, ENEL supported the startup campus program of the University of California by establishing partnerships with CITRIS and the Banatao Institute of UC Berkley. Furthermore, ENEL established 7 global hubs and developed 21 innovative partnerships.

* An organization that helps startups to grow by not only investing capital but also providing training, mentoring, knowledge in marketing, public relations, etc.

4.3 R&D / Personnel / Organizational Culture

Another important requisite for success is the creation of digital culture by operating in-house training programs and fostering human resources to develop technology for digital transformation. For example, this includes introducing learning programs in the digital academy and operating research institutes for each technology sector. In this culture, members can cultivate a digital mind-set and be trained to become internal human resources for technology development.

※ (ENGIE) Operating the digital online learning platform and research institute

[Operating the Digital Academy]
The HR department in ENGIE shall provide the employees with an online digital learning platform for their acquisition and application of new technology. The Academy spreads the digital culture by executing the digital transformation strategies and projects of the group. Moreover, it educates the trainees so that they could be placed in the related departments.

[Development of Engie Labs, an in-house innovation hub]
Engie established nine research institutes, each of which is specialized by country and digital transformation technology sectors, for developing technology and training its human resources. The in-house innovation hub discovers ideas on the digital transformation from group members and promotes the development of smart solution technology.

* The R&D Cofely Ineo Lab operates the following labs: data analysis lab; IoT, sensor, and nanotech lab; mobile app development lab; cybersecurity lab; power grid modernization lab; 3D printing lab; and robot, drone, and AR lab.

<Current State of the Operation of Engie Labs by Region and Specialized Technology>

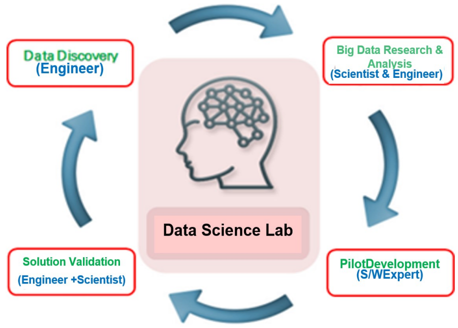
● (E.ON) Development of Energy Research Center and R&D investment

Since E.ON established its energy research center (ERC) in RWTH Aachen University in Germany in 2016, E.ON has focused on investing R&D for digital transformation and training their talents. ERC can be classified into the following four institutes by research subject:

- ⁎ Automation of Complex Power Systems
- ⁎ Energy Efficient Buildings and Indoor Climate
- ⁎ Future Energy Consumer Needs and Behavior
- ⁎ Power Generation and Storage Systems

- **(KEPCO) Operation of Data Science Lab**

- In March 2019, KEPCO established the Data Science Lab to develop and improve business models using AI and Data Mining
- At present, the Data Science Lab is composed of 32 experts and can be classified into 3 teams, such as the data processing team, data analysis team, and prototype development team.
- The Data Science Lab focuses on sophisticating the anomaly detection and error prediction in electric power facilities and fulfilling the projects, such as systemizing failure data of facilities and developing core algorithm/ function in asset management



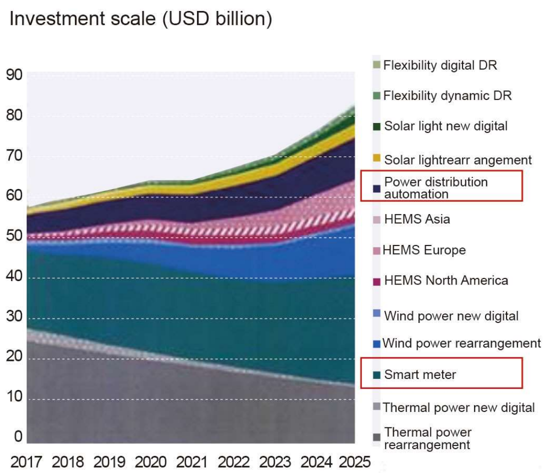
5. Effect of Digital Transformation

Investing in digital transformation may lead to the reduction of expenses related to the energy system and generate additional profits from new business models, such as smart meter, renewable/DER centered distribution automation, home energy management system (HEMS), etc. In terms of customer solutions and the power transmission/distribution of utilities, the performance for investment is somewhat low in the medium and short term. However, such performance is predicted to increase in the long term.

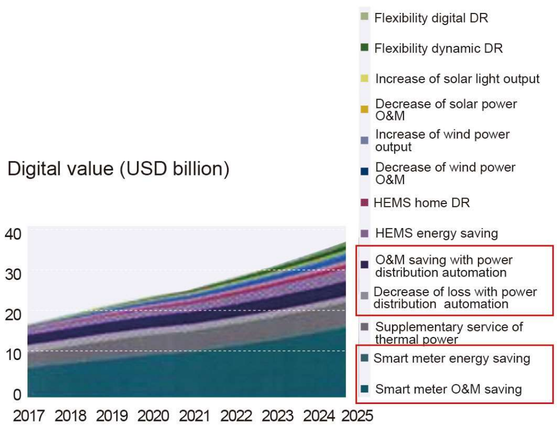
5.1 Cost/Benefit of Digital Transformation

As of 2025, an investment of USD 81 billion is predicted to be required for digital transformation in the energy sector. The volume of new profits and saved costs is expected to reach USD 38 billion. The saved costs mainly come from the investment in power supply facilities. The investment cost for smart meter and HEMS will continue to increase while the investment in thermal power generation will gradually decrease. The benefit mainly comes from the cost reduction by utilizing digital technology such as smart meter, power distribution automation in utilities and data based maintenance in power generation companies and power system operators. However, the benefit of thermal power generation would continue to increase, unlike the costs (investment).

<Annual Investment in Digital Transformation in the Energy Sector>



<Annual Market Scale of the Digital Transformation>



Smart meter	Power distribution automation	HEMS	Flexibility	Thermal power generation	Wind power O&M	Solar light O&M
Enablers to expand digitalization		Support for new renewable linkage		Cost cutting of system		

* Source: Costs and Benefits of Digitalizing Energy, BNEF, 2018

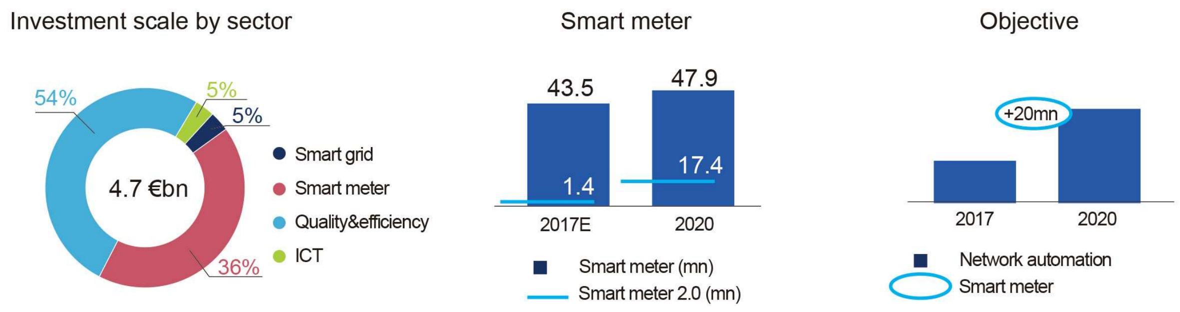
** The costs and benefits of digitalization differ because of the time difference in reflecting the value of digitalization.

