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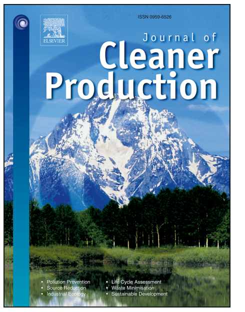

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Sustainable green management system (SGMS) – an integrated approach towards organisational sustainability

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Abstract

The current drive towards sustainability are putting pressure on organizations worldwide to implement procedures to manage the elements of sustainability for an organisation that include emissions, effluent discharge, waste disposal and energy efficiency. Even though these green elements can be managed, monitored and analysed in an integrated manner using some common resources and information, they are typically handled piecemeal under different types of management standards; and quite often, as ad-hoc projects as opposed to programs. This paper reviews the current management systems that relate to sustainability, and proposes the development an integrated green management framework called the Sustainable Green management System (SGMS). A systematic, integrated and efficient approach for collecting, monitoring, analysing and managing information and resources via the SGMS will not only lead to organisational sustainability, but also have the potential to save ample resources, remove significant redundancies, promote cleaner production and enhance the profitability and efficiency of an organisation. An application of the proposed SGMS framework is demonstrated on a facility management case study that uses a unified GI as an indicator for an organizational sustainability.

Keywords: Sustainability; Sustainable Green Management System; ISO standards; Green indicators; Cleaner production

Nomenclature

SGMS	Sustainable Green management System
GHG	Greenhouse gas
CO2	Carbon dioxide
GI	Green Index
ISO	International Organization for Standardization
TQM	Total quality management
EMAS	Eco-Management and Audit Scheme
IMS	Integrated Management System
PDCA	Plan-Do-Check-Act
SOPs	Standard operating procedures
OHSAS	Occupational Health and Safety Assessment Scheme
BREEAM	Building research establishment environmental assessment method
LEED	Leadership in energy and environmental design
CASSBEE	Comprehensive assessment system for building environmental efficiency
EC	Electricity consumption
COP	Coefficient of performance
PL	Chiller plant load
AV	Average temperature
RH	Relative humidity
IAQ	Indoor air quality
WC	Water consumption
SWG	Solid waste generation

FA	Factor analysis
C	Matrix of correlation coefficient for observed variables
A	Matrix of the common factor
F	Matrix of correlation among common factor
E	Unique variance of diagonal matrix
v	Eigenvector
λ	Eigenvalue
po	Base year price
qo	Base year quantity
pt	Given period price
qt	Given period quantity
Io	Base year green elements data
It	Given period green elements data
wo	Base year weighting
RT	Refrigerant tonne

1. Introduction

Growing global concern on climate change and widespread awareness towards environmental sustainability and cleaner production are driving organizations worldwide to implement procedures to efficiently manage the elements of organizational sustainability that include emissions, effluent discharge, waste disposal and energy efficiency.

Since most of the primary source of energy come from fossil fuels, the rapid increase of greenhouse gas (GHG) emissions, and particularly (CO_2), would naturally result from the spike in the energy demand. Al-Amin et al. (2015) in their study reported that energy usage that relates to CO_2 emissions is predicted to increase from 188.0 million tons in the year 2010 to 720.5 million tons in the year 2050. It is forecasted to reach 2024.4 million tons in 2105, which is a 10.28 % increment of average growth rate per year. In line with that, Roh et al. (2016) stated that 30% of the carbon emissions come from buildings. Basri et al. (2014) also added that electricity demand for Malaysia has increase from 41,476 ktoe in year 2010 to 46,710 ktoe in the year 2012 as a result of 11.25 % demand increment. Thus, sustainable measures need to be taken to decouple the growth in energy demand intensity from the industrial development.

Some countries have educated their citizens by developing codes, policies, regulations and best practices in operations as the starting milestone towards sustainability and cleaner production. Countries such as the United Kingdom, the United States of America, Japan and Singapore have adopted various best practices for sustainable development and environmental management without compromising economic and social development. Furthermore, countries from the European Union and the United States provide incentives for organizations that adopt green building standards to drive the implementation of cleaner production and sustainability. In Malaysia, a green agency known as the Ministry of Energy, Green Technology and Water has been established in April 2009 to spearhead and regulate sustainable development efforts in energy, national water and green technology without sacrificing the social development and economic progress (Basri et al., 2014).

Many studies have been done to manage and reduce greenhouse gas emissions, electricity consumption, water consumption, waste generation and air pollution. The management process has been strengthened by the establishment of the ISO 50001 and ISO 14001 that is specifically for electricity consumption and environmental conservation [Department of Standard Malaysia MS ISO 50001:2011, 2011; Department of Standard Malaysia MS ISO 14001:2004, 2004]. Although there are numerous studies on energy management and environmental conservation via the ISO50001 and ISO14001, a holistic method for the management for sustainability in the context of an organization is still lacking. Therefore an integrated system to manage the sustainability aspects of an organisation and promote cleaner production is very much needed. The system should encompass the key elements of sustainability and should best comply with ISO standards related to sustainability so as to enable organisations to seamlessly integrate sustainability aspects in their existing ISO systems.

The objective of this paper is to review the current management systems for sustainability, and propose an integrated Sustainable Green Management System (SGMS) as a framework to efficiently and effectively manage the sustainability aspects of an organisation. A systematic, integrated and efficient approach for collecting, monitoring, analyzing and managing information and resources via the SGMS will not only lead to organisational sustainability, but also have the potential to save ample resources, remove significant redundancies, promote cleaner production and enhance the profitability and efficiency of an organisation. This paper is organized as follows: Section 2 compares and reviews the current available management systems for sustainability. Section 3 describes the proposed SGMS framework. Section 4 presents the application of the proposed SGMS framework on a facility management case study that uses a unified Green Index (GI) as an indicator for an organizational sustainability. The findings and conclusion of the study are presented in Section 5.

2. Comparison of Management Systems for Sustainability

Growing global concern towards sustainable development has encouraged the establishment of management systems that cater for the elements of sustainability. Among the widely used management systems that include elements of sustainability are Total Quality Management (TQM), ISO 9001:2008 management system, ISO 50001:2014 Management System, ISO 14001:2004 Management System and *Eco-Management and Audit Scheme* (EMAS).

The establishment of various management systems to suit numerous sustainability elements has become a challenge for organizations. Due to that, the tendency for implementing a single management system has emerged, and simultaneously encouraged the development of a management system for sustainability (Esquer-Peralta et al., 2008). One of the methods used is by integrating a few management systems that include key sustainability elements, into one single management system, or an Integrated Management System (IMS). Beckmerhagen et al. (2003) interpreted the IMS as combining elements of a few management systems to become one effective management system. In detail, it is a process of putting together specific management systems with different functions into an effective single IMS. The detailed elements of management for sustainability and comparison of a few widely-used managements systems that are related to sustainability are discussed in the next section.

2.1 Elements of Sustainability

Sustainability, in the context of sustainable development has been defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). An approach towards sustainability requires that all elements related to sustainability are addressed simultaneously rather than piecemeal (Vázquez et al., 2015). According to Li et al., (2015) sustainability comprises three elements which are the environmental sustainability, economic sustainability and social sustainability. The main goal of sustainability is to fully integrate the three aforementioned elements into one system (Mebratu, 1998).

Sustainability can be a broad aspect. It could be in the context of global sustainability (Liu et al., 2015), country sustainability (Wagner, 2014) or organizational sustainability (Beasley and Showalter, 2015). This study is focused on elements of organizational sustainability.

