Development of AI Decision Making System for Industry 4.0

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***Abstract*—Currently, there is an energy crisis where the prices of global fuels are rising, especially natural gas. Natural gas is the main fuel used in electricity production in Thailand. Mainly, the cost of electricity is directly proportional with natural gas price. Preliminary studies have shown that coal power production will help stabilize energy prices. According to the readiness of the power plant, it found that the number of shift workers was insufficient to operate the coal-fired power plant. There were many retirees and the problem of damaged equipment. the method of digitalization has been applied to connect for human-to-human, human-to-machine and machine-to-human interaction associated with the data ingestion based on the Cyber-Physical System (CPS) concept for real/near-time machine learning (ML)/artificial intelligence (AI) in workflow management. The development steps of the platform conceptual can be separated consisting of 3 main parts (1) Large data sets of unstructured and semi-structured data flow to data lake (2) Workflow for input determination to training ML/AI and mix rule-based together (3) Action showing the result which can be connected to web and mobile application. Operators can access all information and monitor and track jobs through the platform. Furthermore, the challenging problems can be designed and investigated by domain experts in a comprehensive production process with automatic alerts. New generation can work, confirm and troubleshoot according to standards-based processes designed from the information source gathered from domain expert and can be automatically checked using dashboard at any time.**

Keywords—Decision system, Digitalization, Digital solution, Data center, Knowledge management, Machine learning

I. INTRODUCTION

In 2022, there is an energy crisis where the prices of global fuels are rising but the float time value (FT) cannot fully adjust to the price. Therefore, the Electricity Generating Authority of Thailand (EGAT) must find a way to cope with this energy crisis. From the considerations, it was found that extending the lifespan of electricity generators from the Mae Moh coal power plant would help reduce the cost of producing electricity and help stabilize the overall energy price. According to the readiness of the power plant, it was found that the number of shift workers was insufficient to operate the Mae Moh coal power plant and there will be approximately 130 retirees between 2022 and 2026. There are also limitations in the technology used in this process as reliability from device issues. For example, the water flow malfunction in the water control valve is caused by different water-flow while pumping, blocking the water from being sent to produce steam. For repairs, 2 technicians, 1 of a control technician and 1 an engineer are required. In non-severe cases, maintenance takes at least 24 hours, averaging approximately 96 man-hrs. In case of permanent damage, it is necessary to stop producing electricity to change equipment for at least 3 months. The above example causes the loss of auxiliary equipment and a high-pressure valve estimated to cost not less than 117 million baht. For Instance, there is a problem with the cooling booster fan blade. It is malfunctioning, unable to cool the system, or unable to remove fouling in the cooling pad by using high-pressure water. For repairs, 3 repairmen, 2 operators, and 1 engineer are required. By calibrating the angle of the propeller, it takes a minimum of 36 hours, around 130 man-hr. Another case is cleaning the cooling pad by removing fouling with high-pressure water for at least 40 hours, around 142 man-hr. The total loss expense is approximately 1.95 million baht per day. In the example above, the presenter wants to show the loss incurred. The problems will happen again and create losses when the trouble-shooter doesn't know how to fix the problem, fail to check the root cause, has no knowledge of modifying spare parts for fixing, has no track work, causes gaps in working or failed to work. This problem may be the same or more. All problems take a long time to resolve or cost a lot of money due to the insufficient experience of the editor.

Therefore, there are studies and developments in the application of technology in digitalization to solve the problems of the operation of the power generation and maintenance of the Mae Moh power plant. The objective is to reduce the burden of shift workers by using digital technology. There is the designing and development of a sustainable platform model that comes from the integration of a workflow system, ML and rule-based. The big goal is to solve the same problems that have arisen by using the notification system both preventive alerts and alerts when an incident is found. It also provides corrective guidelines for the trouble-shooter and a step-by-step way to find the cause so that the trouble-shooter can solve problems quickly. The trouble-shooter can work in an orderly, step-by-step approach without wasting time searching or using experience to solve the problem. All of this will help the organization reduce the wastage of work time, the number of personnel and costs in a meaningful way.

