LEAN PRODUCTION SYSTEM AS AN APPROACH TO DIGITALIZATION IN SIEMENS LTD. – ARABIA ELECTRIC LTD.

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ABSTRACT: In order to stay competitive in the global market, continuous improvement in all aspects of operations is essential. Due to the need for fast responses to market changes and an ongoing search for a sustainable future, the constraints of information flow among stakeholders become very critical. A global powerhouse company - workshop is facing this issue, which causes activity delays that are considered non-value-adding operations and results in additional costs. Digital technology has been acknowledged for eliminating non-value-adding operations. Digitalization generally requires huge capital investment. However, there is an opportunity to start digital transformation by utilizing existing platforms and applications. This study aims to develop a new framework to assist the company in digital transformation in a cost-effective manner. The proposed framework consists of six modules: identifying the technologies to adapt, categorizing the operations, assessing potential risks, measuring environmental impacts, identifying the advantages, and implementing change management procedures, profitability assessment, and corporate social responsibility programs. The proposed framework was then applied in a global powerhouse company - workshop based on a case study. The results show a significant reduction in time due to the elimination of non-value-added activity (delay). Another tangible benefit is the reduction

or even elimination of consumption of bond papers by up to 98% or 100%, contributing to the conservation of natural resources and minimizing environmental impact. Further savings of 100% are contributed by the elimination of paper storage and the reduction of service fees for printers.

KEYWORDS: *Digitalization; lean production system; Non-value-added operations.*

1.0 INTRODUCTION

Digitalization refers to Industry 4.0 (I4.0) or the Internet of Things (IoT). It is the trend of current and emerging technologies to achieve more with less and not be limited to it. Digitalization involves the interconnectivity of processes and real-time information availability, responsiveness to real-time issues, and proactive measures to avoid defects/non-conformances [1].

The Lean Production System originated from the Toyota Production System, which focuses on reducing waste (non-value-adding activities) in its processes. There are always non-value-adding operations in any organization, such as production planning, production control, maintenance, and repair [2]. Furthermore, transportation is also considered as a type of waste [3]. While a lean approach is always closely related to waste elimination, its utilization also supports reducing environmental impact as suggested by [4]. Several researchers have discussed approaches in digital migration concerning lean implementation. One of them is Cifone et al. [5], who argued that digitalization technologies support the lean implementation of waste elimination. This means that digitalization enhances lean by eliminating non-value-adding activities that use resources.

The benefits of digitalization have been reported in many articles. It improves the flow of information, efficiency, and flexibility; enhances operations; improves Lean Production System (LPS) effectiveness; improves quality; and reduces costly errors [1,5,6,8,9,10-13]. Even though some authors [2,16] have proposed guidelines and frameworks for implementing digitalization, many challenges and shortcomings during digital transformation have been reported [7,14-15].

This paper is based on a Siemens Ltd. – Arabia Electric Ltd. (Equipment) Workshop case study. The scope of company operations under this study includes receiving production orders and initial planning, fabrication, assembly, ferruling, wiring, inspection, and testing. Based on the observation of the current operation practices, there are a lot of non-value-added activities (waste). First, there is a

significant consumption of technical/production documents (paper and printer ink). Second, current operations are still reliant on manual/paper-based documents, leading to delays in information flow. There is an urgent need for real-time information by respective stakeholders anytime and anywhere. Therefore, the company plans to transform into digital-based operations to provide all required information and document availability through collaborative web-based systems. Adopting a cloud platform will streamline the document filing system, enhance document traceability, auditing, and contribute to reducing carbon emissions. Siemens Ltd. – Arabia Electric Ltd. (Equipment) Workshop is a value-adding facility that operates on a project basis. It is referred to as a workshop because it does not engage in mass production but rather adds value to products manufactured by an operational plant. Operational plants are huge in size and manufacture products.

On one hand, digital transformation usually requires a huge amount of money, resources, and time. Examples include a building automation system, which utilizes communication network technology to manage various building services, and a paperless system that uses radio frequency identification (RFID). This can pose a challenge for companies looking to implement such changes. On the other hand, most digitalization applications/platforms are readily available on office computers (laptops, personal computers/desktops, tablet computers, phones, and other smart gadgets). For instance, Microsoft Sharepoint is a widely used platform. There is an opportunity that digital transformation can be initiated by utilizing existing applications; thus, it could be implemented with cost-effective implementation. This research aims to develop a novel framework to guide the company's digital transformation more economically, particularly to digitalize the identified non-value-adding operations in Siemens Ltd. – Arabia Electric Ltd (Equipment) Workshop.