2.1.1 Environmental Sustainability

In environmental sustainability, the main issue to be emphasised is the impact of organizational activities toward the environment. Organizations need to identify the sources of environmental problems due to their operational activities. Examples of sources that are related to environmental problems are productions (Lemaire et al., 2014), transport (Johansson et al., 2014), procurements (Roberta et al., 2014) and products (Gmelin and Seuring, 2014). The whole supply chain process impact towards the environment needs to be considered and managed efficiently. Few sustainable environmental management systems have been developed and widely used to tackle this environmental issue. This includes the ISO14001:2004 and EMAS. ISO 14001 is a system that guides an organization to develop an environmental policy, set up objectives and processes to accomplish the policy aims, take required actions to improve its performance and comply with the requirements of the International Standard. The overall aim of the ISO 14001 is to support environmental protection and prevent or control pollution in accordance with socio-economic needs (Department of Standard Malaysia MS ISO 14001:2004, 2004). The EMAS is a management tool developed by the European Commission. It is aimed for organizations that are keen to improve their environmental performances. The procedure involves evaluation of the organisation's current environmental performance and improvement of these conditions with tools provided by the management scheme (García et al., 2014).

2.1.2 Social Sustainability

Social sustainability is concerned with meeting the basic needs of present and future generations (Vallance et al., 2011). In the context of organizations, examples of basic needs are education and trainings, health and safety, management competence and wages and benefits (Weingaertner and Asa, 2014). Social sustainability takes into account the interest of employees and the community in the course of providing an equitable and ethical organization. In the context of organizations, an employer would value human capital by providing a safe and healthy working condition as well as providing opportunities for employees engaging in a social partnership. This aspect is similar to part of the Total Quality Management (TQM) principles (Benavides et al., 2014) which focuses on customer satisfaction by continuous process improvement within organizations and, at the same time, increase profitability and productivity (Goetsch and Davis, 2014). TQM general principles consist of customer focus, management commitment, training, process capability and control, and measurement through quality improvement.

2.1.3 Economic Sustainability

Economic sustainability is defined as the utilization of the available assets of an organization effectively and efficiently to allow it to continue functioning profitably over time (Moldan et al., 2012). The management system adopted by organizations for economic sustainability is ISO9001:2008. ISO 9001:2008 is intended to emphasis on the aspect of quality management and can be used by any organization, either large or small, despite its line of activity. ISO 9000:2008 provide guides and tools for any organization wishing to ensure sustainability of their products and services to meet customer requirements, and consistently improve on quality (Department of Standard Malaysia MS ISO 9001:2008, 2009). ISO 9001 has been mostly adopted among other ISO standards and is showing a significant increase in adoption as mentioned by Sampaio et al. (2009) specifically in China, Italy and Japan. Although Ochieng et al. (2015) mentioned that there is no relation between organizational profit and ISO 9001:2008 adoption, on the contrary Psomas and Kafetzopoulos (2014) found that certified ISO9001 companies generated more profit compared to non-certified companies.

As discussed above, currently available management systems include elements of sustainability (see Table 1). The opportunity to integrate the management systems towards achieving sustainability goals is explored and discussed in the next section.

2.2 Integrating Management Systems for Sustainability

In the absence of an integrated management system for sustainability, organizations that wish to implement sustainability best practices may need to adopt more than one management system. As mentioned by Darnall *et al.* (2008), adopting only one of the currently available management systems would not ensure sustainability. As an example, ISO14001 primarily focuses on the environmental elements and neglects the economic and social elements. Table 2 summarises the literature from years 2000 to 2015 on Integrated Management Systems that have been widely used in various sectors either for the purpose of review of similarity of management systems, or for implementation of IMS. Table 2 shows that most organizations would prefer to implement a few ISO systems; in particular, ISO 9001 and ISO 14001. This is due to the fact that ISO management system standards were established according to the common principles of Plan-Do-Check-Act (PDCA) cycle that provides guidance in implementing and operating a management system. The PDCA cycle is described as follows (Management System Standards, 2015):

- Plan: This is the planning phase where organisations are required to identify targets and objectives in order to establish plans to achieve targets and objectives.
- Do: This is the implementation phase where organisations are required to execute the developed plans in order to achieve the targets and goals.
- Check: This the review phase where actual outputs are measured, monitored and compared with respect to planed objectives and targets.
- Act: Within this phase, organizations are required to correct and remove any non-conformities due to the failure to meet the planned objectives and goals. This action provides the opportunity for organisations to improve. Once improvements have been made, organisations revert to the planning phase to make the appropriate adjustments to the action plans.

In the next sections, the elements that are common to most management systems are reviewed.

2.2.1 Common Elements of Management Systems

Simon et al. (2012) mentioned that most management systems have similar common elements. He also added that PDCA cycle model has become the foundation to develop the integrated management system. Within PDCA cycle, the common elements include (a) Policy, (b) Responsibility and authority, (c) Monitoring, measurement and analysis, (d) Documentation, control of documents, operational control, (e) Internal audit, nonconformities, correction, corrective action and preventive action, and (f) Management review. Next, each of the aforementioned elements is described in detail, and the similarities that exist among relevant ISO systems are analysed.

(a) Policy.

A policy is a document that must be owned by any company or organization in implementing any management system standard. Policy is a formal and written statement of the top management of the organization about the company's commitment to pay attention and consider aspects of specific areas depending on the main objectives of the management system. For example, in Quality Management System, clause 5.3 on quality policy emphasises on quality issues and in Environmental Management System, clause 4.2 on environmental policy emphasises on environmental issues. Policies must be consistent throughout the organization, because it provides a framework for establishing objectives for management systems. In addition, Bhardwaj (2016) in his study found out that a comprehensive green policy would enhance an organization’s sustainability. In this point of view, for an integrated management system that aims to cater for sustainability, the policy should be a unified approach which emphasises on elements for sustainability. For example, if an organization is planning to integrate both ISO 9001 and ISO14001, the policy should be a written declaration by the top management of the organization about the company's commitment to pay attention and consider aspects of quality and the environment. A single policy that emphasises on both quality and the environment would be consistent throughout the organization and easier for internal organization to understand rather than two policies which would divide the focus of the organization and cause confusion among internal organizations. Nevertheless, a policy must include commitment to meet the requirements and to continuously improve the effectiveness of the management system. A policy is not only a written document but must be widely communicated and understood internally by organizations, and be continuously reviewed for compliance with organizational activities.

(b) Responsibility

On the responsibility and authority element, top management must establish organizational structure parallel to the adopted management system. Responsibilities, duties and authority of every person in charge for each task are defined clearly and communicated with others. Confusion about responsibilities and authorities could have an impact on the quality of goods or services. Unclear job descriptions would lead to work delays, stress of the person in charge and ultimately reduced productivity. Each task in the organisation should have a clear degree of authority. Therefore, personnel of higher authorities would carry more responsibilities, while those of lower authorities carry less responsibilities. Most ISO standards would have a similar clause to reflect the elements of responsibility and authority. For example:

- ISO 9001 clause 5.5: Responsibility, authority and communication;
- ISO 14001 clause 4.4.1: Resources, roles, responsibility and authority and

- ISO50001 clause 4.2: Management responsibility.

Some of the methods to define and document aspects of responsibility and authority include the use of organization charts, job descriptions and standard operating procedures (SOPs). It is difficult for organizations and for the person in charge to have a different set of job descriptions and SOPs. For example, a process that implements two management systems will typically have at least two sets of SOPs. Nonetheless, at the implementation stage only one process is involved. It would be difficult for the person in charge to follow both SOPs at the same time as this would lead to confusion and impact the quality of goods or services. Thus, having a unified job description that encompasses all sustainable management system requirements for similar processes is practical, and promotes clear responsibilities, duties and authority for every person in charge of each task. This would lead to social sustainability which values human capital by providing a safe and healthy working condition and improve economic sustainability by utilization of the available assets of an organization effectively and efficiently.