II. Related Work

A. Digital Technology

With the change of the era, technology and innovation have been used widely in large organizations. Each organization must focus on "how" to use it and "how" it leads to competitive advantages. Thus, it results in a study of the use of technology as a guideline for data analysis. Internet of things (IoT) and AI are popular in the topics of Industry 4.0 [1]. It attempts to evaluate and identify the most effective ways to facilitate digitalization in the context of manufacturing. Concerning the business processes, management, IT management, production planning, customer services, marketing and distribution appear to be the processes with the most impact on the digital performance of companies to guide the efforts both in academia and in the field concerning the digitalization of SMEs. Not just the application of technology alone, it is also applied to manufacturing as a case study in Germany. According to the research, the supply chain is the center of all operational activity of every manufacturing company and a decisive factor in gaining a competitive advantage. By creating a digitization framework, there are eight factors that practitioners can use to determine the individual status of the organization. The framework for Industry 4.0 realization benefits the supply chain [2].

B. Manufacturing System

At present, manufacturing systems work on progressed innovation that integrates the systematic process and laborer collaboration. Digitalization has induced solutions in many fields, including industrial/SME automation and production systems. Improve performance and efficiency such as human-machine interaction, collaborative robots and big data. The manufacturing industry is also beneficial for the becoming-digitalization and improving customer satisfaction, including eliminating the recreation of models, cycle time reduction, costs and errors [1]. For example, the technology and model of Industry 4.0 were adopted, developed and empirically tested within 38 manufacturing companies' cases in Japan. They focused on the 5C's architectures by following the cyber-physical systems (CPS), data conversion, cyber integration, cognition and self-configuration. It bases on technology such as the IoT (machine-to-machine communication), the internet of service (machine-to-human communication) and the internet of people (virtual human-to-human communication) and CPS integrates the physical world of productions vertically [3]. For instance, the objective of the India case study is to prioritize Industry 4.0 elements. It is one of the elements of Industry 4.0 system integration identified as a "priority" strategic initiative that India will take action on. Industry 4.0 implementation starts with digitization. After that, industrialization or integration subsequently continues with optimization. Indian manufacturing establishments indicate their preference to prioritize the industrial, for example, connecting machines and generating data analytics using IoT, cloud and big data [4].

C. Organizational Resilience

Humans are indispensable in the manufacturing industry as their complexity increases in an Industry 4.0 context. It seems that the development of Industry 4.0 is not only bringing digital technology and innovation to help improve manufacturing or supply chain but also simplifying the sharing of information and knowledge among people at work, especially for Operator 4.0 [5]. The technology investigation effect on sustainable supply chain practices to improve organizational performance and lead to findings that revealed three dimensions of organizational sustainability (operational, environmental and economic performance) [6]. Moreover, the purposes are improving economic benefits and environmental performance, adapting the green practices that lead to reduced production costs and examining reliability by analysts. Similarly, the study in Italy aims to investigate the organizational implications of adopting Industry 4.0 technologies, giving specific attention to operations to build upon a conceptual framework derived from the sociotechnical perspective that analyses the interconnections between technology implementation and organizational change [7]. Organization and Infrastructure Systems must work together with people - employees. It is also an important part of the production process. Those who play an important role in the development of the organization are not only high-level executives but also all developing-potential personnel who want to develop the organization and make the organization successful in the future.

III. Research Methodology

The conceptual platform developed in this research is shown based on semi-structured interviews. This method was used to collect the data, gain appropriate insight into the current situation, achieve the predetermined target for information within time and budget constraints and minimize researcher and respondent bias [8]. A research team has been established to conduct internal surveys and find the real cause of the organization's problems related to each type of work and each group work. The survey will start from the most common and unresolved issues as raw data in the development platform on digitalization technologies. It will be a tool to create the active solution data to work with all aspects of the problem that personnel in the organization will face [9]. The research team set the following objectives:

(1) Productivity: the main problem in the EGAT is that the same data set exists in multiple sources and it is impossible to know the most up-to-date source. Since it is not sure whether it is the most up-to-date data, the same data existed in the organization and resulting in data redundancy [10]. The next problem is storing new information. There are many formats to store data depending on storage capacity of each organization though it is the same data. It makes it more difficult to do data integration.

(2) Process (Operation & Maintenance): the main image of the problems encountered is manpower and capacity planning. Planners need to know the income and expenditures on the enterprise resource planning system (ERP) to plan their work [11, 12]. The example is about operational issues such as ordering works without priority. So, the urgent work is unable completed on time but other unurgent work is completed first. Another problem is that experts in the organization are going to get retired. It results in the knowledge management system (KM) being difficult to use, no one will use it and no one adds data to the KM system [13]. Therefore, the knowledge of the retired professionals will disappear without being passed on to the new generation of employees. Low-experienced employees are unable to solve problems at the root cause level. Ways to solve the problem

based on low-personal experience causing the same problems happen again.