5.2 Result of Utility Digital Transformation

5.2.1 Utility Transmission and Distribution

Efficiency of transmission and distribution line is improved by investing in smart meter dissemination, network automation, technology platform and the benefits such as linking DER are newly generated. With facility investment (EUR 4.7 billion in smart meter dissemination and network automation from 2018 to 2020), ENEL is expected to reduce a power loss rate by 5% compared to 2017 and EUR 200 million of cost through efficiency elevation in 2020. Moreover, Iberdrola has invested EUR 3 billion in the digital transformation of grid networks, such as introducing smart meter and adopting data analysis, and will additionally invest EUR 3.9 billion for the expansion of digital platforms (2018–2022). Through these investments, failure recovery competence has been improved, and the number of variables[1] has been reduced through big data analysis. Furthermore, it is predicted that from 2018 to 2022, the benefit of approximately EUR 500 million would be generated, and the service quality would be improved by approximately 20% through the dissemination of global technology platforms.

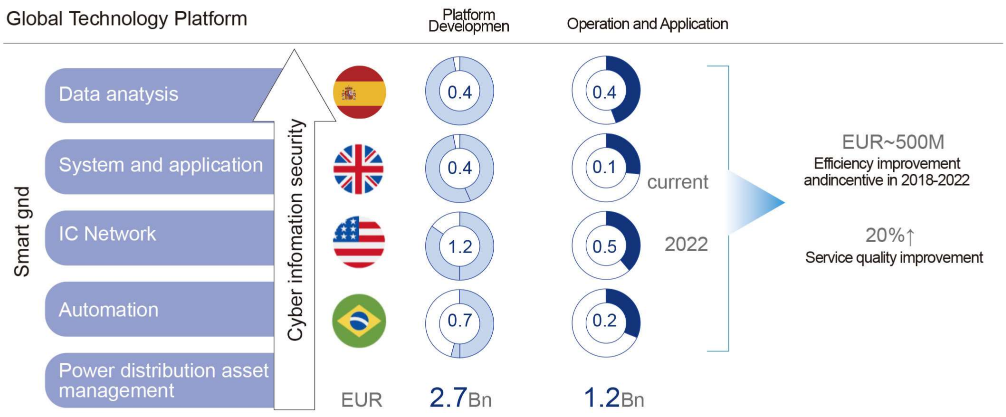
<Investments and Objectives in the Digitalization of Transmission and the Distribution of ENEL>



Project		Outcome
Network operation	Virtual operation, self-help	· **Improve failure recovery by 1.8 times** (Recover within 3 min: 33% (2010) → 59% (2017))
Big data analysis	Analysis of 70+TB data	· **Benefit from the decrease in difficult problems (EUR 17 million annually)**
Smart meter dissemination	10.4 mn of the smart meter (2017)	· Secure customer load data of 240 mn daily
DER linkage	Integration and control	· 2.4 GW (peak contribution level of 1.6 GW) · Decline of output control by 57% (131 min (2007) → 57 min (2017))

[1] It includes unauthorized use without making a contract for electricity use

<Strategy and Prospect for Global Technology Platform of Iberdrola (2018–2022)>



5.2.2 New Energy Business

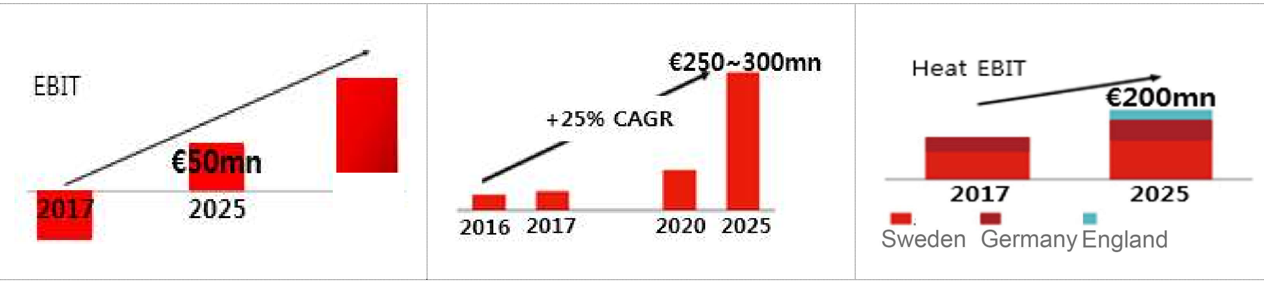
Even if a digital business model emerges as a new source of revenue of suppliers/retailers, its outcome is yet insignificant. However, the business will be notably expanding considerably under the medium- and long-term objectives. In the case of E.ON, it is predicted that in 2025, the target EBIT[2] in customer solution sector would be EUR 550 million, which will account for about 14% of the whole sector[3], and that B2B profitability would increase by 25% every year compared to 2016. In addition, the customer solution of ENEL (EBITDA2) was increased from EUR 100 million (0.6% of the total in 2017E) to EUR 400 million (2.2% of the total in 2020).

<E-Solution Business Field (Gross Margin: EUR 400 million (2017E) → EUR 1 billion (2020)>

B2C **EBIT EUR 50 Million (2015)**	**B2B** **EBIT EUR 250–300 Million (2025)**	**B2M (Municipalities)** **EBIT EUR 200 Million (2025)**
Electrification of home and mobility	Leading of energy service	Partnership between city and community
· **PV+battery** - E.ON Aura (PV+ battery +app) - SolarCloud (Virtual electricity storage) · **Smart home** - E.ON Plus · **Residential heating** - Sales of heating apparatus (Boiler, heat pump, fuel cell)	· **Distribute power supply solution** - Power generation in the demand area (CHP, fuel cell, PV) · **Energy efficiency solution** - Diagnosis, operation, data analysis · **Flexibility and storage solution** - Integrate resources from new renewable/thermal energy - Provide a P2P solution · **Digital energy solution** - Optimize energy analysis and asset operation	· **District heating** · **Integrated urban energy solution** - Share surplus air conditioning and heating energy through the “ectogrid” system connected to buildings in the city and optimize energy consumption

∗ EBIT(Earnings Before Interest and Tax), EBITDA(Earnings Before Interest, Taxes, Depreciation,and Amortization)

∗ It is presumed that an annual average EBIT growth rate of E.ON (CAGR) would be 3% (the total EBIT in 2025: EUR 3.9 billion).



e-Mobility Solution

* Specialized rate plan: E.ON SolarCloud (EUR 21.99/month), E.ON Fixed Two-Year tado° Bundle (Electricity + automatic thermostat, GBP 1,223/year)

Classification	B2B	B2C	B2C-B2B-B2G	B2G
Contents	Consultation and diagnosis service Distributed power supply Energy efficiency DR, Demand Management	Installation and maintenance Home automation management Financial service (credit card) Home 2 Grid	Public charging station Private charger Maintenance and service V1G, V2G	Smart lighting Fiber optic network Distributed power supply Energy service DR, Demand Management
Revenue Source (2017)	· Energy service · DR flexibility service - Use digital platform* - 14,000 C&I, 5.7 GW - Gross margin EUR 80 million	· Distributed power supply (PV, battery) · Home service (Iberia) - Gross margin EUR 66 million · Financial service (Columbia) - Gross margin EUR 9.6 million	· Charging Service · V2G platform, Flexibility - Taking over of MotorWerks	· Open Fiber - 150k fiber km - 2.4 million households - EBITDA (2018): EUR 50 million

* Secure by taking over EnerNOC, Demand Energy

6. Conclusion

A lot of companies share the need for digital transformation as it is already at the center of change, and several firms across different sectors recognize that rapid response and adaptation are needed because the spread is swift. As the number of new sales business operators increases in Europe, the United States, and Australia, and the demand for electric power decreases during the past 10 years, the competition among utilities intensifies. Thus, such operators pay attention to the digitalization of the electric power industry to strengthen competitiveness and secure profitability.

