

Lean Environmental Management Integration System (LEMIS) Framework Development

Puvasvaran, A. P., Suresh V., N. Norazlin

Abstract—The Lean Environmental Management Integration System (LEMIS) framework development is integration between lean core element and ISO 14001. The curiosity on the relationship between continuous improvement and sustainability of lean implementation has influenced this study toward LEMIS. Characteristic of ISO 14001 standard clauses and core elements of lean principles are explored from past studies and literature reviews. Survey was carried out on ISO 14001 certified companies to examine continual improvement by implementing the ISO 14001 standard. The study found that there is a significant and positive relationship between Lean Principles: value, value stream, flow, pull and perfection with the ISO 14001 requirements. LEMIS is significant to support the continuous improvement and sustainability. The integration system can be implemented to any manufacturing company. It gives awareness on the importance on why organizations need to sustain its environmental management system. In the meantime, the lean principle can be adapted in order to streamline daily activities of the company. Throughout the study, it had proven that there is no sacrifice or trade-off between lean principles with ISO 14001 requirements. The framework developed in the study can be further simplified in the future, especially the method of crossing each sub requirements of ISO 14001 standard with the core elements of Lean principles in this study.

Keywords—LEMIS, ISO 14001, integration, framework.

I. INTRODUCTION

MANAGING environmental performance has been viewed as a strategic issue by many companies worldwide, primarily because the environment is now regarded as an asset to be valued. As a result, managers today are not only expected to reduce lead times, improve quality, reduce costs and enhance flexibility but they are also expected to become more environmentally responsible [1]. The International Organization for Standardization (ISO) introduced the ISO 14000 series of standards in 1996 as a response to the urgent need for companies to address the impact of enterprises' activities on the environment issues.

ISO 14001 is the world's most recognized environmental management system (EMS) framework that helps the organizations to improve the impact of their both activities on the environment and also to demonstrate sound environmental

management. ISO 14001 is designed to be flexible enough to be applied to any size of organization in both the private and public sectors.

Meanwhile, Lean is known as business model that focuses on delivering quality products to the customer by reducing cost of production. The principles of lean are founded on understanding of customer needs and demands, eliminating non-value added activities from the production process, involving the workforce in resolving operational issues, define metrics for measuring organizational performance, assist in the decision making process and problem solving [2].

Many organizations are under pressure to demonstrate their performance on management of the environmental impacts on their business activities responsibly and effectively [3]. The industries are currently facing a number of challenges to maintain competitiveness and productivity while at the same time creating a minimal environmental impact [4]. Due to this, many organizations are considering the implementation of an environmental management system (EMS) within this climate of pressure, growing trend towards more responsible corporate governance and also environmental awareness. Furthermore, ISO 14001 is voluntary based standard and there are no any legal requirements to certify on this standard. Voluntary standards are usually seen to be ineffective since its implementation depends on management incentives which lead to less than optimal performance by organizations on the environmental sustainability front [5].

Ghisellini and Thurston [6] argued that ISO 14001 is a "management" standard, and not a "performance" standard where the commitment to continuous improvement is intended to be applied to the EMS itself but not in the actual environmental performance. The lack of guidelines to accomplish continuous improvement element and an operational definition on continual improvement and method to assess it was argued by Zutshi and Sohal [4]. Besides that, the ISO 14001 standard lack of detailed guidance on the implementation, which has resulted in procedures that are not clear and reproducible [7]. The ISO14001 standard blocks the way for other routes that might deliver real performance improvements and sustainable industrial development since ISO 14001 talks about "standardization in the field of environmental management tools and systems" [8]. This clearly indicates that ISO 14001 did not specify the guidelines or operational definition of what continual improvement is and how it is accomplished or assessed. It also indicates that many organizations are struggling to sustain their environmental management system due to lack of proper guidance on the system sustainability [5].

Puvasvaran was a Senior Lecturer in the Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia (e-mail: punesh@utem.edu.my).

Suresh Vasu was with Ansell Industry based in Melaka, Malaysia (e-mail: suresh.vasu@ansell.com).

Norazlin N. was with the Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia (e-mail: dzul_azlin@yahoo.com).

II. LITERATURE REVIEW

A. ISO 14001

ISO 14000's EMS standards are known as process standards without involving the performance standard. Instead, this standard describes a system that will improve an organization to achieve its own objectives and targets. Based on the standards performance, an assumption has been made where by improving the environmental management will indirectly lead to a better environmental performance. ISO 14001 defines continual improvement as "a process of enhancing the environmental management system in order to achieve improvements in overall environmental performance consistent with the organization's environmental policy" by ISO 14001 [9].

