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# Incorporating AI & IoT into Power-Generating Facilities: Status of Development and Challenges

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## Introduction

AI and IoT technologies are currently being introduced in a wide variety of fields/industries, or having their introduction examined. The power industry has seen demand peak as electrical system reform has progressed, energy-saving equipment has become commonplace, and Japan's population has decreased. Despite this, aging equipment needs updating and requires further efficiency improvements, and the business environment is becoming increasingly severe. Considering the situation, there is a significant possibility that digital technologies such as AI and IoT could contribute to resolving industry challenges and improving competitiveness. For example, a report[1] by the IEA reveals that digitalization has improved the operational efficiency of power plants and related systems, reduced unplanned suspensions and downtime, and helped enhance the lifespan of equipment. There is a possibility that these improvements could reduce yearly expenses by as much as 80 billion USD. This report will therefore systematically examine the introduction and development of AI and IoT technologies for use in power-generating facilities, which, even in the industry, are known for their high costs relating to fuel, operations, and equipment, but assuming an important role in providing a stable supply of electricity through stable operations. The report will also examine the benefits and challenges related to this introduction.

## 1. Purposes for Introducing AI and IoT Technologies Per-Source of Power Generation

Functionality provided by the introduction of AI and IoT technologies can be roughly broken down into three different areas. ‘Visualization’ allows for assessments of operational data, such as pressure and temperature, through graphs and charts. ‘Optimization’ allows for this data to be analyzed to uncover parameters related to optimizing areas such as efficiency. ‘Automation’ allows for this data to be utilized by

[1] IEA Digitalization & Energy 2017 （https://www.iea.org/digital/）

machine-based control functions. The following section will examine the purposes of using of these functions for each source of power generation. The six types of power generation considered here included thermal, nuclear, solar, geothermal, wind, and hydro.

Table 1: Purposes for Introducing AI and IoT Technologies Per-Source of Power Generation

| Power Source | Purpose |
|---|---|
| Thermal/Nuclear | ・Stable operation of equipment<br>・Improving and maintaining efficiency for power generation (reductions to amounts of fuel used etc.)<br>・Technology succession<br>・Using predictive management to prevent major accidents<br>・Reducing operational suspension periods<br>・Reductions in personnel through improving task efficiency |
| Solar | ・Stable operation of equipment<br>・Maintaining efficiency of power generation<br>・Reducing operational management costs<br>・Improving safety amongst new participants in the industry |
| Geothermal | ・Improvements to usage rate of equipment<br>・Maintaining efficiency of power generation |
| Wind | ・Optimization of maintenance periods<br>・Maintaining efficiency of power generation<br>・Shortening maintenance periods |
| Hydro | ・Stable operation of equipment<br>・Improving and maintaining efficiency for power generation |

## 2. Examples/Characteristics of Introducing AI and IoT Technologies Amongst Power Generating Sectors in Japan

Major electric power companies and heavy electric machinery makers in Japan are introducing and developing AI and IoT technologies for their domestic power-generating facilities due to their cost benefits (see annex 1: 'List of Examples in Japan' at the end of this document for more details).

Some common characteristics related to introducing AI and IoT technologies into domestic power generating sectors were revealed through this investigation. These include the way in which users such as electric power companies set the specifications, and then work closely with device (software) manufacturers to develop solutions. This is likely because users are good at utilizing operation know-how and data, whereas domestic manufacturers tend to consider things from a vendor-perspective. This means that domestic innovation in AI & IoT technology requires stronger coordination between manufacturers and users, that both groups need to disclose information actively, and that constant confirmation of needs and solutions is required as progress is made. Japan has a lot more experience at dealing with natural disasters such as earthquakes and typhoons compared to the West. Using this knowledge when developing technologies may lead to differentiation with other countries.