(c) Monitoring, measurement and analysis.

The purpose of monitoring, measuring and analysing is to ensure that all processes are carried out under the control specifications and closely follow the required regulations. The monitoring process is carried out to ensure that the output is according to plan. On the other hand, the measurements and analysis function to determine the effectiveness of the process thus enabling a facility manager to find opportunities for improvement. Monitoring, measurement and analysis play a significant role in sustaining the environmental, economic and social elements. This is the stage where the environmental, economical and social plan with statements in the policy is compared with the output of the product or service. This is also the reason why in every

ISO management system, monitoring, measurement and analysis are required. Although the basis to carry out monitoring, measurement and analysis in every ISO management system is similar, there are some slight differences in terms of documentation and implementation in some ISO management systems. For example, in OHSAS 18000 clause 4.5.1, the measurement is in terms of safety performance while in ISO 14000 clause 4.5.1 the measurement is in terms of how we control our processes related to environmental pollution and the resource saving. In ISO 9001 clause 7.6, the measurement emphasises on the measuring equipment, processes, products, and analysis of data. Although there are differences, it still can be combined into one procedure by adding all the required measurement and monitoring in the work instructions, standard of procedure and any other documentation related to the process involved.

(d) Documentation

Documentation is one of the important elements in any management system because it provides a written guide on how organizations should operate. In ISO 9001 clause 4.2.1, it required organizations to have documentation about quality management systems or named as Quality Manual, while in ISO 14001 clause 4.4.4, it required organizations to have documentation about environmental management systems. Documentation can be in the form of policies, SOPs, flowcharts, work instruction forms, checklists and record of corrections and preventive actions. For example, with the organization's policies, manuals and procedures, every personnel or employee has a clear understanding about what must be done, what is prohibited, how, where, and when activity is done. With this in place, the functions of each personnel and department within the organisation can operate according to the plan and at the same time achieve organisational goals. Nevertheless, new employees will learn and adapt to organisational procedures faster with clear documented guidelines. However, multiple documentations due to adoption of more than one management system would cause confusion as a result of unclear guidance. It also causes redundancy because each management system would have different documentations as in manuals, procedures and work instructions although it is for a same process. This would make the controls of documents and operations—the elements in management system—not work smoothly. This is because multiple documentations would need multiple personnel to monitor and record. Each document needs to be recorded in each management system database record and the operation controls would be different in every work instruction or standard of procedure even though it is the same process. Although it can be done by the same person, the probability to make a mistake is higher. Although adopting multiple management systems to suit sustainability elements would require different documentations, it can be combined together by integrating the documentations in policies, manuals, standard operation controls or work instructions. For example, for work instructions, the form could be integrated by including the instructions for tolerance of product for quality management systems. Other examples include raw material consumption limitations to reduce pollution for environmental management systems and machine operating hours limitation to reduce electricity consumption for energy management. By integrating the three criteria, the organization would be in line with sustainability, and compliant with three ISO standards. In addition, such integration would reduce the redundancy of records for nonconformities, correction actions, corrective actions and preventive actions done in the same process which is one of the important elements for management systems.

(e) Internal Audit.

Internal audit is the evaluation of system, process, or product of the organization. Internal audit is carried out by the competent, objective, impartial, and independent organization personnel named as the auditor. The goal is to verify that the operations of the organization are in compliance with the adopted management system. The audit findings are very important where it does not only identify the criteria that are not being met but also identify the best solution for improvement opportunities. Luthra et al. (2016) also mentioned that the internal management plays a vital role for an organization to achieve the intended performance outcome. Before any audit can be done, an audit program must be declared and notified earlier to the auditee. Although most ISO standards require internal audits to be conducted a minimum of once a year, the process of auditing requires human resources to plan, organize and conduct internal audits. In addition, internal audits require a lot of time to be conducted due to the involvement of both auditor and audittee during the interview and checking of documents and records. This would be difficult for any organization who adopted multiple management systems for sustainability, due to the increased need of human resources, as more time will be spent on audits and more costly as well. Thus, auditing multiple management systems at one time is only possible when the policy, standard of procedure, work instruction and records of nonconformities, correction action, corrective action and preventive action documentation are all integrated together. This integration would reduce human resources, reduce audit time and less implementation cost.

(f) Management Review

A management review is an activity that is carried out periodically to evaluate the management system. The purpose is to assess the effectiveness of the system and to ensure continuous improvement. Management reviews are not the same as the internal audit. Internal audit is part of the agenda of management review. In practice, organizations usually implement the management review through management review meetings. ISO 9001 clause 5.6.2: input review, listed the agenda that needed to be reviewed in the meeting such as result of audits, customer feedback, process performance and product conformity, status of preventive and corrective actions, follow-up actions from previous management reviews, changes that could affect the quality management system and recommendations for improvement. Although in the other ISO standard management systems the listed agenda were for the specific areas, the basis is still the same. For example, in the Environmental Management System, review of environmental performance is similar to the review of process performance as in Quality Management System. Although the list of agenda would be more than reviewing a single management system, it is more rational to be done in such a way compared to conducting multiple meetings for each management system.

2.2.2. Summary.

In summary, there are many similarities in management system structures resulting in overlapping requirements in management systems for sustainability. Although adopting the aforementioned management system would provide sustainability for an organization, the overlapping and redundant requirements would be very challenging for organizations to implement. Rather than implementing it in a piecemeal manner, it is important for the overlapping requirements to be rationalized and removed. Thus, an integrated approach towards organizational sustainability needs to be developed and implemented to ensure that the sustainability goals are effectively achieved.

2.3 Challenges and Limitations of the current Management Systems for Sustainability

According to Santos et al. (2011), there are benefits, drawbacks and challenges for organizations to integrate the management systems. This is in agreement with Bernado et al., (2015) where in their study, it was found out that implementing IMS would improve management efficiency, organization image and relationship with stakeholders. In addition, Asif et al., (2010) mentioned that, although IMS would lead to savings in audit and accreditation, it is a challenge for operators to understand the work-flow due to the integrated processes in the IMS. Table 3 shows the summary of benefits, drawbacks and challenges to integrate management systems mentioned by the aforementioned researchers.

2.4 Rating Systems

Management system for sustainability is not the same as a rating system. If sustainability management system is a guide on how organizations are supposed to operate, then rating system is the performance indicator for the organization. The widely used rating system around the world as mentioned by Nguyen and Altan (2011) are the Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Building Environmental Efficiency (CASSBEE), GREEN STAR, and HK-BEAM. These rating systems evaluate the sustainability performance using a predeclared set of criteria that requires points to be assigned for each criterion (Larsson, 2004). A comparison of the rating system criteria is shown in Table 4.

Table 4 shows the aforementioned green assessment tool consisting of ten (10) similar criteria for new and existing buildings, but differ in weighting schemes (credit and scores). For example, LEED, BREEAM and HK-BEAM emphasise more on energy efficiency while

GREENSTAR emphasises more on indoor environment quality/health. In addition, Table 4 shows that energy efficiency, water efficiency, indoor environment quality/health and materials are the most important elements; followed by site management, waste, pollution/emission, land use/ecological, transport and innovation for both new and existing buildings. Differences in weighting schemes and their respective elements are due to the needs and priorities of their countries of origin.