ISO 14001 aims at continuous improvement in the environmental performance of a business to bring about a positive impact on the overall environment in which the company functions [10]. The ISO standard consists of five important steps: designing the environmental policy, planning, implementation and operation, checking and corrective action and management review. Once the standard is implemented in the organization, it creates a self-sustaining cycle that focuses on continuous improvement and helps the company reach its environmental targets [11].

The standard also has been criticized by a number of companies [12]. One of major barriers to certificate and develop an effective EMS is that, companies become vulnerable to legal claims as they start to develop EMS. The development of an EMS creates documentation on environmental performance and these documents can become a basis for court action against an organization that does not go according to its targets [13]. These litigation problems can create caution on the development of an EMS. The good side however is that, the standard does not mention reporting of environmental performance by companies [14]. Auditors may have access to information on performance and can leak such information out.

B. Lean

Lean manufacturing focuses on eliminating waste from organizational processes with a view to deliver more value to a customer. Thus, integrating Lean with the ISO 14001 standard will make the standard more sustainable because it will be customer-oriented which is consistent with the objectives of many organizations [15], [16]. Implementing Lean principles also emphasize on perfection which is achieved through continuous learning and improvement. These two aspects can also be applied to the ISO 14001 standard so that environmental outcomes of an organization are enhanced as an organization learns to improve the management of the standard impact on the environment [17], [18]. The principles also advocate for production based on customer demand so that there is no unnecessary production. This is an important concept in reducing avoidable environmental emissions. Puvanasvaran et al. [19] also mentioned that effectiveness of integrating Lean and EMS can

be realized by adopting processes and procedures which are designed to eliminate waste and create an economically sustainable work environment.

Lean exists in conceptual form which means that it is not a particular methodology to be applied to organizational processes [20]. However, the philosophy provides a unified focus for organizational operations which eliminates wasteful activities that do not deliver value to customers [21]. This essentially implies under the Lean philosophy where all managerial decisions should be evaluated on the basis of the value that they add to consumers and those decisions that do not add value should be discarded.

Based on the findings, Lean is a not only benefits the manufacturing sector but it also benefiting other sectors, such as service sector where it shows how lean has been deployed by various industries to meet their goals. Besides that it also proved that continuous improvement element is the key success factor for the system. Since the study intend to focus on ISO 14001 standard sustainability, lean would be the perfect system to be integrated with lean to address the claim by Zutshi and Sohal [4] that ISO 14001 lack of guidelines to accomplish "continuous improvement" element and the claim Martin and Koppen [22] that ISO 14001 standard lacks of an operational definition on continual improvement and method to assess it.

C. Integration

A study on the integration of QMS, EMS and occupational health and safety management system by Wilkinson and Dale [23] argued that integration can be carried out in different number of ways and may have resulted in differences in understanding of meaning of the term and in applying it. Karapetrovic and Willborn [24] call the integrated system "a system of systems". They argued that the integration of two systems means to link them in a way that results in a loss of independence of one or both. Integration normally leads to a stronger and more comprehensive management system.

Lean Six Sigma combines the lean and six sigma approaches to focus on improving quality, reducing variation, and eliminating waste. Lean Six Sigma is a combination of lean and six sigma principles began in the late 1990's and is emerging as a powerful principle. Majority of applications of lean six sigma has been in the private sector, mostly in manufacturing arena, though many lean and six sigma experts suggest use of these tools and principles in non-manufacturing sectors such as software development, service industry, education, transactional industry such as accounting and order processing, material procurement and new product development [25].

According to the study by Andersson [26], proper application of lean tools in the integration process, we would get to a level of improved effectiveness and efficiency in the organization. In a comprehensive lean risk management integration strategy, the future state of risk management process would be drawn following lean principles with an eye on extension work for developing the lean risk management policies throughout the supply chain. Lean thinking and risk

management process have natural coexistence whether the organization understand the relationship or not. The correlation between risk management and lean thinking can be integrated and upgrade the organization or company in terms of efficiency as well as safety and security.

Applications of lean principles make a quick response enterprise with proper level of flexibility which results in an aware personnel attitude in a lean risk management working environment. Process of integrating lean principles into risk management process would be practicable with the aid of appropriate tools. The lean tools can vary depending on the nature of the organization and the focus sector, whereas integration work requires different tools in a manufacturing environment in contrast to the service sector. However through proper application of lean tools in the integration process, the level of improved effectiveness and efficiency in the organization would be high. The result to the integration work would be a lean organization with hunger and thirst to make more improvements to the status of our lean risk management [26].