However, even if most of the utilities expressed their will for digital transformation from years ago, the digital transformation has not been promoted in earnest. The core of digital transformation is to transform a business into an active digital-attacker. Therefore, utilities and the government are required to cooperate in building a digital and customer-oriented corporate culture, overhauling related laws and regulations, and addressing social consensus and job issues to ensure the successful digital transformation of utilities and the safe-landing of energy transition therethrough. As such, the present publication examined the future direction in two different levels: the role of utilities and public policies.

First, establishing the foundation for organizational culture is essential to promote the digitalization of the electric power industry. Thus, an energy company is required to newly establish a dedicated digital organization directly under the Chief Digital Officer (CDO). This dedicated digital organization shall be guaranteed for its authority to plan, execute, and determine businesses in a digital sector and supervise the following matters: establishing and executing strategies, developing IT technology, operating a system, etc. As such an organization establishes strategies, performs businesses, and carries forward R&D, utilities can make their decisions promptly and efficiently.

A successful digital transformation shall be preceded to develop not only the physical foundation for digital architecture and infrastructure but also the organizational culture for digital transformation.

Second, customer-oriented culture shall be accepted. As the digitalization of the energy market accelerates, digital enterprises shall satisfy customers' needs, which tend to be diversifying and complicated. For example, consumers can participate in a local microgrid or trade energy through blockchain and act not as a consumer but as a prosumer. As such, enterprises can improve their service using digital technologies, such as a chatbot, mobile application, etc., and generate new profits by developing customer-centered business models, such as the establishment of energy platforms, receipt of fees for platforms and supplementary service, etc.

Third, In 2016, the World Economy Forum forecasted that 7.1 million jobs would be lost globally in five years because of the digital transformation, whereas a total of 2.1 million jobs would be created. The less a job requires the social cognitive ability, creativity, perception, and application, the more the job would be replaced by automation. In the digital transformation era, job issues are expected to become prominent in the future.

As such, enterprises must approach job issues with new business models and expanded business areas. Internally, they should expand the market with investments in new digital technology-based businesses and continue to generate demand for new jobs. On the other hand, externally, they should strive to expand cooperation channels with other firms and create an ecosystem for the power industry by building platforms. For example, Common Wealth Edison (USA) retained 500 meter personel who were on the verge of losing their jobs by retraining and transferring them to other jobs, such as smart meters installation, customer counseling, and power distribution. Meanwhile, Centrica, a British company, established a platform called “Local Heroes,” an intermediary service platform that connects personal engineer services, such as plumbing, electricity, and repair to consumers, aiming at enhancing flexibility in the local labor market and generating new revenue through service fees.

Therefore, companies should train core talent through the establishment of HR strategies linked to digital transformation and provide opportunities for transition through retraining/relocating human resources. In terms of securing core talent, it is essential to present clear digitalization blueprints and roles and motivate the members through incentives and partnerships with excellent educational institutions.

At the same time, the government needs to respond quickly to these digital transformation trends because energy transition policies pursued at the government level are closely linked to digital transformation. For example, with digital technology connecting consumers and producers to respond to real-time demands, the production/transmission/consumption of energy will be converged through AI and big data analysis to improve energy efficiency. Moreover, P2P energy trade should be activated in line with the expanded supply of renewable energy and surplus power through digital technology.

Legal and institutional supplementation should come together with such technological development to materialize the objective. Hence, the role of policymakers in terms of the legal and institutional overhaul is crucial. Therefore, policymakers should make comprehensive efforts, such as continually verifying the appropriateness of the strategy, reaching social consensus, and overhauling related regulations to induce long-term energy transition in a desirable and sustainable direction.

First, establishing a platform in which sufficient discussion can be made on a permanent and open basis is essential so that social consensus on the vision and long-term goals of energy transition and digital transformation can be reached. As such, the process of reaching social consensus needs to be more systematic and open, and it should also be examined to know whether it is investing appropriate time to reach social consensus.

In addition, it is also necessary to diagnose whether the information needed for discussion in this social consensus process is sufficiently shared with all stakeholders in the power market, including businesses and consumers. Not only policymakers but also civil society affected by the policies should have widespread awareness and importance related to energy transition and digital transformation. Moreover, beyond the position of beneficiaries affected by policies, civil society must have more opportunities to take part in the energy transition process as active designers.

Second, it is also essential to expand the social support network by creating an environment in which leading policymakers can take a leading role in the operation of transition policies. The expanded social support network can ease anxiety and uncertainty about performance output, thereby strengthening the foundation for operating energy transition policies based on long-term performance that has been set as a goal.

For example, in Korea, government ministries, such as the Ministry of Trade, Industry and Energy in charge of the energy sector, the Ministry of Science and ICT in charge of digital transformation, and the Ministry of Economy and Finance render active political support by forming a government-level consultative body to induce energy transition and digital transformation of all public agencies. In particular, KEPCO, a leader in the power market, is striving to take the role of a comprehensive energy solution provider that creates new values from the conventional role of a power supplier by spreading cases of digital transformation to other public agencies.

Third, policies for energy transition and digital transformation, as well as related regulations, should be flexibly designed and operated considering technology, market, system, and social factors comprehensively. Moreover, securing the independence of such policies from political cycles, such as regime change, is essential as, because of the nature of policies that must be carried out continuously for a long time, consistency can be negatively affected by political cycles.

Regulations on the development and utilization of new technologies should also be applied flexibly to create a digital ecosystem for the power industry. Thus, opportunities to share energy data and participate in the energy market need to be more open through the expansion of regulatory sandboxes to create new values in the digitalized energy sector. However, the exponential growth in data collection and exchange also creates various risks, including cybersecurity, privacy breaches, and disputes over data ownership. Therefore, efforts on the policy front to minimize these risks are also required.

As explained above, governments and businesses should cooperate in creating a national consensus, laying the institutional foundation, and continuously strengthening their capabilities to revitalize the digital transformation of the power industry and ensure a stable transition to clean energy.

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8. Appendix

1.Cases of Digital Transformation in Power Transmission and Distribution of Utilities

Transmission

- **[Exelon, US]**
  Predict and manage an accident in electrical grid facilities using data analysis technology
- **[TEPCO, Japan]**
  Automate the inspection of transmission circuit and improve its accuracy using a drone, AI, and deep learning technology

Transformation

- **[AEP, US]**
  Maintain the outdated transformer and circuit breaker through an asset management system and evaluate the asset integrity assessment

Distribution

- **[Iberdrola, Spain]**
  Monitor the smart meter–based distribution network and automate the network operation
- **[E.ON, Germany]**
  Predict and maintain the failure in distribution network through AI analysis
- **[ENEL, Italy]**
  Detect conduction and perform predictive maintenance with C3 IoT’s application

2. Digital Business Model of Utilities

- **[EDF, France]**
  Residential solar self-consumption model, Mon Soleil et Moi (DECENTRALIZED ENERGY, B2C)
- **[E.ON, Germany]**
  Battery-free solar storage solution, Solar Cloud .
  Electric power service + smart home technology service, E.ON Plus (DECENTRALIZED ENERGY, B2C)
- **[EDF, France]**
  Home energy optimization solution, HeatSmart (+Amazon Echo) (SMART HOME, B2C)
- **[ENEL, Italy]**
  EV smart charging management and grid balancing solution (MOBILITY, B2C)
  BTM distributed generation optimization platform (ENERGY EFFICIENCY, B2B)
- **[ENGIE, France]**
  Smart building digital service platform, Vertuoz (ENERGY EFFICIENCY, B2B)
  Energy management platform, blue pilot (ENERGY EFFICIENCY, B2B)
  Energy management service of Ohio State University (SMART CITY, B2T)
  City solution of UK Transport for London (TFL) (SMART CITY, B2T)

[Appendix 1]

Cases of Digital Transformation in Power Transmission and Distribution of Utilities