3. Proposed Sustainable Green Management System

The SGMS development strategies and framework that is in line with sustainability goals and cleaner production is discussed in detail next. Comparison of ISO standard criteria is described in section 3.1 to identify the similarities and redundancies between three ISO standards (ISO9001, ISO14001 and ISO5001). Section 3.2 describes how the selected criteria is integrated into process-based model that follows the Plan-Do-Check-Act (PDCA) Cycle to develop SGMS. Development of the green indicator (GI) that utilizes factor analysis (FA) and the stock composite index methodology is described in section 3.3. FA was used as the weighting scheme due to its capability to investigate the relationship strength among multiple variables. The weighting schemes were then integrated with common capitalisation-weighted index that has been used in stock composite index calculations to develop the GI. A case study that demonstrates application of the strategies and the significant impact towards greenness performance is discussed in section 4.

3.1 The Development Strategy

This study uses common ISO standard criteria as the basis for integration. The chosen criteria are frequently used by most organizations for the integration of ISO standards. Bernardo et al. (2009) stated that the most commonly-integrated ISO standard requirements are planning, internal audits, management reviews, control of nonconformities, preventive and corrective actions, product realisation, resource management, determination of requirements, improvements, document control, record control and internal communication. Furthermore, note that the TQM principle is aligned with the implementation of ISO9001 (Babatunde & Sui Pheng, 2015), but emphasising on customer focus, management commitment, human resource management, process control and continuous improvement (Ooi, 2014). An example of the TQM implementation was at the management review process where it helps an organization to review their weaknesses and opportunity in order to enhance operation efficiency, while simultaneously increasing customer satisfaction (Jimenez et al., 2015). Simon et al. (2012) mentioned that most organizations should conduct a detailed analysis of the common elements of the ISO standards before the integration process. Based on these findings, the criteria chosen for integrating ISO 9001, ISO50001 and ISO14001 to develop common criteria for green management are as mentioned in section 2.2. These include the policy; responsibility and authority; monitoring, measurement and analysis; documentation, control of documents, operational control; internal audit, nonconformities, correction, corrective action and preventive action and management review.

The criteria for each ISO standard is reviewed compared and summarised to develop common interrelated criteria for green management as tabulated in Table 5. Table 5 shows that most of the ISO criteria can be combined together to achieve sustainability goals and promote cleaner production. This approach would eliminate multiple documentations and provide clear instructions for organization personnel, for example, the work instruction, checklist and forms can contain a combination of environmental, economical and social parameters rather than separate work instructions for a similar process as discussed in detail in section 2.2. In addition, the combination of all responsibilities of the person in charge of SGMS or named as Green Manager in this study would optimize human resources and provide a clear scope of responsibility and authority. Furthermore, elements of monitoring, measurement and analysis of environmental performance and energy performance can be combined into a single green indicator and will be discussed in a later section.

3.2 The SGMS Framework.

The ISO framework is a process-based model that follows the Plan-Do-Check-Act (PDCA) Cycle. This framework was chosen due to its sustainable framework and proven effectiveness in the field of management (Bernardo et al., 2015). Fig. 1 shows how ISO 50001, ISO14001 and ISO9001 frameworks are combined together to create the SGMS Framework. The lines are the linkages as shown in the figure's legend. Fig. 2 shows the relationships between ISO Standard requirements with the final SGMS Framework after combining the integration method from Table 5 into the SGMS framework from Figure 1.

The ISO 50001, ISO14001 and ISO9001 are based on the same Plan-Do-Check-Act framework. Therefore, a combination of the aforementioned ISO Standards with the TQM principle is believed to produce a unique and sustainable framework for SGMS. This framework would be a guide on how to implement SGMS into the current business structure and comply with ISO standard requirements as seen in Fig. 3. The person responsible for SGMS would be designated as the Green Manager who is responsible to take care of all the green elements and ensure the plans and target are achieved accordingly. Performance evaluation of the system would be best done using a single Green Indicator that would be able to incorporate the effect of all green elements and portray the green performance of an organisation. The Green Manager would use this tool to identify the drawbacks or opportunities for improving resource and environmental performance, and at the same time improve customer satisfaction.

3.3 Monitoring, measurement and analysis strategy

Monitoring, measurement and analysis strategy is vital in any management system because this is the part where the data is collected, measured and analysed. In the SGMS framework, this process is named as green indicator as in Fig. 1. In Section 2.2, we have compared various widely-used rating system and they vary in the way of evaluation. However, there are a number of researches showing that the current green rating does not portray the actual greenness performance of a facility. For example, Newsham et al., (2009) found that LEED-certified building consumed more energy compared to non-LEED building. In addition, Scofield (2009) mentioned that LEED certified buildings showed no significant impact on building energy consumption. This problem happens due to:

1. Currently available green rating use a pre-declared set of criteria and has point assignment which is still considered as qualitative evaluation (Zuo and Zhou, 2014).
2. Inconsistent weighting scheme (Yu et al., 2014) and depending on the needs and priorities of its country of origin that lead to non-standard and inconsistent assessment protocols (Chandratilake & Dias, 2015)

Therefore, the green indicator, known as the GI in this study was developed to counter those limitations using the statistical method. The overview of the GI calculation step is as shown in Fig. 3.

Referring to Fig. 3, green elements data collection is the data collected from the daily operation of an organization. The data is best taken for the duration of a year and would next be analyzed using factor analysis. This data was analyzed using factor analysis to investigate the relationship between green elements (e.g. energy, water, waste generation) with an unobserved common factor. For this study, the green elements are electricity consumption (EC), chiller coefficient of performance (COP), chiller plant load (PL), IAQ - Average temperature (AV), IAQ - Average relative humidity (RH), IAQ - CO_2 level (CO_2), water consumption (WC) and solid waste generation (SWG). Factor analysis (FA) is a useful tool for investigating relationships strength among multiple variables. It has been widely used by many researchers to study the relationship among variables in various areas of study. The relationship strength between green elements and the unobserved common factor is known as the factor loading yielded from the factor analysis calculation result and would be used as the weighting scheme for GI calculation. Since the weighting scheme is the relationship strength between the green elements and the unobserved common factor which depends on the green data, the weighting scheme is practical in the sense that it is based on the actual operation of the facility and not on the needs and priorities of its country of origin. The equations that express the factor analysis model are as follows (Hardle & Hlavka, 2015):

$$C = AF + E \tag{1}$$

where, C is the matrix of correlation coefficient for observed variables, A is the matrix of the common factor, F is the matrix of correlation among the common factor, and E is the unique variance or diagonal matrix. This equation is represented in matrices and describes the causal relationship between the observed variable and common factors. Determining the factor loading in the weighing scheme of this study can be determined by finding the eigenvalues and eigenvector of the F matrix using the equation as follows (Bjorck, 2015):

$$Av = \lambda v \tag{2}$$

where, v is the eigenvector of matrix A and λ is the eigenvalue.

The next step in determining the GI value is by integrating the weighting scheme result with common capitalisation-weighted index that has been used in stock composite index calculations. The common capitalisation-weighted index equation is given in Eq. (3):

$$\text{Capitalisation weighted Index} = \frac{\sum p_t q_t}{\sum p_o q_o} \times 100 \tag{3}$$

As capitalisation-weighted index takes into account both the price and quantity differences, the calculation needs the input for base year price (p_o), base year quantity (q_o), given period price (p_t), and given period quantity (q_t), which are the independent variables whereas the composite index is the dependent variable.