III. LEMIS FRAMEWORK DEVELOPMENT

The lean principles and ISO 14001 had different goals and thus they could not be integrated [27]. This made companies develop an EMS and Lean culture differently. However, studies have shown that there is a close link between environmental management and reducing wastage in organizations [28]. This calls for the organization to think of the ISO 14001 implementation as a product or service which has to be produced based on Lean principles [29]. Therefore, this research was intended to develop Lean-EMS integration model to help organization to sustain the Environmental management system though effective continuous improvement method. Integration of Lean and ISO 14001 standard requires the application of Lean principles into the implementation of the standard. Fig. 1 shows the framework development steps. Five principles of lean were detailed out into nine core elements which give a better view of each principle. The framework for this phase was adopted from Pichhi [30] research paper.

In the development phase the 42 sub requirements of ISO14001 were compared with the Lean principles Core element. This was done by crossing the each Sub requirements of the ISO 14001 with each lean principles core element. The 42 sub requirements of ISO14001 represented in rows and the Lean core elements were represented in columns. Table I illustrates an example of integration process.

IV. RESULT

A. Framework Development Phase

In framework development phase, the sub requirements of ISO 14001 standard were integrated with the core elements of Lean principles. This was done by crossing each sub requirements of ISO 14001 standard with the core elements of Lean principles. The variables are one of common techniques which has been used to cross-tabulate variables in his studies

[30]. This researcher has used this technique to design the system and select, adapt or create techniques which are coherent with lean philosophy.

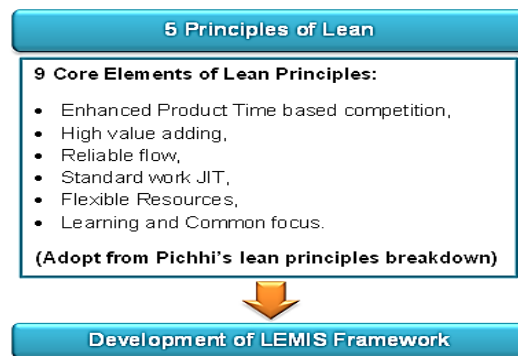


Fig 1 The LEMIS Framework Development

TABLE I
INTEGRATION USING CROSS TABULATION METHOD

		ISO 4001 Sub requirements
		CLAUSE 4.2: ENVIROMENTAL POLICY- Define an environmental policy of commitment statement
Lean principles core elements	Value	Enhanced product/service package value
		Time based competition
	VSM	High value adding in the extended enterprise
		Flow
	Pull	Dense, regular, accurate and reliable flow
		Standard work
	Perfection	JIT production and delivery
		Flexible resources
		Learning
	Common focus	

The 42 sub requirements of ISO14001 were represented in rows and the Lean core elements were represented in columns. As an example, ISO 14001 sub requirement 1 (SR1) were crossed with lean core element 1 (CE1), then crossed with CE2 until CE9. The same steps were used for rest of ISO

14001 sub requirements. Fig. 2 shows the matrix of how the ISO 14001 sub-requirements cross-tabulated with lean core elements. The handbook of EMS and information gathered through extensive literature reviews were used as reference during the cross-tabulation processes. Tables II-VI show an example on how the sub requirements of ISO 14001 standards were integrated with the lean principles core elements.

B. Framework Validation

Framework validation for this study was done using focus group methodology. Eight industrial experts from related field were invited to participate in the focus group. The well-designed focus group usually consists of between 6 and 12 participants [31]. A set of validation question including relevant documents were provided to the group. The questions were divided into four sections, which are fundamental, methodology, integration and critical success factors. Fundamental and methodology sections are more on agreement type of questions and the focus group participants were given full freedom to voice out their opinion. Meanwhile, the integration and critical success factor questions are more to feedback type of questions and the focus group participants were given full freedom to voice out their opinion based on their experience. Table VII shows the list of questions used to get the feedback from experts.

The result for fundamental questions shows that both lean and ISO 14001 have a major impact to an organization's performance in terms of environmental and waste management. During the focus group session, all the

participants admitted that the methodology adopted in this study are easy to understand and some of the participants even praise on the effort given on this study. Besides that, they feel that this methodology will lead to a good framework development. They agreed that integrating Lean with ISO 14001 standards gained more attention and become an interesting subject since most of the companies realize the significance of environment protection, ensure optimization of resources by considering the cost and environment aspects. Meanwhile, the standard also will be the customer-oriented which is consistent with the objectives of many organizations. It also helps in overcoming operational challenges, improves business efficiency and helps to specify an organization's performance measures by ensuring the standard sustainability and continual improvement. The result shows that the integration model helps an organization to manage the environmental issues through lean principles. Besides that, it also ensures sustainability of the standard through value added activities which benefits an organization. The entire focus group participants agreed with all critical success factors. During this session, participants shared their views on each factor and justify their view by giving supportive statements. The participants agreed that management commitment, communication, training, teamwork, quality commitment, employee welfare and employee involvement are the most pertinent issues which are critical for the successful integration of lean principles and ISO 14001.