(3) Support: the problem in the support departments is similar to the problem of Productivity and Process. Data can be collected from many sources and it is impossible to know the correct data. Recording data about repairing is not collected in a systematic manner such as the use of machines and the number of machines working hours after the last servicing, maintenance documentation or specification machines. Sometimes, the maintenance cannot be done at efficiency level and it necessary to order new equipment or buy a whole new set of the machine. On the other hand, another work problem is that the department cannot follow up on maintenance work. It is impossible to track the time spent on maintenance in each step because there is no record of before and after processing. If source data is digital, the process of the input data to the KM system can be done automatically without wasting time filling in the information later [14]. The employees will not waste a lot of time at work.

(4) Finance: most problems are related to planning and prioritizing when buying spare parts. It is impossible to plan the purchase of necessary spare parts because there is an inability to know the remaining budget and cannot access the recording of buying parts and the price. Most budget data is stored in the ERP system, but only some departments can access it. In a survey from the financial department, they commented that if the system of accessing the data is well managed, it will make the process of planning to be better.

IV. Analysis and Findings

The researcher has collected, synthesized and categorized problems into three parts, obviously. The impact on each other is upstream, midstream and downstream [15] as demonstrated in Fig. 1. An upstream is a problem from financial matters that are the root of everything such as getting a budget, knowing the budget, expenditure and remaining budget, respectively. In addition, problems arise from the operations according to the routine of EGAT personnel with various systems, multiple data sources make the data source, not data governance or blockchain which provides a single source of data and directs its use. Midstream is a problem that is affected by upstream. It is not possible to determine the priority of each day, week or month's work. Every job has a flow, but there is no tracking, timer or capital charge for time-consuming work, especially maintenance. Also, there is no repair flow created in any method. The recommendations for damage-checking before repairing are not from reputable sources or using manuals to help guide repairs that will cause delays and affect the overall power generation system. Downstream is a problem caused by upstream and midstream. The problem solvers have to try each method using their experience to solve problems without expert advice. The data is not easily accessible when problem solvers need to know the remaining budget to repair the machine. Moreover, the detailed data on the replacement parts are difficult to access because the data is not saved or cannot be searched. Finally, the problem solvers gave up the idea of repair and switched to ordering new equipment or a whole new set of machines.

Therefore, the organization's main problem is that there is no guideline for flow data and action tracking systems to automatically comply with the policy of C-level in the aspect of data visualization. The examples of data visualization are maintenance, ordering, investment calculations versus non-profitable maintenance [16]. These data must be searched by multiple upstream organizations and held on until midstream will add data or follow guidelines. The information will be displayed to the downstream for decision making in due course [17].

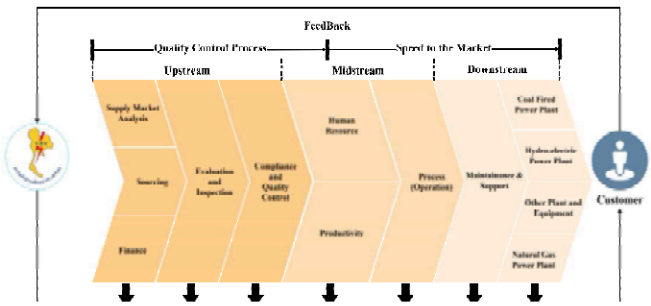

Fig. 1. Illustrattive problem of upstream, midstream and downstream.

From the analysis of project problems of the system, it was found that the relationship between EGAT new generation developer and EGAT domain expert can bring knowledge from near-retirement personnel to teach to the ML system of the platform. The developed ML/AI will be able to learn and make decisions based on the ideas of experts. Recurring problems in the past can use the AI Platform to help guide and help prioritize. It also helps to track down the problem.

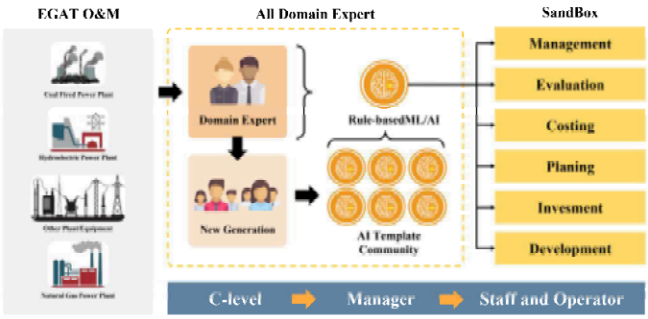

Fig. 2. Show the problem in upstream, midstream and downstream.