In Eq. (3), all independent variables were represented by the green elements. The buying and selling activities by traders caused the prices in the stock market to fluctuate with time. Similarly, the green element behaviour changes with time. For example, the consumption of electricity and water, and indoor air quality levels fluctuate continuously as an effect of human activities. The stock quantity is translated into weighting scheme because it signifies the importance of the stock within the composite index. The GI equation derived from the capitalisation-weighted index equation used in this study is given by:

$$\text{Green Index} = \frac{\sum I_t w_o}{\sum I_o w_o} \quad (4)$$

Similar to Eq. (3), but applied for the GI development, variables in Eq. (4) are represented in terms of the base year green elements (I_o), base year weighting (w_o) and given period green elements (I_t). The base year weighting (w_o) is the factor loading as described earlier and obtained from Eqs. (1) and (2) using the green elements one year data. Although the formulation of the GI proposed in this study is similar to the stock composite index, however in the stock market, a positive index value indicates that profit is generated and is desired in the trading session. In contrast, an increase in GI value depicts an increase in the environmental degradation, which is not desirable for a conservation programme.

4. Case Study

Fig. 4 is an illustrated diagram of a district cooling system plant under study. As shown in the figure, this plant consists of 4 centrifugal chillers, 2 brine chillers, common headers for chilled water, and condenser water. Each chiller set comprises a chiller with its dedicated chilled water pump and condenser water pump. This plant can generate up to a maximum of 8,900 refrigerant tonne (RT) of cooling capacity at a time, and up until December 2011 to a maximum of 9,400 RT after the extension was completed (Abdullah et al., 2013). The chilled water generated from this plant would enter the primary loop of the building heat exchanger at 5^{o}C and leave at 13^{o}C, while chilled water from the building enters the secondary loop of the heat exchanger at 14^{o}C and leave at 6^{o}C. Since this plant consumed the highest amount of electricity compared with other buildings in the university, adapting a Sustainable Green Management System in this place would be a rational choice.

Based on the situation above, the integrated system would be compared with the three ISO standards as shown in Table 5 in order to view how integrated systems would be a more efficient, cost effective, promote cleaner production and reasonable choice for organisations that plan to adapt environmental conservation in their daily operation and maintenance.

5. Results and Discussion

From Table 5, data shows that adapting ISO standards separately would waste resources in terms of a different person who will be responsible for each ISO standard and separate documentation needs to be compared with the integrated system. For example, in this case study, one ISO standard would require an officer as a document controller. A document controller is a person who is responsible to ensure that a plant operates as described in the documented ISO management manual. If the fee for a document controller is RM42,000.00 annually, it would cost an organization RM126,000.00 annually to manage three ISO standards. On the other hand, an IMS would need only one document controller and costs only RM42,000.00 in annual fee. Since chiller plant operation and maintenance deals with energy, water, chemical usage and indoor air quality, an integrated system would be a better choice compared with separate ISO standards, which would cause redundancy and possible mistakes during record compilation. Furthermore, the cost for an external audit could be reduced significantly because a onetime audit visit caters for three ISO standards. According to Abdullah, (2015), for this case study, the initial consultation cost for adopting the ISO standard is RM35,000.00 for one ISO standard and RM105,000.00 for three aforementioned ISO standards. The consultation cost shall include preparations of management manuals and organization programs, conduct internal training and assist an organization to get certified. On the other hand, an IMS typically excludes any redundancies in the preparation of management manual, work program, checklist, internal training and even certification preparations. As a result, the initial consultation cost is only RM84,000 to cover all three aforementioned ISO standards. Totaling both human resources cost and consultation cost, the cost saving by adopting IMS is RM21,000.00 which is 20% lower as compared to adopting separate ISO standards.

Apart from that, adopting the IMS would reduce the time for data collection and documentation compiling. For example, a plant operator would need to spend up to 10 minutes to record data for a chiller operation. In order to record the data 4 times a day, an operator has to spend a total 160 hours annually for one ISO standard. On the other hand, for the IMS, an operator may spend up to 15 minutes for each of the 4 data collection session due to the additional data required. Therefore, the total amount of time required annually for the IMS data collection time is only 240 hours. This means that the IMS would result in a significant savings of 240 working hours (or 30 working days) annually.

Referring to Table 5, the GI has been introduced as the monitoring method for SGMS. Note that, different ISO standards require different green elements monitoring. For example, ISO 50001 requires energy monitoring, ISO 14001 requires indoor air quality and energy monitoring, whereas ISO 9001 requires quality monitoring. SGMS manage the green elements in such a way that all green elements of the data are required by the aforementioned ISO standards are collected and monitored by a single indicator called as the GI. The GI is an indicator that consists of few green elements such as the electricity consumption, water consumption, waste generation and indoor air quality. As mentioned in section 3.3, the green elements for this study are electricity consumption (EC), chiller coefficient of Performance (COP), chiller plant load (PL), IAQ - Average temperature (AV), IAQ - Average relative humidity (RH), IAQ - CO_2 level (CO_2), water consumption (WC) and solid waste generation (SWG). Following the GI calculation steps as mentioned in section 3.3 and Fig. 3, the simulation data for this case study (Table 6) is factor-analyzed to determine the weighting scheme shown in Table 7. The result in Table 7 is calculated using Eq. 1 and Eq. 2. The mathematical and statistical computations are made using Microsoft Excel with XLSTAT. Nevertheless, the simulation results are only applicable for assessment of the facility under study as the selected green elements would vary according to the activities of a facility.

The results yield one common “unobserved” factor, labelled as F1 that have influence on the green elements of the facility. The percentage of F1 is 77.6%, which represents the eigenvalues variability which reflects the overall correlation strength among green elements and the common factors. The numbers assigned for each respective green element in Table 7 are the factor loadings. Factor loadings can range between -1 to 1. Green elements that have factor loadings close to -1 or 1 indicate strong effects to common unobserved factor (F1). Green elements that have factor loadings close to zero indicate a weak effect on common unobserved factor (F1). Note also that, the positive or negative value of the factor loading indicates that the variable is proportional (positive value) or inversely proportional (negative value) to the factor. Results show that in the group of common factor F1, electrical consumption has the highest factor loading compared to other green elements. This would help green manager to identify which green element needs to be optimized in order to implement action plans for cleaner production and significantly improve the green performance of a facility.

The GI value for the initial month for any case would always equal to 1.0. This is because, in GI calculation the initial month is assumed as the referring month. Due to that, the data for base period would be the same as the given period which resulting to GI = 1.0. Table 8 shows the result of the GI calculated using Eq. 4 for the year of 2015, while Fig. 5 shows the GI trend. The GI trend shows that, few sharp rises occur throughout the year particularly in April and July. The GI peaks can be attributed to the increase in electricity consumption due to the more intense operation of the chiller system to maintain the facility designated indoor air temperature and humidity comfort level when the external air was warmer and more humid than usual. Observation of the GI trend in Fig. 5 enables facility managers to visually monitor the green performance of their facilities and analyze it to coordinate green conservation measures.

6. Conclusion

A Sustainable Green Management System (SGMS) framework has been proposed to holistically manage the sustainability elements of an organisation. The procedure involves integrating the sustainability-related key elements of ISO systems. These insights can assist facility managers to implement conservation effectively and enhance future sustainability. Among the key benefits of implementing SGMS framework within and integrated management system, include focus and clear insights of the framework towards sustainability goals, cost and time savings via avoidance of redundancies, while simultaneously enhancing productivity. Furthermore, an integrated management system would reduce the time for document preparations, manpower for document controller, cost for internal and external audits, as well as encouraging facility managers to implement action plans for cleaner production. The aforementioned benefits have been demonstrated using a case study on application of the SGMS framework that utilises a unified GI that simultaneously cover aspects of energy, water and materials conservation, as well as reduction of environmental emissions.