ISO 14001		Lean Principles								
		P1		P2		P3		P4		P5
Requirement	Sub requirement	CE1	CE2	CE3	CE4	CE5	CE6	CE7	CE8	CE9
R1	SR1	SR1 x CE1	SR1 x CE2	SR1 x CE3	SR1 x CE4	SR1 x CE5	SR1 x CE6	SR1 x CE7	SR1 x CE8	SR1 x CE9
	SR2	SR2 x CE1	SR2 x CE2	SR2 x CE3	SR2 x CE4	SR2 x CE5	SR2 x CE6	SR2 x CE7	SR2 x CE8	SR2 x CE9
R2	SR3	SR3 x CE1	SR3 x CE2	SR3 x CE3	SR3 x CE4	SR3 x CE5	SR3 x CE6	SR3 x CE7	SR3 x CE8	SR3 x CE9
R3	SR4	SR4 x CE1	SR4 x CE2	SR4 x CE3	SR4 x CE4	SR4 x CE5	SR4 x CE6	SR4 x CE7	SR4 x CE8	SR4 x CE9
R4	SR5	SR5 x CE1	SR5 x CE2	SR5 x CE3	SR5 x CE4	SR5 x CE5	SR5 x CE6	SR5 x CE7	SR5 x CE8	SR5 x CE9

Legend	
ISO 14001 requirement (Rx, x=1-18)	
ISO 14001 Sub requirement (SRx, x=1-42)	
Lean principles (Px, x=1-5)	
Lean principles core element (CEx, x=1-9)	

Fig. 2 Integration using cross- tabulation methods

A. LEMIS

Integration of Lean principles and ISO 14001 standards involve by linking the nine core elements of lean with the implementation of the ISO 14001 standard and named it as LEMIS model as shown as Fig. 3. For instance, a clear definition of the organization's environmental policy will help to improve the firm's environmental performance. Fast-tracking by implementation of such as policy will make the organization beat its competitors by winning customers who

are more environmentally sensitive. This aspect relates to time-based competition under Lean principles [32]. Moreover, the establishment of a clear environmental policy and educating employees at the same time leads to consistent performance of the organization on the environment front. This aspect relates to the core elements of standard work, high value adding, learning, and reliable flow in Lean philosophy [33]. Thus, integration of Lean with an ISO 14001 standard essentially entails applying the core elements of the philosophy in the implementation of the standard.

TABLE II
SUB REQUIREMENT 1 INTEGRATED WITH 1ST LEAN PRINCIPLES CORE
ELEMENTS

ISO 14001 CLAUSE	Lean 1 st principle "Value"	
4.1 General Requirements	Enhanced product / service package value (CE 1)	Time based competition (CE 2)
*Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)	-To stay competitive in the market -Able to deliver the customer needs -To show social responsibilities towards the environment	-Shorten implementation time with proper implementation planning
*Define and document the Scope of EMS (SR2)	-Implementation of EMS will be more effective since the area, activities or processes involved were defined	-Organization will be more focused and easy to manage all the aspect that significant for the environment within short period of time

TABLE III
SUB REQUIREMENT 1 INTEGRATED WITH 2ND LEAN PRINCIPLES CORE
ELEMENT

ISO 14001 CLAUSE	Lean 2 nd principle "Value stream mapping"	
4.1 General Requirements	High value adding in the extended enterprise (CE 3)	
*Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)	- Eliminate non value added procedures and activities towards effective implementation	
*Define and document the Scope of EMS (SR2)	-Mapping and eliminating unrelated processes, activities and procedures to ensure that management can be more focused and ease to manage all the aspect that significant for the environment.	

TABLE IV
SUB REQUIREMENT 1 INTEGRATED WITH 3RD LEAN PRINCIPLES CORE
ELEMENTS

ISO 14001 CLAUSE	Lean 3 rd principle "Flow"	
4.1 General Requirement	Dense, regular, accurate and reliable flow (CE 4)	Standard work (CE 5)
*Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)	-Adopting good coordination and planning activities among those involved in the system to enhance the implementation of the system	-Standardization of procedures among the involving parties -Use database to manage data and exchange information's
*Define and document the Scope of EMS (SR2)	-Clearly define the scope which directly links the management system with the activities, products and services	-Scope should be simple and easy to understand by all interest parties.