Exelon. Preemptive electrical grid management using data

■ **(Overview) Use data analytics technology in predictive maintenance and incident response in electrical grid facilities**

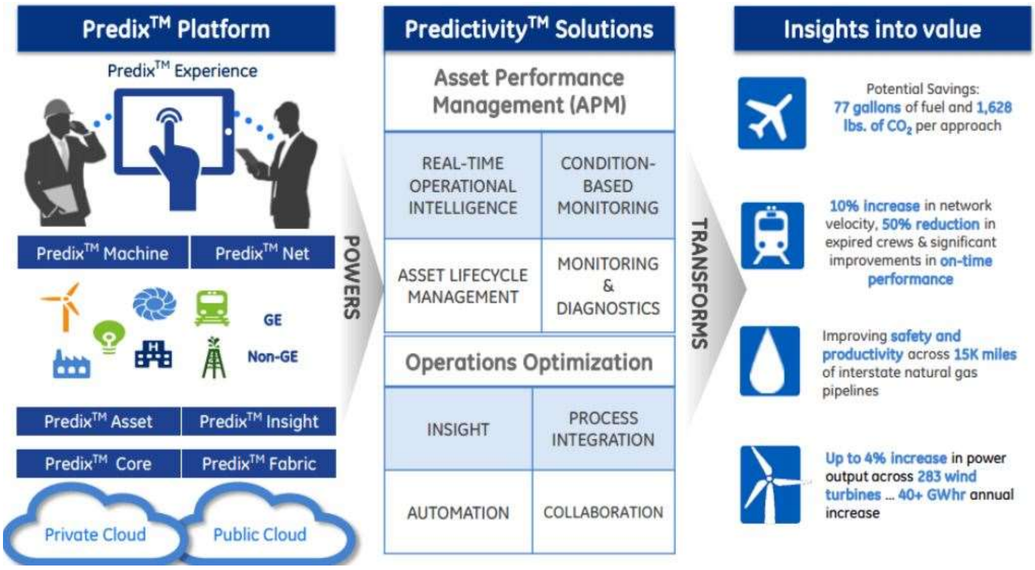
- Cooperate with GE (US) and adapt Predix as data analytics technology

○ **(Application)** Power transmission and distribution facilities in an area to which electric power is supplied and a subsidiary of utilities

○ **(Element technology)** Sensor/smart meter (data acquisition) + Predix (IT resources, analytics)

- Data transmission (facility, area, weather) → Comprehensive analysis → Real-time information provision (state, prediction)

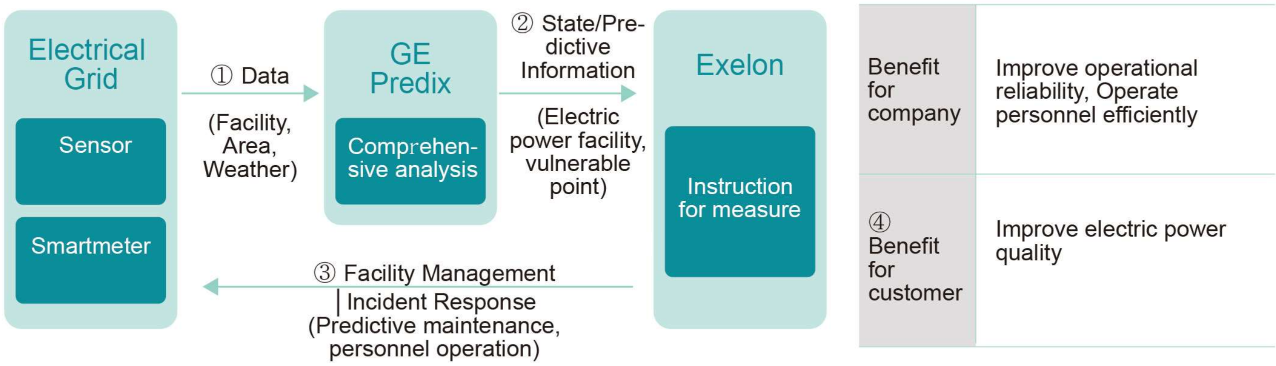
<Case of the Application of GE Predix>



○ **(Value to be provided)** Improve the reliance on electric power service by increasing the efficiency of incident response and reducing outage duration

- **(Facility management)** Provide the information of the state of electric power facilities (transformer, etc.) → Induce preventive replacement/exchange
- **(Incident response)** Provide the information of points vulnerable to incident → Induce preemptive personnel operation and corrective action

<Overview of Exelon's Operation of Data-Based Electrical Grid>



TEPCO | Image-based transmission line inspection automation

■ **(Overview) Using AI, automate a process to inspect transmission lines based on image data.**

- Cooperate with Technos (Japan) and adopt technology to analyze images to use deep learning and report analysis results

  * As to transmission lines on which the manual inspection is limited, TEPCO detects any abnormality with the manual examination of images shot from a helicopter. Such an inspection process is inefficient in terms of time and cost.

○ **(Application)** Process to inspect in-house overhead transmission lines

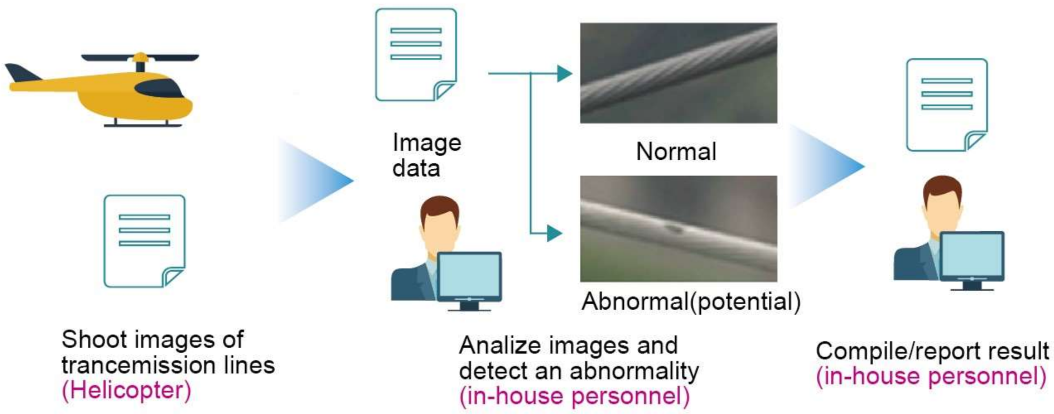
○ **(Element technology)** Drone (acquisition of data) + Cloud service (IT resources) + Deep learning (analytics)

- Data transmission (image shot) → Image analysis (detection of abnormality) → Provision of inspection result (generation of a report)

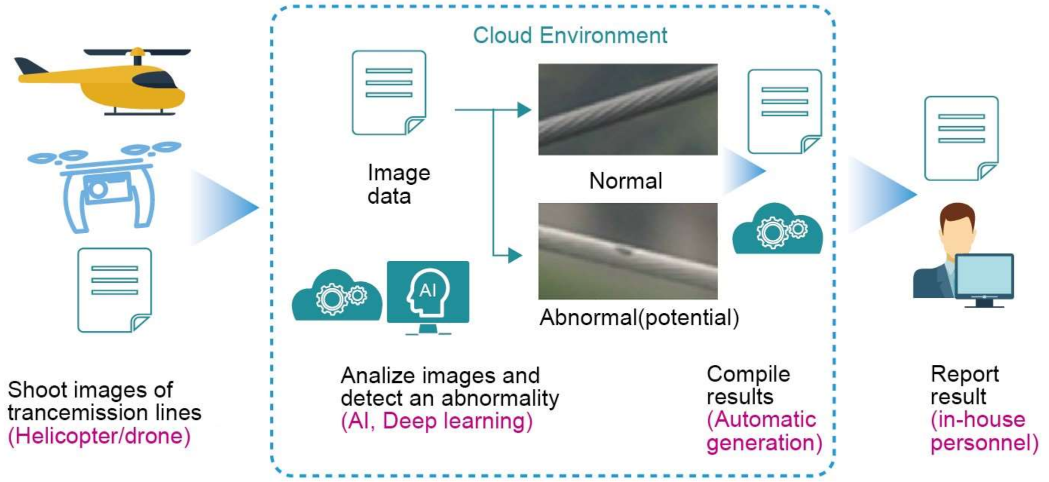
○ **(Value to be provided)** Improve the accuracy of line inspection, increase work efficiency, and expand the use of drones

- It is expected that the time required for the inspection process would decrease by 50%, and the drone’s utility in inspecting facilities would be confirmed.