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Table 1: Relationships among selected management systems with sustainability elements

Environment sustainability	Economic sustainability	Social sustainability
ISO 50001:2014 Management System	Total Quality Management	Total Quality Management
ISO 14001:2004 Management System	ISO 9001:2008 Management System	ISO 9001:2008 Management System
EMAS		

Table 2: Literature review of Management system standards mostly used for integration

	Quality Management (ISO9001)	Environmental Management (ISO14001)	Occupational Health and Safety Management Systems (OHSAS- 18001)	Occupational Health and Safety Management (BS8800)	European Foundation for Quality Management (EFQM)	Total Quality Management (TQM)	Risk Management – Australia Standard (AS/NZS 4360:1999)	Socially Responsible Corporate Management (SA8000)	*Eco-Management and Audit Scheme* (EMAS)	Customer Satisfaction And Complaints Systems (ISO 10001)
Wright (2000); Griffith (2000); Douglas & Glen (2000); Winder (2000); Wilkinson & Dale (2001); Wilkinson & Dale (2002); Karapetrovic & Jonker (2003); Labodová (2004); Karapetrovic & Jonker (2003); Griffith & Bhutto (2004); Zutshi & Sohal (2005); Pheng & Kwang (2005); Jorgensen et al, (2006); Mohammad et al, (2006); Zeng et al. (2006); Zeng et al. (2007); Rocha et al. (2007); Salomone (2008);Griffith & Bhutto (2008); Jorgensen (2008); Azadeh et al. (2008); Djapic & LUKIC (2008); Arifin et al. (2009); Karapetrovic &Casadesús (2009); Rajkovic & Aleksic (2009); Asif et al. (2009); Badreddine et al. (2009); Griffith & Bhutto (2009); Khanna et al. (2009); Badreddine et al. (2009); Bernardo et al., (2010); Khanna et al. (2010); Zeng et al. (2011); Santos et al. (2011); Domingues et al, (2011); Domingues et al. (2011); Hamidi et al. (2012); Al-Darrab et al, (2013); Ferreira et al. (2014); Almeida et al. (2014); Zeng et al. (2015); Zeng et al. (2015); Mežinska et al. (2015)	√	√	√							
Karapetrovic & Jonker (2003); Rocha et al., (2007); Salomone (2008); Rajkovic & Aleksic (2009)	√	√	√					√		
Jorgensen (2008); Ho (2010)	√	√	√			√			√	
Scipioni et al. (2001); Beckmerhagen et al. (2003)	√	√		√						
Funck (2001); José & Molina (2010)	√	√			√					
Flávio & Moy (2003)	√						√			
Zeng et al. (2008); Celik (2009)	√		√							
Asif (2010); Okrepilov (2010)	√	√	√					√		
Garengo & Biazzo (2013)	√				√	√				
Asif et al. (2011); Asif et al. (2013)	√	√								√
Botta et al. (2013)								√	√	
Karapetrovic (2002); Ofori et al.(2002); Poksinska et al.(2003); Jonker &	√	√								

Karapetrovic (2004); Zeng et al. (2005); Pheng & Tan (2005); Oke & Charles (2006); Bernardo et al. (2008); Bernardo et al. (2009); Leopoulos et al., (2010); Simon et al. (2011); Simon et al., (2012); Bernardo et al. (2012); Castillo et al. (2012); Simon et al. (2013)											

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Table 3: Summary of Integrated Management System benefits, drawbacks and challenges (Bernado *et al.*, 2015; Santos *et al.*, 2011; Asif *et al.*, 2010)

Benefits	Drawbacks	Challenges
• Resources such as financial and humans are optimized due to focus on maintaining one goal compare with few systems with same goals. • Reduce management cost. • A unified internal audits. • Emphasis on employee training. • Redefine management responsibilities and authority. • Simplified management system reduce conflict, confusion and duplication in documentation. • Less bureaucracy. • Easy to comply with legislation. • Improved organization performance and efficiency. • Enhanced organization. • Enhanced organization external image. • Improved communication system. • Supply chain integration and strategic flexibility • Continuos improvement infrastructure.	• Increment in non-conformities would increase intial cost. • Constant updates of all documentation with the negative effects within the management activities. • A problem in the system would give impact to the overall integrated management system.Causing higher organizational problems. • Incompatibility between systems. • Incomprehensible organizational system.	• Incompatibility of the standards. • Challenges of simultaneous implementation of all systems compared with piecemeal implementation. • Systems integration Challenges. • Profound changes in the management system due to changes in operations. • Challenges in training personnel and organizational change management in methods and culture. • Integration delay. • Employees resistance .

Table 4: Green assessment tool criteria and credit comparison (Nguyen & Altan, 2011; Chandratilake et al., 2013; Azhar et al., 2011)

	Management/ Sustainable Sites	Energy Efficiency	Water Efficiency	Materials	Waste	IEQ /Health	Pollution/ Emission	Land use/ Ecological	Transport	Innovation
FOR NEW BUILDING										
BREEAM	22	30	9	12		10	13		9	10
LEED	14	17	5	13		15				5
CASSBEE	Point calculated using formula, BEE = Q/L, Q = Quality and L = Loading									
GREENSTAR	15	22	10	19		26	17	8	12	10
HK-BEAM	26	68	14	23		49				5
FOR EXISTING BUILDING										
BREEAM		26.5%	8%	8.5%	5%	17%	14%	9.5%	11.5%	
LEED	9	13-30	4-10	9-14		16-20				4-7
CASSBEE	Point calculated using formula, BEE = Q/L, Q = Quality and L = Loading									
GREENSTAR	15	22	10	19		26	17	8	12	10
HK-BEAM	26	106	12	14		45				5

Table 5: ISO standards management system relationships (Malaysia Standard MS ISO 50001:2011, 2011; Malaysia Standard MS ISO 14001:2004, 2004; Malaysia Standard ISO 9001, 2012)

ISO Criteria	ISO 9001 Documentation Requirement	ISO 50001 Documentation Requirement	ISO 14001 Documentation Requirement	Integrating Method
Policy	Statement of Top Management on organisation's quality policy	Statement of Top Management on organisation's energy performance improvement	Statement of Top Management on organisation's environmental policy	Integrate Energy Policy, Environmental and Quality Policy as new Green Policy
Responsibility and authority	Job description, responsibility of person in charge, and organisation chart showing lines of communication	Job description, responsibility of person in charge of the energy management and organisation chart showing lines of communication	Job description, responsibility of person in charge of the environment management and organisation chart showing lines of communication	Combine all responsibility to person in charge called as the Green Manager
Monitoring, Measurement and analysis	Documentation on how to measure and monitor effectiveness to suit customer requirement	Documentation on how energy was monitored, measure and analyse to conform to the energy target plan	Documentation on how environmental impact was monitored, measured and analysed.	Using Green Indicator to measure and monitor the greenness
Documentation	Quality Manual	Energy Manual	Environmental Management	Integrate into Green Operation Manual
Control of documents	Document control procedure – approval, issued, numbered, etc.	Document control procedure – approval, issued, numbered, etc.	Document control procedure – approval, issued, numbered etc.	Integrate all procedure approval, issued, numbered, etc.
Operational Control	Work instruction, checklist, forms	Work instruction, checklist and forms to control energy efficiency	Work instruction, checklist and forms to control environmental impact	Integrate work instruction, checklist, and forms.
Internal Audit	An in-house audit check that requires an audit procedure, audit schedule, audit plan, check sheet and records	An in-house audit check for energy management that requires an audit procedure, audit schedule, audit plan, check sheet and records	An in-house audit check for environmental management that requires an audit procedure, audit schedule, audit plan, check sheet and records	Integrated internal audit
Nonconformities, correction, corrective action and preventive action	Documentation of procedures on how to identify and control the use of nonconforming product. Records of complaints, complaints procedure and staff suggestion scheme	Documentation of procedure on how to identify the causes to nonconformities and records of correction and preventive action	Documentation of procedure on how to identify the causes to nonconformities and records of correction and preventive action	Combine all records of complaints, complaints procedure and staff suggestion scheme
Management Review	Records of top management review on suitability of the Quality Management System	Records of top management review on suitability of the Energy Management System	Records of top management review on suitability of the Environmental Management System	Top management will review the weakness, strongpoint and suitability of SGMS