The inputs of the LEMIS model are organizational goals for an effective EMS and enhanced environmental performance. These goals are important in helping the organization to enhance its reputation in the marketplace for being environmentally sensitive [33]. These goals are facilitated by Lean principles which help to remove wasteful processes in the EMS by encouraging perfection in every aspect of the system. The outputs of the integration model are an effective EMS model with better environmental outcomes by an organization.

TABLE V
SUB REQUIREMENT 1 INTEGRATED WITH 4TH LEAN PRINCIPLES CORE
ELEMENTS

ISO 14001 CLAUSE	Lean 4 th principle "Pull"	
4.1 General Requirements	JIT production and delivery (CE 6)	Flexible resources (CE 7)
*Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)	-Delivering proper and adequate information at right time and at right place to ease the EMS implementation process	-Involvement from all levels of employees provides flexibilities for the organization to drive the system
*Define and document the Scope of EMS (SR2)	-Area of scope should be focused and achievable	-Involvement from all levels of employees provides flexibilities for the organization to drive the system

TABLE VI
SUB REQUIREMENT 1 INTEGRATED WITH 5TH LEAN PRINCIPLES CORE
ELEMENTS

ISO 14001 CLAUSE	Lean 5 th principle "Seek for perfection"	
4.1 General Requirement	Learning (CE 8)	Common focus (CE 9)
*Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)	- Benchmarking on successful EMS practitioners gives an learning opportunity for the involve parties - Provide adequate training for the employees to drive the whole system	-Creating means for all workers participation in processes improvement, including sub-contractors and other interest parties
*Define and document the Scope of EMS (SR2)	- Ensure adequate trainings are available for the employees to drive the whole system	- Creating means for all workers participation in process improvement, including sub-contractors and other interest parties

Before developing the inputs of the LEMIS model, the organization has to come up with an environmental policy. This policy is then converted into an action plan with clear and measurable goals which become the inputs of the model [29]. The goals are aimed in reducing the environmental impact of all the organizational processes. As a result of the integration of Lean principles with the ISO 14001 standard, the output of the LEMIS model includes a more effective and efficient EMS which can produce better performance of the organization on the environmental front [34].

Effectiveness of the EMS is enhanced clearly by defining the goals and establishment of measurable environmental outcomes. These factors in turn lead to better environmental performance of the organization. The deliverables of the LEMIS model are a more effective EMS which is well understood by all employees in the organization and higher environmental performance by the organization since all of the firm's operations will have a common focus on reducing the impact of its operations on the environment [35].

TABLE VII
EXPERT REVIEW ON LEMIS FRAMEWORK DEVELOPMENT

Questions	
Fundamental	<ol style="list-style-type: none"> 1. Lean is a set of principles and techniques that drive organizations to continually add value to the product they deliver by enhancing process steps that are necessary, relevant and valuable while eliminating those that fail to add value 2. Lean organizing and optimizing production in the perspective of a whole-system that focuses on providing services and products according to real demand of customer 3. The strong competitiveness drivers have made lean widely adopted by business in different industries 4. Lean leads in achieving competitive advantage, improving financial position, improving services, increasing quality and process standardization 5. Lean Thinking is a complex combination of philosophy, system and techniques, and a misunderstanding of this combination, for example focusing on isolated techniques (or tools), is one of the most common reason for poor partial implementations with few results 6. ISO 14001 Standards has been designed to be flexible enough to be applied to any size of organization in both the private and public sectors 7. ISO14001 provides assurance to the management, that it is in control of the organization's activities and processes which have environmental impacts, increased market opportunities and compliance with environmental legislation and regulations 8. ISO14001 improves efficiency and productivity by identify ways to minimize waste and dispose it more effectively
Methodology	<ol style="list-style-type: none"> 1. The ISO 14001:2004 clauses were reemphasize from 18 main clauses to 42 sub clauses to give a better understanding on the clauses and ensures that all the clauses are well considered for the standards sustainability 2. WH questions method were used to identify the essential of each sub clauses of ISO14001:2004 standards 3. Lean principles deployed to a detailed conceptual level, named core elements, is argued to be a better basis for potential applications in different environments 4. LEMIS framework constructed by crossing Lean core elements and ISO14001 Standards sub clauses to provide a system view to help the EMS practitioners to design their system and select, adapt or create techniques coherent with lean philosophy
Integration	<ol style="list-style-type: none"> 1. Integrating Lean with the ISO 14001 standard within firms can help in overcoming operational challenges and improving business efficiency 2. Integrating Lean with the ISO 14001 standard helps to specify an organization's performance measures by ensuring the standard sustainability and continual improvement 3. Integrating Lean with the ISO 14001 standard ensures optimization of resources by considering the cost and environment aspects 4. Integrating Lean with the ISO 14001 standard ensures the standard more sustainable and it will be customer-oriented which is consistent with the objectives of many organizations
Critical Success Factors	<ol style="list-style-type: none"> 5. LEMIS ensures that the environmental impact of all processes leading to the delivery of products to customers are identified and dealt effectively 6. LEMIS induce the commitment from the top management which leads to an effective implementation of EMS. 7. LEMIS promotes better communication among the employees of an organization to ensure the effectiveness of the EMS 8. LEMIS promotes people development through effective trainings and education 9. LEMIS stimulates better teamwork among the involve parties in the system 10. LEMIS ensures that the employee's welfare is well considered and promotes a positive working environment among the employee's 11. LEMIS promotes to non-compromise quality commitments among the employees