<The Existing Process to Inspect Lines Manually>



<Plan to Automate Line Inspection>



AEP AMERICAN ELECTRIC POWER Substation facility asset management system

■ **In 2007, AEP developed "VENTYX," the substation asset management system, through the partnership with ABB**

○ (**Purpose of development**) Cut operation and maintenance costs generated by the deterioration of assets held

- A total of 33% of transformers in AEP are 50 years old or more, and 34% of circuit breakers are 30 years old or more.

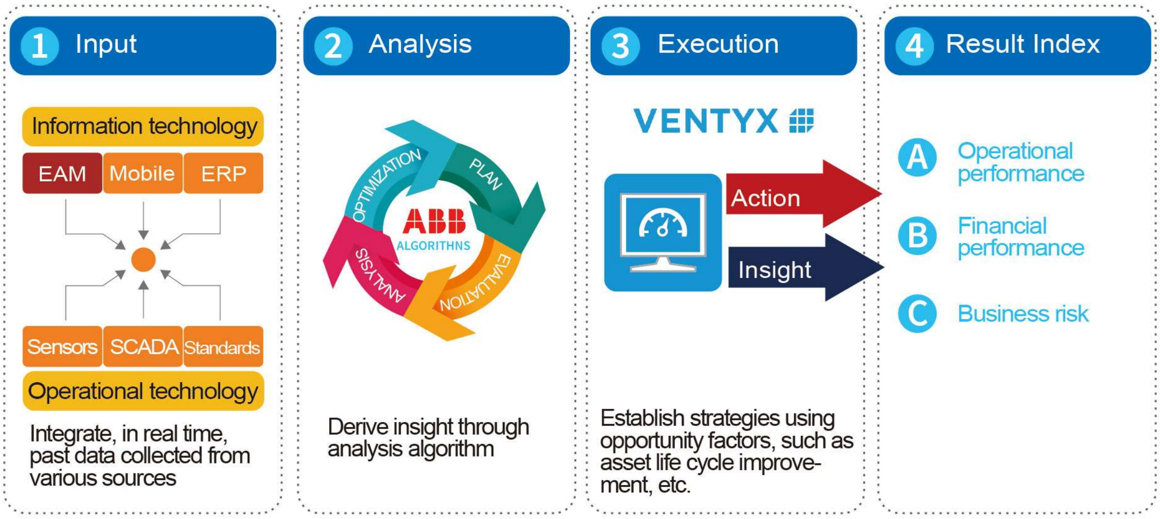
○ (**Necessity**) ① Prevent a failure ② Optimize facility maintenance ③ Review the asset service life extension as the top priority

○ (**Details**)

- Establish Asset Health Center (AHC), which is an asset management system; collect data using the software called VENTYX; and assess the asset integrity with its own algorithm.
- Save, in AHC, the data collected through the sensor and various monitoring systems. AHC

provides an asset manager with information on facility maintenance through data analysis.

<AEP's Asset Management Process using VENTYX>



○ (**Expected effect**) Contribute to cut maintenance costs by strategically operating assets based on data.

Challenge		Expected Effect	
· Deterioration of assets · Reduction of O&M costs	· Management of failures · Review of the priority of service life extension	· Calculation of optimal O&M costs · Support for decision-making on repair and replacement	· Reduction of maintenance costs (by 20%–30%)

Strengthening of the monitoring of distribution network and the automation of operation thereof

■ **(Overview) Improve the operation of customer service and distribution networks using data collected from smart meters.**

- Replace the existing watt–hour meters in accordance with the Spain government's policy for obligating to install smart meters.

  * The Spain government legislated to obligate small and medium-sized businesses to install only smart meters from 2007 to 2018

○ **(Application)** Customers whose contract demand is 15 kW or less (household, small and medium-sized business), secondary substation

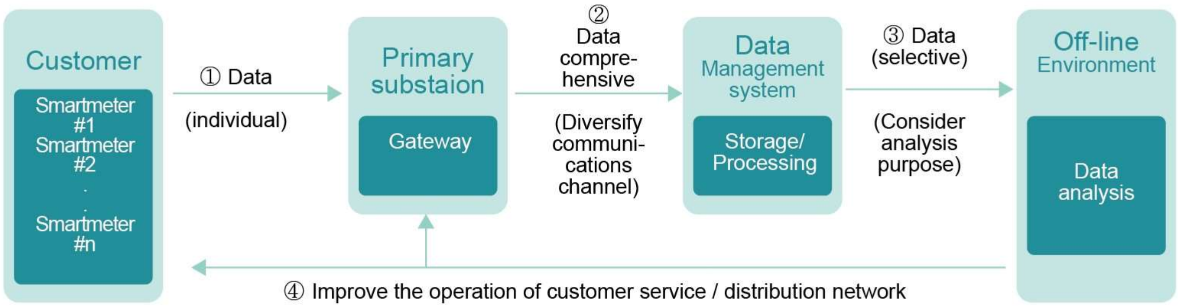
○ **(Element technology)** Smart meter (data acquisition) + IT infrastructure (data management) + Analytics

- Data transmission (power consumption, electricity power grid) → Analysis of customer/event pattern → Improvement of the operation of service/network

○ **(Value to be provided)** Simplify a process to request customer service and charge rates, improve the reliability of the operation of distribution network

- **(Service)** Understand customer's consumption pattern → Provide customized plans and prevent a billing error
- **(Electrical grid)** Transmit information of electric power quality and failure event → Use the information in operating a distribution network and establishing a plan

<Overview of Iberdrola's Management of Customer Service and the Operation of Disctribution Network based on Smart Meter Data>



e·on Predictive maintenance of the distribution network

■ **Schleswig-Holstein Netz AG (network operating business operator), which is a subsidiary of E.ON, uses AI solution in performing the predictive maintenance of distribution network (medium-tension)**

○ E.ON DataLab develops a self-learning algorithm for the predictive maintenance of distribution networks.

○ Improve failure-prediction probability through AI analysis based on data, such as the type and age of electrical grid, maintenance and weather information, real-time power loads, etc.

○ Save costs by predictive maintenance (by 30%) and improve transparency in budget allocation and priority of the replacement of electric power facilities.

□ **It will expand the application of AI solution to a substation, low-tension cable, etc.**

enel Fraud detection and predictive maintenance of distribution assets

■ **Enel has been promoting the company-wide digital transformation in cooperation with C3 IoT since 2013. The digital transformation in the field of distribution includes fraud detection, predictive maintenance, etc.**

○ (Fraud detection) Develop AI / machine learning algorithms and adapt the knowledge of experts with 30-year experiences to them.

- Replace the existing "process to detect the abnormal use of electric power" with the "C3 IoT Fraud Detection application."
- Integrate and connect data (about 10 trillion) from many Enel systems.
- Continue to update the possibility of fraud in meters of an individual customer through the analysis of machine learning.