Table 6 Monthly data on the green elements of the chiller plant case study

Month	Total Electricity Consumption (kWh)	Average Chiller Coefficient of Performance	Chiller Plant Load (kWh)	IAQ - Average Temperature (°C)	IAQ - Average RH (%)
Jan-15	33,135	5.5	139,903	24.7	53.25
Feb-15	32,603	5.4	136,155	24.7	53.25
Mar-15	35,557	5.4	148,836	24.8	53.25
Apr-15	39,601	5.3	164,447	24.9	53.31
May-15	38,865	5.3	161,147	24.9	53.38
Jun-15	37,824	5.3	157,565	24.9	53.31
Jul-15	38,246	5.4	159,754	24.9	53.25
Aug-15	34,132	5.4	142,546	24.8	53.25
Sep-15	35,167	5.4	147,487	24.8	53.25
Oct-15	35,870	5.4	150,296	24.8	53.31
Nov-15	33,288	5.4	139,804	24.7	53.31
Dec-15	35,744	5.5	150,329	24.8	53.25

Table 7 Factor loading

Variables	F1 (77.6%)
Total Electricity Consumption (kWh)	0.9927
Chiller Coefficient of Performance	-0.8665
Chiller Plant Load (kWh)	0.9707
IAQ - Average Temperature (°C)	0.9294
IAQ - Average RH (%)	0.5820

Table 8 Green Index and Green Elements

Month	Green Index	Total Electricity Consumption (kWh)	Chiller Coefficient of Performance	Chiller Plant Load (kWh)	IAQ - Average Temperature (°C)	IAQ - Average RH (%)
Weighting scheme		0.96	0.003	0.84	-0.87	-0.88
Jan-15	1.00	33,135	5.53	139,903	24.7	53.25
Feb-15	0.98	32,603	5.43	136,155	24.7	53.25
Mar-15	1.07	35,557	5.42	148,836	24.8	53.25
Apr-15	1.18	39,601	5.29	164,447	24.9	53.31
May-15	1.16	38,865	5.28	161,147	24.9	53.38
Jun-15	1.13	37,824	5.33	157,565	24.9	53.31
Jul-15	1.14	38,246	5.36	159,754	24.9	53.25
Aug-15	1.02	34,132	5.42	142,546	24.8	53.25
Sep-15	1.06	35,167	5.42	147,487	24.8	53.25
Oct-15	1.08	35,870	5.41	150,296	24.8	53.31
Nov-15	1.00	33,288	5.40	139,804	24.7	53.31
Dec-15	1.08	35,744	5.47	150,329	24.8	53.25