An EMS that is based on the guidelines of the ISO 14001 standard only may not be effective as the standard. It does not

specify environmental outcomes which can be used to measure the organization's performance. Integrating the standard with Lean principles, however, leads to the creation of these measurement standards for evaluating the organization, making its environmental efforts more realistic, focused, and attainable [36]. The LEMIS model also eliminates any wasteful processes in the organization's implementation of the standard thus leading to higher environmental performance.

V. CONCLUSION

Earlier it was thought that Lean and ISO 14001 have different objectives and hence cannot be integrated. The integration of Lean and EMS can present increased challenges to the organizations in the form of implementation strategies, identification of the true potentials of the systems and the creation of awareness among the workforce on the changing practices and procedures at workplace. This is where the idea of integrating lean and ISO 14001 comes into the picture. By focusing to the problem statement, the main objective of this study is to develop a new model to ensure effective and efficient EMS and better performance of the organization on the environmental. Extensive studies on literature reviews and information from questionnaire survey leads to this framework development. The integration was done by integrating the core elements of lean principles with the ISO 14001 requirements. The framework was validated by industrial experts and it was well received by them.

Organizations over the past few decades have focused on applying the principles of Lean and EMS for a sustainable development and optimizing their production resources. The primary objectives behind the application of such standards are both cost savings and environmental considerations. The business models developed along the lines of these principles are guided by the need for continual improvement in production processes. Considering the challenges posed by the rapid changes within the business environment this study contributes to the development of a new framework known as Lean Environmental Management Integration system (LEMIS) that helps the firms in complying with the needs of sustainable growth and development objectives.

There are several recommendations for the continuation of this study. The recommendations are the model can be applied in the ISO 14001 certified companies in Malaysia where the success of lean principles and EMS integration can be measure, identifying a proper set of indicators to adequately assess and monitor the environmental performances, establishment of metrics and indicators that can be used to accurately track the environmental performance over time, and further elaboration of performance frameworks, where it would be important not only to investigate ways of using indicators as external benchmarks, but also to explore the ways indicators can support the internal motivational processes of the company.