Table 2: Breakdown of Examples in Japan

| Example No. from Annex 1 | Power Source | Added Functionality | Developer/Implementer |
|---|---|---|---|
| 1 | Thermal | Optimization | User + Manufacturer |
| 2 | | Automation | User + Manufacturer |
| 3 | | Automation | Manufacturer |
| 4 | | Visualization | User |
| 5 | | Optimization | User + Manufacturer |
| 6 | Solar | Automation | User + Manufacturer |
| 7 | | Visualization | Manufacturer |
| 8 | | Optimization | Manufacturer |
| 9 | Geothermal | Visualization | User + Manufacturer |
| 10 | Wind | Visualization | User + Manufacturer |
| 11 | | Visualization | User + Manufacturer |
| 12 | Hydro | Optimization | User + Manufacturer |
| 13 | | Optimization | User + Manufacturer |
| 14 | | Visualization | User + Manufacturer |

## 3. Examples/Characteristics of Introducing AI and IoT Technologies Amongst Power Generating Sectors Overseas

Progress is also made with utilizing AI and IoT technologies amongst power generating sectors in other countries. General Electric (US) is being particularly proactive in the development of these technologies. Introduction of these technologies is also proceeding in Asian countries. This can be seen in particular amongst new coal-fired and gas turbine combined cycle (GTCC) power plants (see annex 2: 'List of Overseas Examples' at the end of this document for more details).

The results of the investigation showed that, particularly in the US, large amounts of sensors are being installed in power plants to allow for the utilization of IoT devices, revealing the high level of interest in these technologies. Another characteristic seen overseas is the large number of cases where development was primarily centered around device (software) manufacturers such as device and IT vendors. Users such as power companies then utilize these finalized products, receiving support from the manufacturers regarding usage methods. Users are not heavily involved in development. The situation is likely to differ per-manufacturer, but one business strategy that can improve the advantage of device manufacturers is to select data and functions that are seen as useful, then use this information to implement and provide extra services (O&M[2] etc.).

## 4. Future Outlook

As mentioned previously, most overseas examples are based around independent development by manufacturers. By comparison, most domestic cases involve reciprocal cooperation between users (power companies, etc.) and device (software) manufacturers when examining the introduction of these technologies and performing development. This difference is due to strategic differences between countries related to technology implementation. These technologies are not yet functioning at their fullest or producing significant benefits, so it's difficult to say which strategy is best.

To allow for the further advancement of these technologies in Japan, users need to accept new technologies and methodologies, and have the flexibility to avoid being trapped by conventional techniques. Manufacturers need to gain a clear understanding of the needs and challenges being faced by users, advancing solutions in a way that matches users' needs. Users also need to provide clarity regarding their needs, making careful consideration about how they can use existing solutions to realize them. Digitalizing technicians' know-how is essential for implementing the combination of big data and AI. Maintaining the ability of technicians in existing power plants is also vital, as are actions to ensure that required personnel are trained and retained.

It's also important to incentivize technological development through institutional reforms, including the easing of existing systems, such as realizing six-year periodic

[2] Operations and Maintenance

inspections of thermal power generation facilities through the use of AI and IoT technologies.

Currently, the introduction and development of these technologies is most advanced in the field of thermal power generation, where the capacity of existing equipment is large, leading to increased benefits. Further advancement and penetration of these technologies in this field is required. This development will act as a beachhead for their horizontal deployment amongst renewable energy solutions such as wind and solar, which are expected to become more commonplace.