2.0 METHODS

The proposed framework was developed by adopting insights from several previous studies [4, 5] and learning from experiences related to actual industry requirements. The concept in developing this framework is to provide guidelines to successfully identify the cost-effective approach in adapting digitalization into value-added and non-value-added operations. This case study focuses on digitalizing non-value-added operations, such as production plans, maintenance and repair reports, and reducing/eliminating technical drawing hard

copies. The proposed framework ensures that digital technology adoption would be successful while considering the legal industry requirements of today's world.

To start the digitalization journey, it is crucial to select the appropriate I4.0 technologies [5]. In addition, learning from actual industry experience also helps formulate this framework. It requires years of experience in collaboration and implementation.

The proposed framework consists of six modules, as shown in Figure 1, and is defined as follows. Module one (Technology) is derived from a literature review by [6]. This module emphasizes the type of digitalization technology to be adopted. Module two (Process) is based on literature reviews and real industry experience. This module is essential in determining which digitalization activities are intended to improve the unreachable frontier of improvement. Module three (Risks and Opportunities) is based on real industry experience, highlighting the necessity for occupational health and safety management systems in order to address risks and opportunities. Module four (Environmental Sustainability) is also actual industry experience, which requires an environmental management system to assess the lifecycle impact of a product to understand its overall impact on the environment. Module five (Advantages and Change Management) is another actual industry experience that highlights the advantages and change management that is required in a quality management system. This is to ensure that the changes achieve their desired results. Module six (Management Impact) is based on the reviewed literature by [2], which assesses the profitability of the adopted digital technology using the cost-benefit ratio (CBR). This ratio is calculated by dividing the proposed total benefit by the proposed total cost. This approach also addresses the corporate social responsibility (CSR) programs that define the company's business ethics. Furthermore, this will ensure support for the company's commitment to management system requirements.

The context of the proposed digitalization framework is to integrate the methods/findings/recommendations of reviewed literature with newly identified criteria. These criteria are based on learnings from experiences in actual industry experience to enhance the efficiency of value-adding and non-value-adding operations through digitalization and relevant legal requirements of today's business structure with consideration of the environmental impact.

3.0 RESULTS AND DISCUSSION

This section describes the application of the proposed framework to

support Siemens Ltd. – Arabia Electric Ltd on their digitalization journey following six modules or phases (i.e., Technology, Process, Risks and Opportunities, Environmental Sustainability, Advantages and Change Management, and Management Impact).

The first module (Technology) begins by categorizing fields of technology for digital transformation [10], specifically information and communication technologies (ICT), identification technologies (IDT), and automation technologies (AT). ICT refers to technical devices capable of processing, storing, and transmitting data/information for data exchange and communication. An example of these technologies is communications between machine-to-machine and human-to-machine interfaces, among others. IDT involves technical solutions for object identification and data capture, such as optical identification systems and RFID solutions. AT are technical processes within a technical system where a computer collects, processes, and displays information to operators. Examples of these technologies are sensors and actuators connected to computers. The proposed digitalization of non-value-adding operations is categorized as ICT.

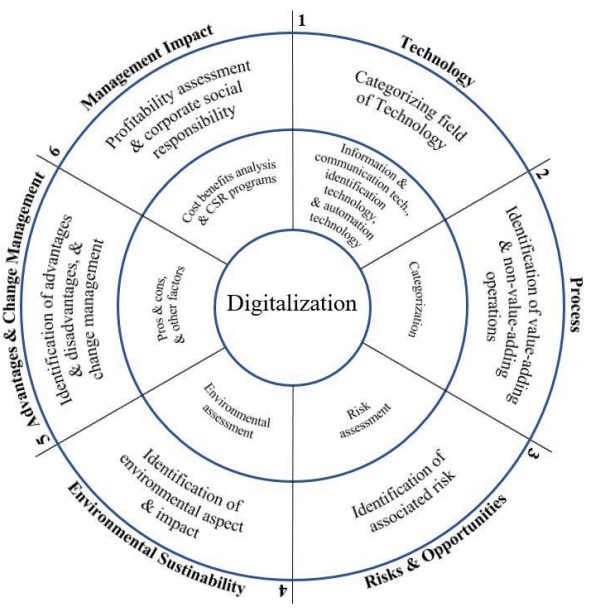

Figure 1: Proposed framework for the digital transformation in Siemens Ltd. – Arabia Electric Ltd (Equipment) Workshop

The next module (Process) involves the identification and categorization of existing value-adding and non-value-adding operations following the Lean Production System concept. Non-value-

added operations include production plans, production control, maintenance, and repair that are indirect and required [8]. Value-added operations are also identified, which will contribute to the ease of the digitalization journey's succession planning roadmap, as shown in Table 1.