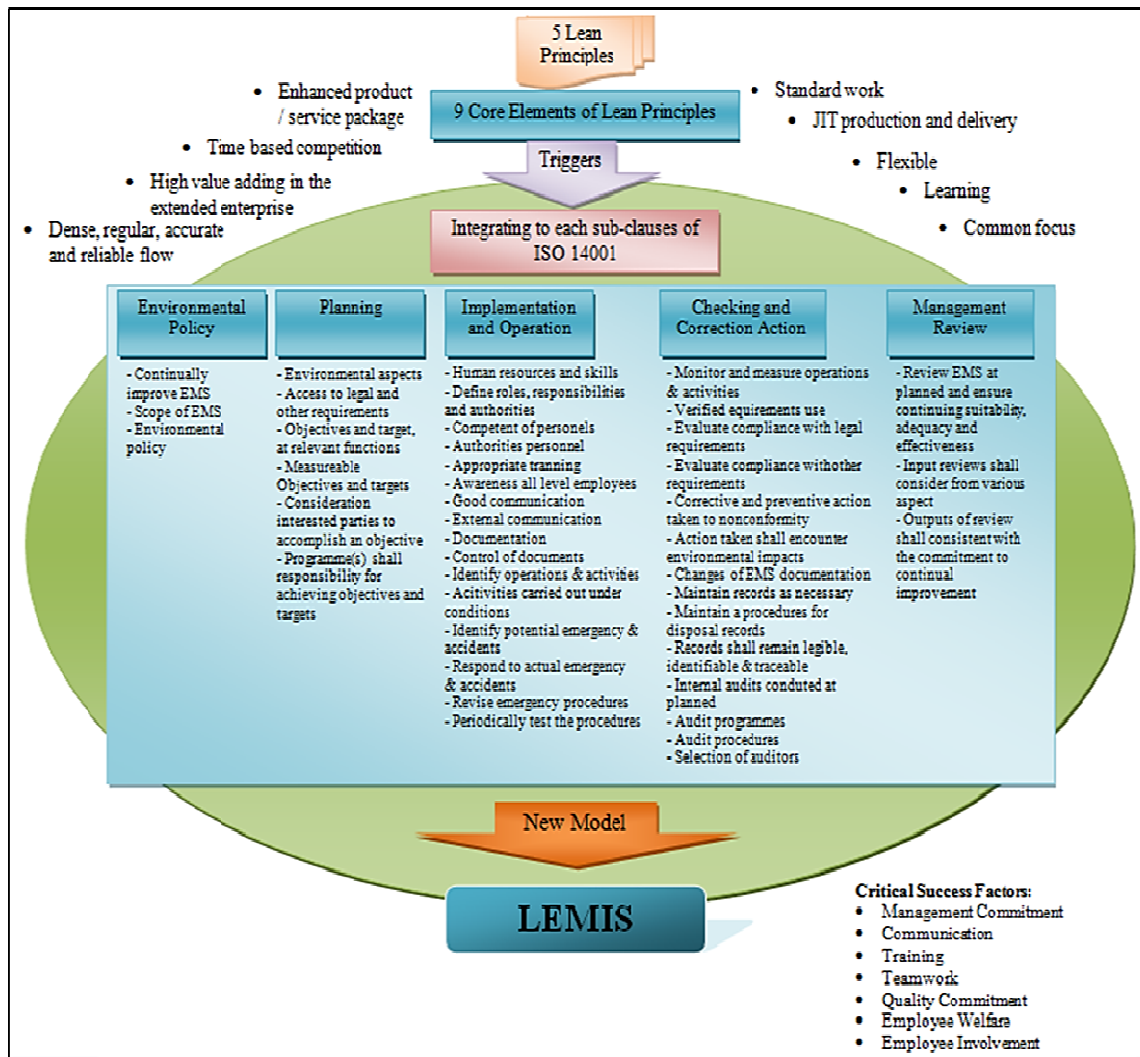


Fig. 3 LEMIS Model

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REFERENCES

- [1] Montabon, F., Melnyk, S. A., Stroufe, R., & Calantone, R. J. (2000). ISO 14000: assessing its perceived impact on corporate performance. *Journal of Supply Chain Management*, 36(2), 4-16.
- [2] Ross, B. AEC (2004). Findings and recommendations on Lean production and Environmental Management Systems in the shipbuilding and ship repair sector.
- [3] Hall, J. (2000). Environmental supply chain dynamics. *Journal of cleaner production*, 8(6), 455-471
- [4] Zutshi, A., and Sohal, A., 2004. Environmental management system adoption by Australasian organisations: part 1: reasons, benefits and impediments. *Technovation*, Vol. 24, No. 4, pp. 335-357.
- [5] Pojasek, Robert B. "Creating a complete business management system." *Environmental Quality Management* 17.4 (2008): 87-95.
- [6] Ghisellini, A., and Thurston, D. L., 2005. Decision traps in ISO 14001 implementation process: case study results from Illinois certified companies. *Journal of Cleaner Production*, Vol. 13, No. 8, pp. 763-777.
- [7] Pojasek, Robert B., 2006. Quality toolbox: Is your integrated management system really integrated? *Environmental Quality Management*. Wiley Periodicals, Inc. pp. 89-97.
- [8] Pullin, J (1998), Green Stamp Giveaway, *Professional Engineering*, Volume 16, Number 16, pp.28.
- [9] ISO 14001:2004 – Environmental Management System – Requirements with guidance for use. International Organization for Standardization. Geneva, Switzerland.
- [10] Hancock, J., 2005. Investing in Corporate Social Responsibility: A Guide to Best Practice. *Business Planning and The UK's Leading Companies*, Kogan Page Publisher, London: Heinemann, Butterworth.
- [11] Lesourd, J. & Schilizzi, S. (2003). The environment in corporate management: new directions and economic insights. Edward Elgar Publishing.
- [12] Yiridoe, E. K., & Marett, G. E. (2004). Mitigating the high cost of ISO 14001 EMS standard certification: lessons from agribusiness case research. *International Food and Agribusiness Management Review*, 7(2), 37-62.
- [13] Kolk, A., 2005. *Economics of Environmental Management*, Pearson Education Limited, Prentice Hall, England.
- [14] Stone, G., M. Joseph and J. Blodgett, 2004. Toward the creation of an eco-oriented corporate culture: a proposed model of internal and external antecedents leading to industrial firm eco orientation, *Journal of Business & Industrial Marketing*, 19(1): 68-84.