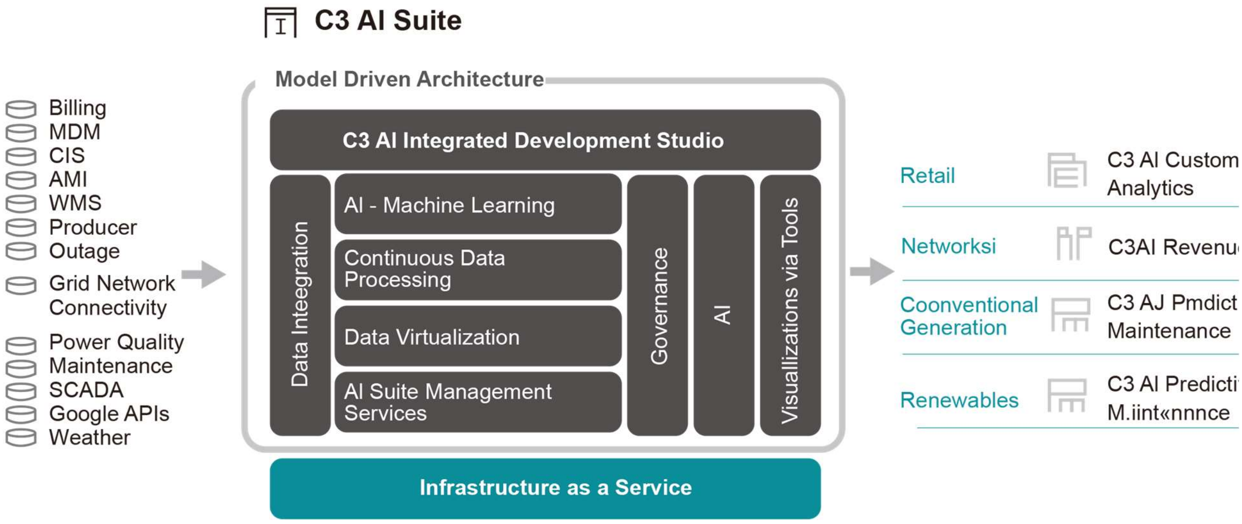
○ (Predictive maintenance) Apply the “C3 predictive maintenance application” to five control centers.

- Analyze, in real time, using AI, network sensor data, smart meter data, asset maintenance record, weather data, etc. and predict failure in advance.

□ C3 IoT platform provides comprehensive information and insight of Enel operating assets by integrating eight independent systems* that Enel possesses

* SCADA, Grid Topology, Weather, Electric Power Quality, Maintenance, Workforce, Work Management, Inventory

<C3 IoT Solution Architecture>



*source: C3 AI website

※ Utilities, such as Engie, ConEdison (US), etc., other than Enel cooperate with C3 IoT

[Attachment 2] Cases of Digital Business Model of Utilities

Decentralized Energy | **EDF Mon Soleil et Moi, Solar self-consumption model**

■ **(Overview) This is a residential solar self-consumption model. Customers can optimize their solar power generation/consumption/storage with this energy management solution.**

❋With this energy management system in tablets or smartphones, the solar power generation and consumption patterns are monitored. The solar power generation is stored at peak hours, and surplus electric power is resold.

□ **(Application)** Residential customers

□ **(Composition)** PV (roof, garden, terrace), residential energy storage system, energy solution (app)

□ **(Value proposition)** Customer's efficient energy consumption, cost cutting, resale of surplus electric power, CO_2 reduction, etc.

❋France adopted new statutes for the self-consumption of new renewable energy (February 2017).
- Grant the "investment premium" for the generation for self-consumption of 100 kWp or less and permit to resell surplus electricity (May 2017)

<Unit Price of Investment Premium and Resale>

Classification	3 kWc or Less	3–9 kWc	9–36 kWc	36–100 kWc
Investment Premium (EUR/kWc)	400	300	200	100
Resale (ctc EUR/kWc)	18.7	15.89	12.07	11.5

□ **(Profitability)** Profit from monthly rates (long-term contract) or direct purchase

※ EDF Energy established Sunplug in collaboration with Lightsource (new renewable energy company in the United Kingdom) (June 2017)

※ Sunplug's contract options for the "PV + home battery + online app" solution
- (Option 1) 20-year long-term purchase contract (annual average of GBP 0.12/kWh)
- (Option 2) Direct purchasing cost (GBP 7,999)
  - Details: PV (5 kW), inverter, battery (6.6 kWh), personnel expenses for two years, operation and maintenance, HEMS two-year license (exclusive of installation fees and VAT)

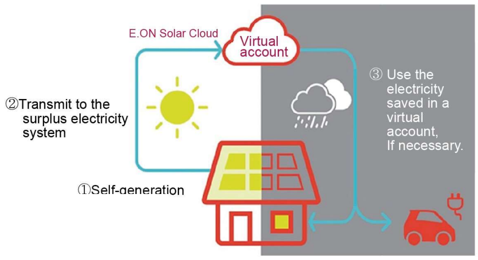
□ **(Market)** As of June 2017, a total of 1,700 people participated in this model (an average of 3 kW with a self-consumption rate of 60%), which accounted for 12% of residential self-consumption sector in France (14,000 people).
- It is predicted that the self-consumption rate would rise to 80% if a new smart management solution is applied.

Decentralized Energy | E.ON SolarCloud, battery-free solar storage solution

■ **(Overview) A consumer can transmit self-generated photovoltaic electricity to the power system through the "virtual account" without installing his/her own battery and use such electricity, if necessary.**

❋This service has been provided for one year to customers who had the "E.ON Aura battery storage system." In addition, since January 2018, this service has been expanded to be provided even to customers without battery.

<Conceptual Diagram of E.ON SolarCloud>



<Overview of E.ON Aura>

※ One solution composed of "residential PV + battery + energy management app + green plans"
- Promote projects in Germany (April 2016), UK (April 2017), etc.
- Installation costs are as follows: GBP 3,095 for installing new PV, GBP 4,495 for installing only a battery to the existing PV, and GBP 6,095 for installing new PV and battery

□ **(Application)** Residential customers

□ **(Composition)** Virtual account

□ **(Value proposition)** Customers are not required to pay expenses to purchase, install, and maintain storage devices.

□ **(Profitability)** Provide basic and premium plans (in Germany)

<Examples of E.ON SolarCloud Plan (3,000 kWh (Year))>

Classification	Basic	Premium
E.ON SolarCloud (virtual storage device)	√	√
E.ON Aura Manager app	√	√
E.ON Aura PV panel	√	√
Additional service - E.ON PV system efficiency check - E.ON sunshine guaranty - All-risk insurance	 - - -	 √ √ √
Fixed Charge	**EUR 21.99/month**	**EUR 26.99/month**

□ **(Market)** It tends to expand the residential PV self-generation and consumption because of the reduction of support for new renewable energy, such as FIT, etc. and the fall in PV expenses.
- This project will be expanded to customers who own "heat pump, EV, etc." in the future.

Smart Home | EDF HeatSmart (+Amazon Echo), Home energy optimization solution

■ **(Overview) Optimize the energy consumption by controlling the heating remotely with a smartphone, tablet, PC, AI, speaker, etc. after installing an automatic thermostat.**

❈ AI speaker (Amazon Echo) is used for the following functions: audio-based remote control, management of balance in the energy account, checking of the due date of the charge/plan, submission of reading information, etc.

<Heatsmart Solution>

※ Even people who are not customers of EDF Energy (UK) can use this service.

※ Automatic thermostats and AI speakers are provided without charge.