Table 1: Value-added and non-value-added operations

Value-Added Operations		
Activity	Description	Remarks
Fabrication (mechanical process)	Includes CNC punching, CNC bending, degreasing, and powder painting	For future digitalization
Assembly (mechanical process)	Includes panel assembly, device/component installation, and fixing labels	
Wiring (electrical process)	Includes ferruling (wire tags), pre-wiring, and panel wiring	

Non-Value-Added Operations		
Activity	Description	Remarks
Production plan	Contains the status/progress of the project	Digitalization plan
Periodic maintenance schedule	Contains the status of the planned and actual execution date of preventive maintenance	
Preventive maintenance and repair reports	Contains the preventive maintenance and repair report	
Work instructions	Contains procedures on task/activity	
Inspection and testing reports	Includes in-progress inspection (mechanical and electrical processes), factory inspection test, and factory acceptance test	
Risk assessment	Contains the identified hazard and risk assessment of all activities/operations	
Environmental assessment	Contains the environmental aspect and impact assessment of all activities/operations	

The third module is Risks and Opportunities. In this module, potential risks and opportunities are identified based on existing conditions and proposed digitalization (Table 2). This module assesses the likelihood and severity of the risk that hinders the success of implementing digitalization. It also means that identified risks can be proactively prevented in the planning phase.

Table 2: Risk assessment of existing and proposed digitalization

Topic	Activity	Hazard	Effect	S	L	RR	Risk and Opportunity	Actions	Revised Risk		
									S	L	RR
Existing process	Use of computers, network, and printing equipment	Exposure to low voltage equipment during operation and setup activities	Personnel may be exposed to electrical hazard from poorly maintained IT equipment (e.g., desktops, printers, scanners)	3	3	9	*Risk:* Personal injury and asset damage *Opportunity:* Use of sustainable solution by opting to the paperless system through digitalization	Additional care must be provided when working with and around electrical and electronic equipment Potential exposure to printing by-products must also be considered Shift to a digitalized and paperless process	3	1	3
		Slipping and tripping hazards	Personnel may be injured from poorly maintained cabling of IT equipment (e.g., desktops, printers, scanners)	3	3	9			3	1	3
		Ergonomic hazard in DSEs	Potential ergonomic issues resulting from poorly managed workstations (e.g., tables, chairs in coordination with working posture)	2	4	8			2	1	2
	Printing equipment maintenance and/or disposal of printing consumables	Potential exposure to hazardous chemicals	Potential ill health effects from uncontrolled exposure to printing waste	4	2	8			4	1	4
		Ergonomic hazard in manual handling	Potential ill health effects from poor material and/or equipment handling	4	2	8			4	1	4

Table 3: Environmental aspects and impact assessment

Topic	Activity	Aspect	Impact	S	L	IR	Risk and Opportunity	Actions
Existing process	Use of computers, network, and printing equipment	Energy use	Loss of non-renewable fossil fuels	2	4	8	*Risk:* Loss of recyclable materials and occupies large landfill space *Opportunity:* Use sustainable solutions by opting for a paperless system through digitalization	Establish a strong commitment of the organization toward environmental sustainability
			Impacts on air quality and contribution to climate change	2	4	8		
	Disposal of paper, stationery, printing materials, and filling materials	Waste generation	Loss of recyclable materials and landfill space	2	4	8		
			Soil and water pollution if contaminated	2	4	8		
	Disposal of electronic equipment (e.g., laptops, computers, printers)		Soil and water pollution if disposed of incorrectly	3	3	9		
	Use of paper, stationery, printing materials, and filing materials	Using raw materials	Loss of non-renewable resources	3	3	9		
			Soil and water pollution if disposed of incorrectly	3	2	6		
Paperless system	Use of computers, network, and printing equipment	Energy use	Loss of non-renewable fossil fuels	1	4	4	*Risk:* Loss of non-renewable energy (fossil fuels) *Opportunity:* Use of sustainable renewable energy (solar farms, wind farms, and others)	
	Disposal of electronic equipment (e.g., laptops and computers) (no printing equipment)	Waste generation	Soil and water pollution if disposed of incorrectly	2	3	6		

The fourth module (Environmental Sustainability) identifies the environmental impact of existing and proposed digitalization (Table 3). The module assesses the likelihood and severity of the environmental impact of implementing digitalization. It is also relevant for today's organizations to consider the environmental impact of their policies. The digitalization approach proposed in this study agrees with previous studies by [17, 18] as a way to support lower carbon emissions; however, there are potential drawbacks that should be considered as previously reported by [17].

The fifth module (Advantages and Change Management) identifies and compares the advantages and disadvantages of existing and proposed conditions, as shown in Table 4. This module assesses other factors that have yet to be covered in the second to fourth modules as defined. This includes change management to measure the success of implementing the initial phase of digitalization. In change management, it is crucial to address the main reasons for changes, the impact of its changes, or the known risk associated with this change; to define the necessary resources to implement this change; and to validate the change initiative. Similarly, the pros and cons of proposed digitalization have also been reported by [19,20].