- [15] Simpson, D. F., and Power, D. J., 2005. Use the supply relationship to develop lean and green suppliers. *Supply Chain Management: An International Journal*. Vol. 10, No. 1, pp. 60 – 68.
- [16] Shah, R., and Ward, P. T., 2007. Defining and developing measures of lean production. *Journal of Operations Management*. Vol. 25, No. 4, pp. 785 – 805.
- [17] Zhu, Q., and Sarkis, J., 2004. Relationships between operational practices and performance among early adopters of green supply chain management in Chinese manufacturing enterprises. *Journal of Operations Management*. Vol. 22, No. 3, pp. 265 – 289.
- [18] Kleindorfer, P. R., Singhal, K., and Van Wassenhove, L. N., 2005. Sustainable operations management. *Production and Operations Management*, Vol. 14, No. 4, pp. 482 – 492.
- [19] Puvanasvaran, A.P., Kerk, R. S. T., and Muhamad, M. R., 2011. Principles and Business Improvement Initiatives of Lean Relates to Environmental Management System. *Proceedings of the 1st International Technology Management Conference*, pp.439-444. IEEE.
- [20] Pun, K. F., Fung, Y.K., and Wong, F. Y., 2006. Identification of critical success factors for total quality environment management. *Proceedings of the 3rd annual international conference on industrial engineering theories, applications and practice*, Hong Kong.
- [21] Sakar, D., 2008. *Lean for Service Organizations and Offices*. India: Pearson Education.
- [22] Martin, A.C., Brouwer, and Kris, C. S. A., 2006. The soul of the machine: Continual Improvement in ISO 14001. *Journal of Cleaner Production*. Vol. 16, pp. 450-457
- [23] Wilkinson, G., and Dale, B. G., 1998. System integration: the views and activities of certification bodies, *The TQM Magazine*, Vol. 10, No. 4, pp. 288-92.
- [24] Karapetrovic, S., & Willborn, W. (1998). Integration of quality and environmental management systems. *The TQM Magazine*, 10(3), 204-213.
- [25] Bossert, J., and Grayson, K., 2002. Your opinion. *Six Sigma Forum Magazine*, ASQ, Milwaukee, WI, Vol. 2, Issue 1.
- [26] Andersson, R. (2009). *Supply chain resilience through quality management*. Göteborg: Chalmers tekniska högskola; Borås: Högskolan i Borås.
- [27] Maxwell, J., S.; Rothenberg, and Schenk, B. (2001). *Does Lean Mean Green? The Implications of Lean Production for Environmental Management*, Working Paper, MIT, Cambridge, MA.
- [28] Deming, 2004. *The New Economics for Industry, Government, Education*. Cambridge, MA: Massachusetts Institute of Technology.
- [29] Russell, R., 2008. *Operations Management along the Supply Chain*, India: Wiley.
- [30] Picchi, F. A., 2001. System view of lean construction application opportunities. *Proceeding of the 9th Annual Conference of the International Group for Lean Construction*, Singapore.
- [31] Antony, J. O, Dickinson, W. B., Leech, N. L., and Zoran, A. G. (2009). Toward more rigor in focus group research: A new framework for collecting and analyzing focus group data. *International Journal of Qualitative Methods*, Vol. 8, No. 3, pp. 1-21.
- [32] Covington, W., 2008. *Tough Fabric: The Domestic Apparel and Textile Chain Regains Market Share*. Chesapeake Consulting, Inc.: Severna Park, MD.
- [33] Cheng, J.L., 2008. Implementing Six Sigma via TQM improvement: An empirical study in Taiwan. *The TQM Journal*, Vol. 20, No. 3, pp. 182–195.
- [34] Cowley, M., 2007. *Beyond Strategic Vision: Effective Corporate Action with Hoshin Planning*. 1st ed., Butterworth-Heinemann, Boston.
- [35] Bansal, P., and Bogner, W. C., 2002. Deciding on ISO 14001: Economics, Institutions, and Context. *Long Range Planning*, Vol. 35, No.3, pp. 269–290.
- [36] Cragg, W., 2005. *Ethics Codes, Corporations and the Challenge of Globalization*. Edward Elgar Publishing, 1st ed., Cheltenham.

in Malaysia from 2005 to 2008. The framework was successfully adopted by the company to include under their Lean House as a foundation pillar.

Puvanasvaran A.P an Associate Professor at Faculty of Manufacturing in Universiti Teknikal Malaysia Melaka (UTeM), Malaysia. The author has 6 years' experience in the semiconductor industry and was employed as an End of Line Process Engineer. During this time, he was also a team member of the company's QS 9000 Quality Systems implementation project team. The author's framework "People Development System" was developed during his doctoral study is thru attached with Aero Composite Manufacturing Company