□ **(Application)** Residential customers

□ **(Composition)** “Netatmo,” which is an automatic smart thermostat, Amazon “Echo,” and App

□ **(Value proposition)** Increase efficient energy consumption, reduce costs, and improve convenience

□ **(Profitability)** Newly introduce the “Connect + Control 2” plan

- Install an automatic thermostat and provide Amazon “Echo” without charge (a value of GBP 289) (however, with an exit fee of GBP 135)

<Example of Residential EDF Energy Plan (UK)>

Plan	Electricity (year)	Gas (year)
Online Saver	GBP 934.83	GBP 891.90
Blue + Heating Protect (heating facilities insurance)	GBP 939.29	GBP 905.70
Connect + Control 2 (automatic thermostat, Amazon Echo)	**GBP 950.79**	**GBP 924.87**
Smart Saver	GBP 956.02	GBP 962.94
Standard (variable plan)	GBP 964.94	GBP 972.73

□ **(Market)** Utilities provide their services using various automatic thermostats on a competitive basis (for example, Nest of First Utility).

Smart Home | E.ON Plus, the "Electric Power Service + Smart Home Technology" service

■ **(Overview) Provide customized service by combining energy (electricity, gas, etc.) with various smart home solutions, such as smart lighting, smart heating control system, etc.**

❋Smart home solution: (Philips Hue) smart lighting, (Tado) smart heating control system

<E.ON Plus Bundling Service>

□ **(Application)** Residential customers

□ **(Composition)** Electric power + smart lighting + automatic thermostat, etc.

□ **(Value proposition)** Consume energy efficiently (cost cutting), provide customized service (personal bundle) through various options (60 or more combinations), and hedge, through a fixed charge plan, a risk of increase of charges, etc.

□ **(Profitability)** Introduce the new "E.ON Fixed Two-Year tado° tariff" plan (UK)

<Example of Energy (Electricity + Gas) Plan of E.ON (UK)>

Fixed Charge Plan	Energy Charge (year)
E.ON Go Online One Year (Basic)	GBP 945
E.ON Clean Energy Fixed One Year (New renewable energy)	GBP 1,064
E.ON Fixed One Year Cinema Bundle (Movie ticket)	GBP 1,117
E.ON Fixed Two-Year tado° Bundle (Automatic thermostat)	**GBP 1,223**

<Charges under E.ON (Germany) Plus (under one year contract, August 2017)>

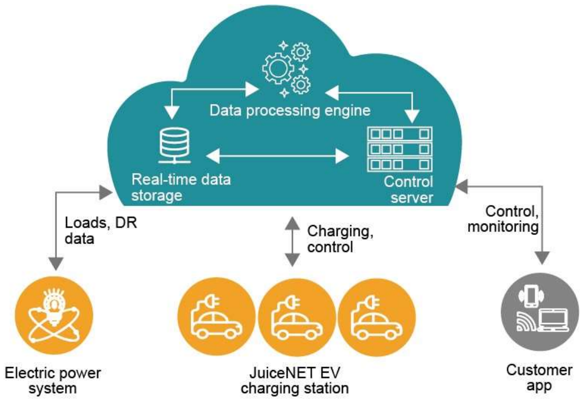
Classification	Charge (month)
tado Radiator Starter Kit	EUR 3.59
tado Thermostat Starter Kit	EUR 4.49
Philips Hue White Starter Set	EUR 7.50
Philips Hue White and Color Ambiance Starter Set	EUR 15.00

Mobility | Enel, EV smart charging management, and grid balancing solution

■ **(Overview) Optimize customers' EV charging through V2G integrated platform (JuiceNET) and provide an opportunity to participate in the grid service (provide JuicePoints at the time of participation and then convert it into cash).**

※ Enel took over eMotorWerks (US) to make inroads into an e-Mobility market in the United States (October 2017)

<Overview of JuiceNET Cloud Platform and e-Mobility Solution>



Integrate and predict charging patterns, real-time charges, new renewable energy availability, system operation information, etc.

→ Control connected EVSE and provide optimization / system reserve

* Customers perform remote control through a smartphone app, web browser, AI speaker, etc.

□ **(Application)** Residential and general customers

□ **(Composition)** V2G integrated platform (JuiceNet), charger (JuiceBox)

□ **(Value proposition)** Customers cut costs by optimizing charging, create profits by participating in reward programs, and secure system reserve.

□ **(Profitability)** Profits from sales of the charger, platform, accessory, etc., platform upgrade service fees (JuiceNet Green, USD 50), EV charger and platform service fees (USD 99/month), balancing service, etc.

<Examples of the Price of a Charger (JuiceBox)>

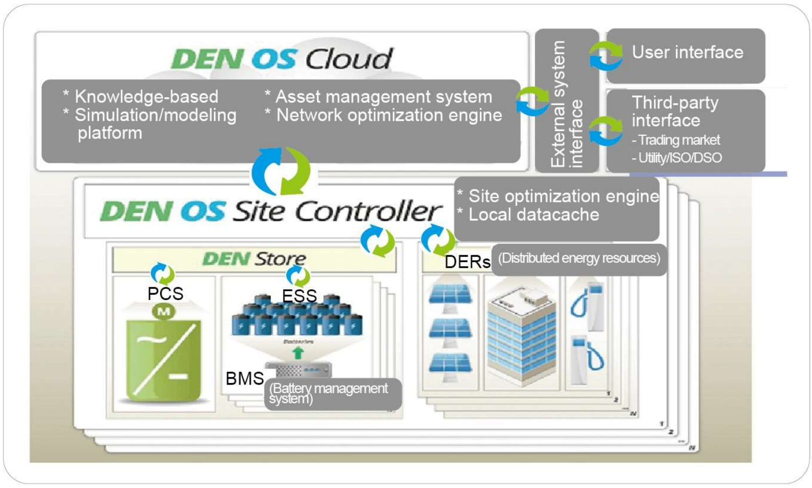
Classification	JuiceBox Pro 40 Lite	JuiceBox Pro 40	JuiceBox Pro 75
Maximum output	40 A / 10 kW	40 A / 10 kW	75 A / 18 kW
LED display, etc.	√	√	×
App & dashboard	√	√	√
Time of Use (TOU) configuration	×	√	√
Alarm, AI speaker	×	√	√
Load balancing	×	√	√
Portable	√	√	×
JuiceNet Green (new renewable)	×	√	√
Charges	**USD 549**	**USD 599**	**USD 899**

Energy Efficiency | Enel, BTM distributed generation optimization platform

■ **(Overview) Cloud-based SW platform that aggregates, controls, and optimizes BTM storage system and distributed generation**

❈ Enel secured "DEN.OS[4]" SW platform, which is a distributed energy network optimization system, by taking over Demand Energy (ESS developing company in the United States) in January 2017

<Overview of Demand Energy's DEN.OS™ Platform>



* DEN.OS is an SW system to be provided in the form of subscription service

- Monitor and control DER generation and energy consumption in real time
- Be composed of DEN.OS Cloud and DEN.OS Site

<Overview of Enel's DR (flexibility) Platform>

□ **(Application)** General/industrial customer, utility

- General/industrial building, microgrid and VPP, photovoltaic/wind power generation, as well as use in utility's transmission and distribution network, etc.

□ **(Value proposition)** Cut energy costs and provide grid service (DR)

□ **(Profitability)** USD 2.1 million (use DEN.OS SW and participate in the Massachusetts Distributed Energy Project)

□ **(Market)** BTM energy storage device of 555 GW (2040)

[4] Decentralized Energy Network Optimization System

Energy Efficiency | Engie, Vertuoz smart building digital service platform

■ **(Overview) Digital platform that uses data collected from devices[5] connected to buildings and optimize energy consumption through AI algorithm (real-time control of thermostatic value, switch, LED, etc.)**

❋In 2012, the Vertuoz platform was developed to optimize the energy performance of buildings. As the data scope continued to be expanded, the "Vertuoz Pilot," which was an open digital solution, was released in February 2017.