Table 4: Advantages and disadvantages of existing and proposed digitalization

Topic	Advantages	Disadvantages
Existing operations	• Convenience • Easy implementation (can be done with simple verbal instructions) • Accustomed physical documents	• Non-transparent information • Take time to trace the documents • Non-continued flow of information • Consumes productive time • Consumes paper and ink
Proposed digitalization (paperless system)	• Convenience • Transparent to all stakeholders • Ease of traceability • Faster flow of information (timely) • Optimizes productive time • Reduces/eliminates the use of paper and ink	• Unfamiliarity of the applications/forms • Difficulty in accepting new process(es) • The extent of the features may not be fully utilized

The final module is Management Impact, which assesses the profitability of digitalization implementation [8] and CSR programs. The module determines the financial gain in implementing

digitalization, as well as considerations of social and environmental issues of the organization. It also determines the financial, social, and environmental strategy and direction of the initial digitalization phase. Cost-benefit analysis (CBA) is utilized to measure the profitability of the digitalization of non-value-adding operations by dividing the amount of benefit and cost. This addresses the direct cost of the implementation (initial investment for the chosen collaborative platform). Table 5 presents the CBR and net benefit of the proposed digitalization. It also addresses the cost benefits of replacing the old system with a paperless system and user intangible benefits for the seamless availability of information anytime and anywhere. This result is consistent with a previous study by [8]. For CSR, a commitment is to be included in the context of the organization's policy and also in its business conduct guidelines. Related programs for environmental protection should be implemented to conserve resources.

Table 5. Cost-benefit analysis

Costs				
Description		Intangible Benefits		Costs ($)
Collaborative platform (Microsoft Sharepoint) for 17 users on the shop floor		Elimination of physical documents Accuracy of information [8] Availability of real-time information at anytime and anywhere [8]		3,000.00
PC tablets for 17 users		Tool as a source of all production information		12,104.56
			Total	15,104.56
Benefits				
Description		Tangible Benefits		Costs ($)
Reduce A3 size paper consumption for technical drawings of 96 reams		Reduce/eliminate paper waste and conserve natural resources (trees and fossil fuels) [10]		3,840.00
Reduce A4 size paper consumption for technical drawings and production-related documents of 36 reams				720.00
Paper storage of 1 m^2		Reduce/eliminate storage areas for papers [10]		486.58
Reduce ink consumption of four cartridges		Reduce/eliminate hazardous waste and conserve energy [10]		1,654.11
Service contract for printers annually		Eliminate contract agreements [10]		2,559.55
			Total	9,260.24
Cost-Benefit Ratio for 3 Years Span				
	1st Year	2nd Year	3rd Year	
Cost-Benefit Ratio	0.61	3.09	3.09	

As for consumption of bond papers up to 98% or 100%, it helps conserve natural resources and minimizes or eliminates environmental impact. Moreover, there are further savings of 100% on the elimination of paper storage and the cutting of service fees for printers.
Based on the findings of module assessments, risk and environmental assessments demonstrate the significance of transitioning identified activities from an existing process to a paperless system (0% paper usage). Thus, there is no longer a need for storage and printer service fees (cut by 100%). This change leads to cost reduction, a similar outcome to that reported in [10]. It also indicates a significant reduction in environmental impact. The benefits underscore the significance of the qualities that digital technologies offer, as outlined in Table 3. Lastly, the CBA reveals that while the net benefit in the first year is negative, but in the succeeding years, the net benefit becomes positive. In adapting digitalization to non-value-adding operations, the results have demonstrated significant improvements in mitigating risks and environmental impact, enhancing information flow, and yielding a positive net benefit in succeeding years.

4.0 CONCLUSION

The new framework aims to assist the company during digital transformation with minimal investment costs by following these six steps: (1) defining the new generation by identifying the technologies to adapt, (2) categorizing the operations, (3) assessing potential risks, (4) measuring environmental impacts, (5) identifying the advantages, and (6) implementing change management procedures, cost and benefit analysis, and CSR programs.
This framework has been implemented and is continuously identifying the value-adding and non-value-adding operations digitalization at Siemens Ltd. – Arabia Electric Ltd. (Equipment) with positive results. It can be adapted to organizations of any size, including small-medium enterprises and large companies. This framework can facilitate digital transformation by reducing delays and providing real-time information. However, further studies are required to ensure its applicability in supporting other industries.

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AUTHOR CONTRIBUTIONS

P.D. Karningsih: Conceptualization, Methodology, Supervision, Writing-Reviewing, and Editing; M. F. Narvas: Conceptualization, Methodology, Writing - Original Draft Preparation, Writing - Reviewing, and Editing; M. N. Young: Conceptualization and Supervision

CONFLICTS OF INTEREST

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest on the manuscript.

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