Moreover, it is important for improving the community online portal by sharing all ML/AI to all departments within template format as presented in Fig. 2 to create organizational sustainability. Users from other departments can copy the shared ML/AI for other similar tasks without having to develop a new one. There is also a sandbox system available to designers who want to edit the sample data and test results before release to the main system. As a result, EGAT new generation developer can create ML/AI output in many formats, for example, displaying, advising, giving orders to those involved and data recording with meta-keyword or connecting to various systems. Moreover, it can also create dashboard for executives to see the cost reduction in operation and maintenance.

V. Discussion and Recommendation

From studying and collecting data to analyse problems and develop a platform to help solve problems. There are 4 parts of pain points: Productivity, Process (Operation & Maintenance), Support and Finance. Problems will be designed and developed in the form of a sustainable platform

and can be used to solve all current and future problems. There is a collaboration of new systems and technologies such as workflow systems, rule-based and ML/AI systems as shown in Fig. 3 which consists of 3 important parts, details of each part are as follows.

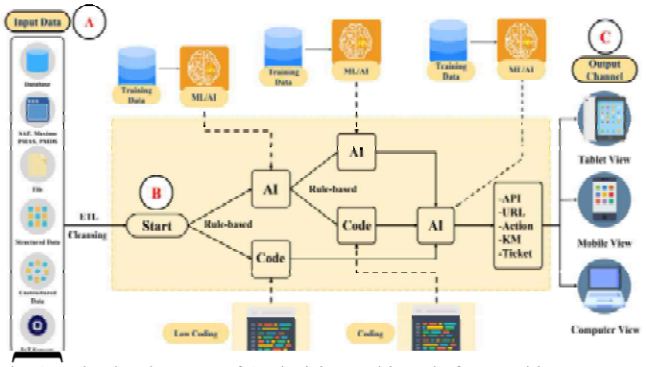

Fig. 3. The development of AI decision making platform architecture.

Part A is the part that receives data from different parts of the EGAT. The design and development will create a data lake to support all formats such as databases, API applications, files, structured data, unstructured data and IoT data. Information entered into the system must be agreed upon between the information provider and the recipient for data governance.

Part B is the main part of the work. It is the part that can create the workflow and defines the input from the data source or data lake. Once a workflow is created, ML/AI can be generated through the interface provided for training ML/AI. Rule-Based can also be incorporated into this section to increase decision versatility and work accuracy in some case.

Part C is the display action section. It can connect to the web and mobile applications can send APIs to commands through IoT devices. It can define various properties through the interface of the system by designing a sustainable concept and secure for the future. It will create a community online portal that will share all knowledge in a template format and can be applied to similar works. It has the following strong point:

1. Able to create a new one by drag & drop (low & zero-coding) without doing programming

2. Able to choose a template created by the EGAT domain expert to use immediately

3. Create your own rule-based and ML/AI from the available data without programming

4. Can test on sandbox with virtual data and can mockup various scenarios to test it

VI. Conclusion

The viewpoint of the study provides an aim to develop the ML/AI system of decision making within the organization and also considers the composition of digitalization and human component. The first step is an interview to collect data about the needs, strengths and weaknesses of each department. Most of the problems related to humans to the machine are found after analyzing the interviews. So, the solution is clearing up the existing data and making it available to use. After the raw data was summarized and made clear. The manufacturing system was controlled depended on data flow to the decision-making system automatically for Productivity, Operation and Maintenance. KM system has been applied for both of domain expert and the new generation of employees to exchange experiences. The all information and track jobs monitoring can be accessed via operators while the notification was connected to web and mobile application. Consequently, information of a workflow system will help improve the dealing of products and services read-time or near read-time between department in organization with machine monitoring in manufacturing which can be used for efficient financial resource and investment design decisions. Furthermore, organizational culture will be revised by applying ML/AI techniques to management and operational decisions. Results will be assessed to improve ML/AI and let AI make decisions. Finally, executives should set guidelines to develop employee's potential and changes the way of working. It is best to focus on comfortable work for employees in the organization based on professional training, training for managers or online courses. Employees or workers have to understand the system and pass on knowledge within the department.

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