※ Cases of application of "Vertuoz Pilot": Apply to 140 schools in Paris

- Engie Coefly has entered into the Energy Performance Contract (EPC) with Paris in March 2016
- Term of contract: 15 years
- Objectives: Cut building energy costs by 20%–25%
- Overview of Engie solution:
  - · Connect 15,000 devices in classrooms of 140 schools (temperature sensor, occupancy sensor, etc. in each classroom)
  - · Improve the convenience of 21,000 students by applying the Vertuoz solution
- Sales: EUR 20 million, EUR 0.8 million/year in O&M (a total of EUR 12 million)

□ **(Application)** Industrial customer (B2B, B2B2C), B2T

- Mainly public building, school, apartment, small-scale office building, etc. without heating/lighting system remotely controllable

□ **(Composition)** Connect to devices with sensors, such as an automatic thermostat, LED lighting, switch, etc. through the mobile app ("Vertuoz Live")

- As there is no harmful side effect in using local radio networks with low frequency, it is especially suitable for schools.

□ **(Value proposition)** Contribute to customers' efficient energy consumption, cut costs, and improve convenience

□ **(Profitability)** Create profits through contracts entered into mainly with industrial customers

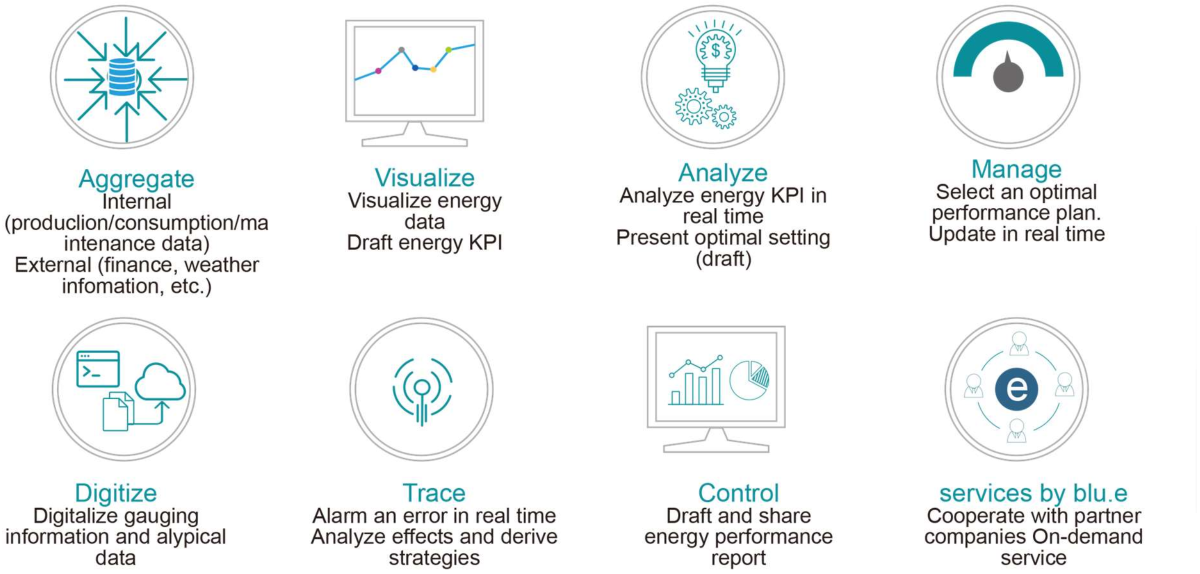
□ **(Market)** Provide service mainly for the tertiary industries (service industries), expand into an education sector (schools in Paris), and, in 2018, to the connected housing.

[5] CO_2sensor, temperature sensor, occupancy sensor, switch, valve, etc. (use energy harvesting wireless technology of EnOcean (Germany))

Energy Efficiency | Engie, "blu.e pilot," energy management platform

■ **(Overview) A digital SW platform that makes the energy performance indicators (ENPIs) with industrial process data and derives a plan (scenario) to manage the energy optimization**

<Overview of blu.e Digital Platform>



※ Cases of the application of "blu.e.pilot" platform: PSA Group (automobile company in France)

- PSA Group adopted the blu.e solution to optimize the energy consumption in its workplaces
  · Analyze big data on the measurement of ENPIs, influence factors, and the facility operation
- In 2017, a manufacturing plant in Poissy, France, applied the **Blu.e pilot® platform.**

□ **(Application)** Industrial customers

□ **(Value proposition)** Optimize the energy management over the whole value chain of customer companies

□ **(Profitability)** Sales of blu.e (startup of Engie) (EUR 500,000, 2015)

Smart City | Engie, Ohio State University Energy Management Service

■ **(Overview) A solution to operate and manage utility systems, such as electricity, heating, gas, water supply facilities, etc., in 485 buildings of Ohio State University in the United States**

❋Engie-Axium (infrastructure company in the United States) consortium entered into a cooperation agreement for energy management with Ohio State University in April 2017.

※ Overview of Ohio State University Energy Management Service
- Objectives: Save energy consumption by 25% in 10 years
- Contract term / investment scale: 50 years / EUR 1.2 billion

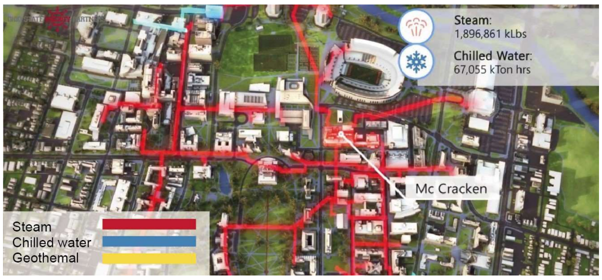
- Details
  ① **Operate and optimize** university **utility system** with an energy-saving management service in the existing system and new facility investments
  ② **Establish new energy innovation center** for energy research and commercialization

□ **(Application)** Ohio State University

□ **(Composition)** Optimize university utility system and establish a new energy innovation center

- Engie provides customized infrastructure and service for Ohio State University using 3D modeling technology (data visualization) of Siradel (an enterprise in France, taken over in 2016)
- Establish an innovation center in which the next-generation technologies and services, such as smart energy system, new renewable energy, green mobility, etc., can be developed in cooperation with researchers in University/Engie and experts in enterprises

<3D Map of Ohio State University>



<Overview of 3D Modeling Technology>

※ Visualize data, such as urban traffic flow, air quality, noise level, solar potential, Wi-Fi coverage, etc.

→ Develop a smart city by simulating the effect of electric buses on air quality, etc.

□ **(Value proposition)** Improve sustainability by saving energy consumption and developing and commercializing innovative technologies

□ **(Profitability)** Improve the status as a global leader in the field of sustainable energy

□ **(Market)** The global smart city market is predicted to grow to USD 1.7 trillion in 2025 (McKinsey).

Smart City | Engie, Transport for London (TFL) city solution

■ **(Overview) Technical service to maintain electrical, mechanical, and fire safety system in traffics in London and service to install PV/ESS and improve energy efficiency**

- 300 employees at Engie use computer-aided facilities management (CAFM) SW and operate help desks 24/7.
- Install PV panel of 1.1 MW and storage device in 24 areas, such as station, wharf, bus stop, trainmen's quarter, etc.
- Improve energy efficiency by upgrading, etc. the heating and lighting system in building, station, office, etc.

□ **(Application)** The overall traffic in London

□ **(Value proposition)** Improve the performance and efficiency of the London traffic system, save costs, optimize TFL assets, and improve the air quality for London residents

□ **(Profitability)** PV + energy efficiency service (GBP 4.5 million)

<Current State of Engie's Global B2T Solution>