## (Annex 1: List of Examples in Japan)

| No. | Company Name | Overview | Source |
|---|---|---|---|
| 1 | MHPS | Development of an AI-based automated system for heat adjustment on coal-burning boilers | https://www.MHPS.com/jp/news/20170110.html |
| 2 | Tohoku Electric Power/ Nihon Unisys | Efforts relating to automating patrols at power plants | http://www.tohoku-epco.co.jp/news/normal/1201327_1049.html |
| 3 | MHPS | Development of a predictive sensing system for abnormalities (Pre-ACT) | MHPS-TOMONI: Thermal power generation digitalization platform Cloud/edge service and system architecture (Ishigaki, Mori, Goto, Nagafuchi) |
| 4 | TEPCO | Introduction of tablets for equipment inspections at thermal power plants | https://sgforum.impress.co.jp/article/3274 |
| 5 | Kansai Electric Power Co./ DeNA | AI-based fuel operation optimizations in coal-fired power plants | https://www.kepco.co.jp/corporate/pr/2019/0205_1j.html |
| 6 | NEC Networks & System Integration Corporation | Solar panel inspection service that utilizes drones and AI | https://www.nesic.co.jp/news/2019/20190422.html |
| 7 | Sumitomo Electric | Determining defects in solar panels through AI | https://sei.co.jp/company/press/2018/12/prs108.html |
| 8 | Toshiba | Development of AI-based solar power output prediction technologies | https://www.kankyobusiness.jp/news/022828.php?utm_source=mail&utm_medium=mail190723_d&utm_campaign=mail |
| 9 | Toshiba Energy Systems | Research into improving utilization rates of geothermal power plants through AI and IoT technologies. | https://www.toshiba-energy.com/info/info2018_0807.htm |
| 10 | NEDO | Fault prediction technologies that utilize | https://www.nedo.go.jp/news/press/AA5_100939.html |

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|---|---|---|---|
| | | wind-turbine monitoring data and AI | |
| 11 | Fujitsu/<br>Siemens Gamesa | Utilizing AI for wind-turbine inspections | https://pr.fujitsu.com/jp/news/2017/11/8-2.html |
| 12 | Kansai Electric Power Co. | Optimization of water system integrated hydroelectric power plants through IoT technologies | https://www.kepco.co.jp/corporate/pr/2018/0918_2j.html |
| 13 | TEPCO | Research related to improving the operations of hydroelectric power plant dams through AI utilization | http://www.tepco.co.jp/press/release/2017/1377001_8706.html |
| 14 | TEPCO/<br>Nihon Unisys | Demonstrative trial of sensor-based monitoring of the effects of inclinations on water channels in hydroelectric power plants | https://www.itmedia.co.jp/smartjapan/articles/1802/09/news024.html |

## (Annex 2: List of Overseas Examples)

| No. | Company Name | Overview | Source |
|---|---|---|---|
| 1 | GE/<br>Scottish and Southern Energy (SSE) | Introduction of Asset Performance Management (APM) and the establishment of an Equipment Performance Center (EPC) to provide centralized monitoring of equipment | https://www.ge.com/content/dam/gepower-pw/global/en_US/images/softwaresolutions/Discover%20the%20Power%20of%20Digital_Customer_Stories_06.01.18.pdf |
| 2 | Emerson/<br>Tucson Electric | Introduction of a predictive maintenance program at coal-fired generating station in Springerville (Arizona). | https://www.emerson.com/documents/automation/download-1-title-en-us-20392.pdf |
| 3 | GE/ | Introduction of GE-produced boiler optimization software | https://www.worldcoal.com/power/04072016/coals-digital-revolution-2016-1056/ |

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|---|---|---|---|
| | Owensboro Municipal Utilities | (BoilerOpt) at the Elmer Smith coal-fired power plant (Kentucky) | |
| 4 | GE/ PJB | Introduction of Predix-based Asset Performance Management (APM) at 21 power plants in Indonesia | https://www.genewsroom.com/press-releases/pjb-spearheads-digital-energy-indonesia-deployment-ge-digital-power-plant-software |
| 5 | GE/ Panama Group | Introduction of an operations optimization solution to allow for energy production forecasts at Panama's 70MW wind power plant | https://www.ge.com/content/dam/gepower-pw/global/en_US/images/softwaresolutions/Discover%20the%20Power%20of%20Digital_Customer_Stories_06.01.18.pdf |

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