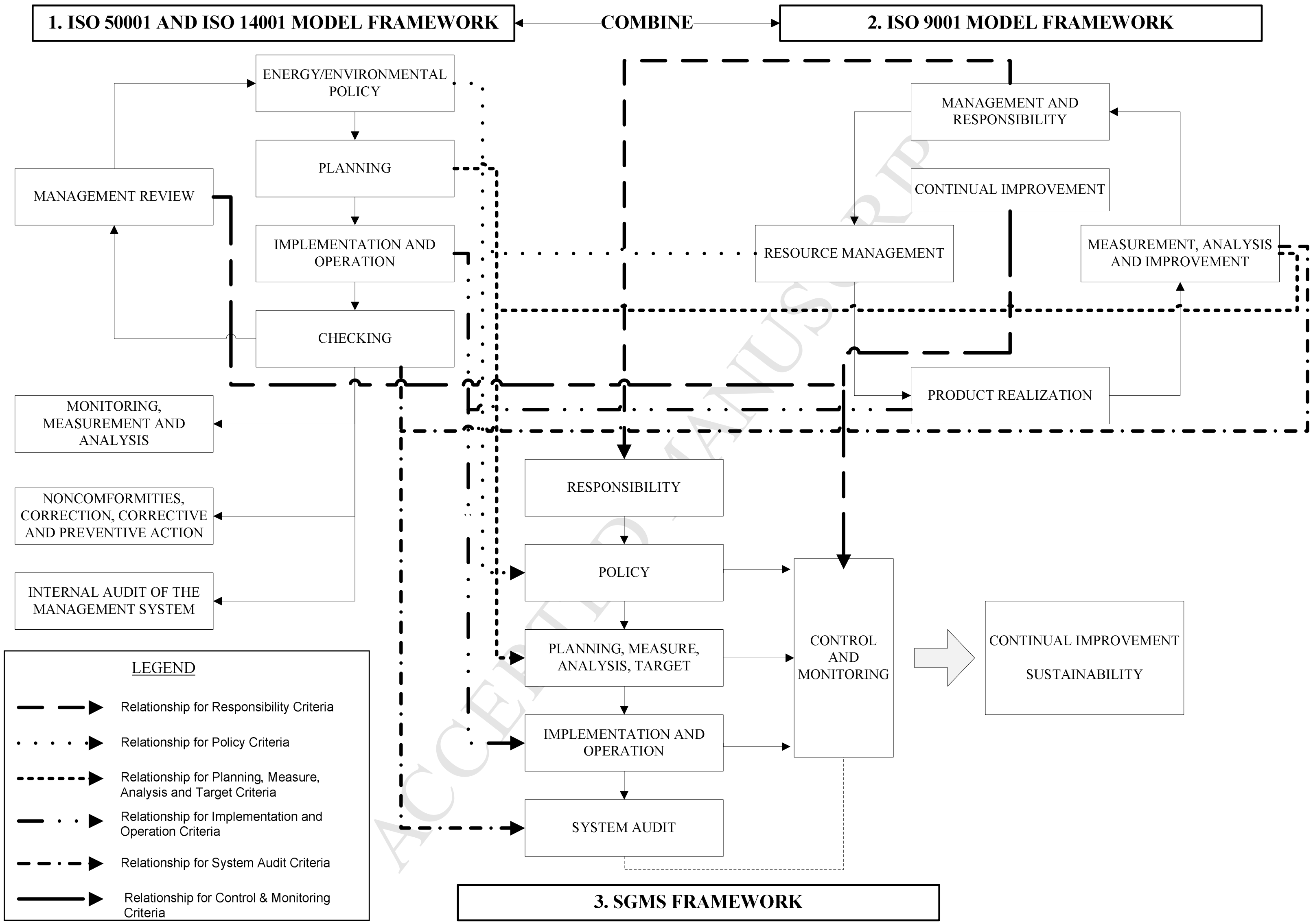

Figure 1: Essential ISO Elements for the SGMS Framework

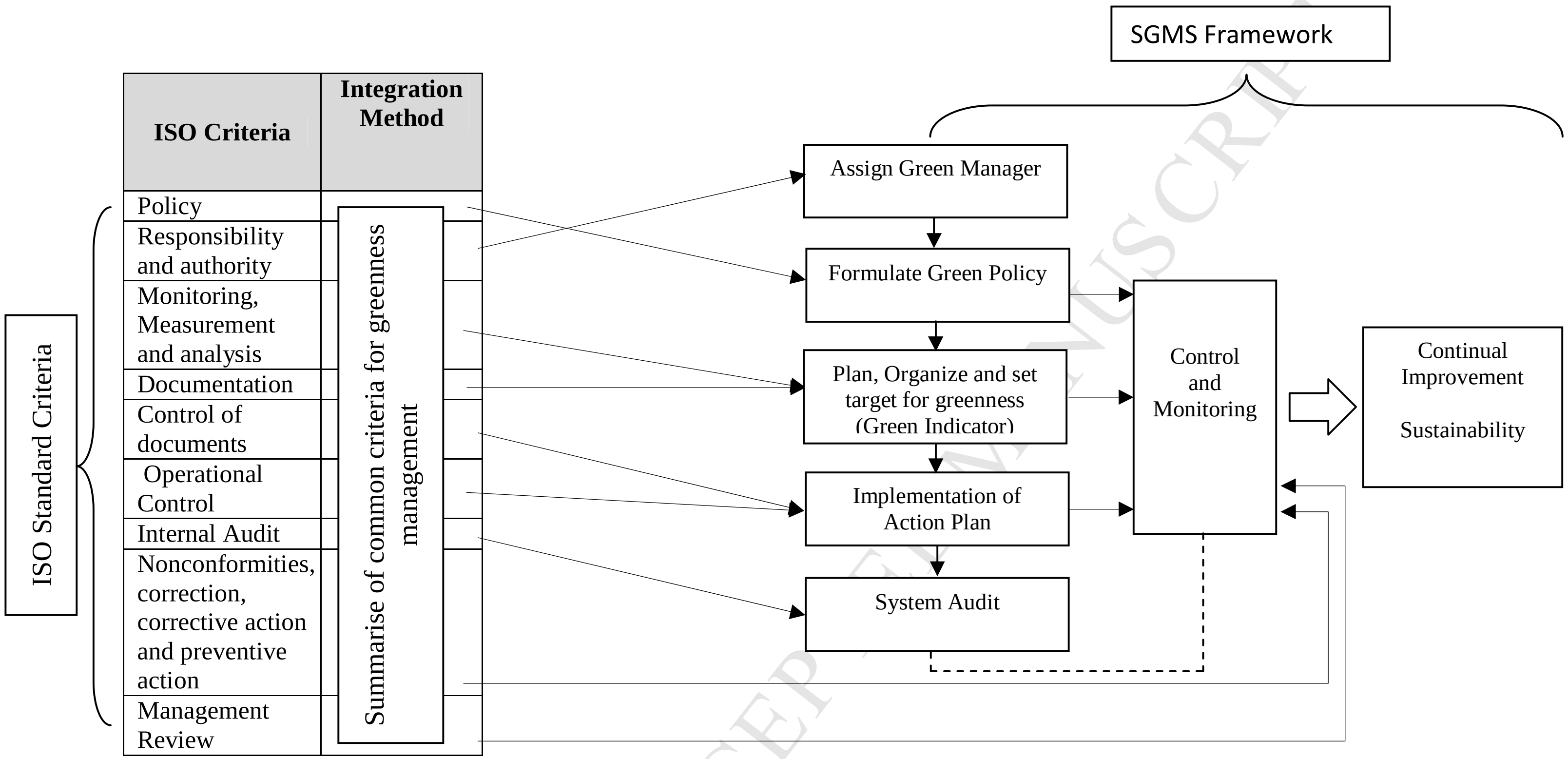

Figure 2: Relationships of the ISO Standard requirements with SGMS Framework

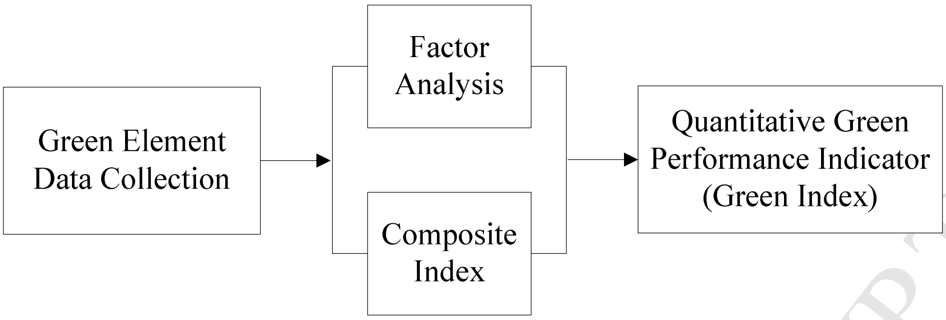

Figure 3: Overview of Green Index Component

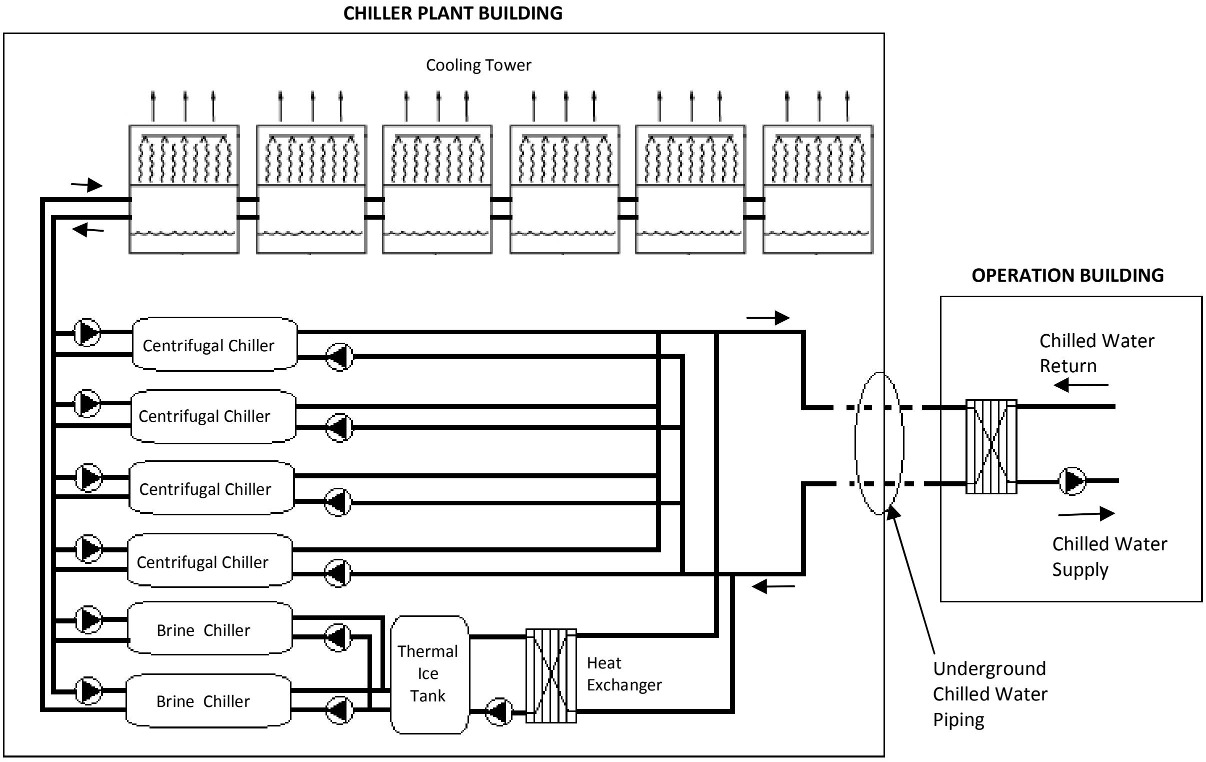

Figure 4: Diagram of a District Cooling System Plant

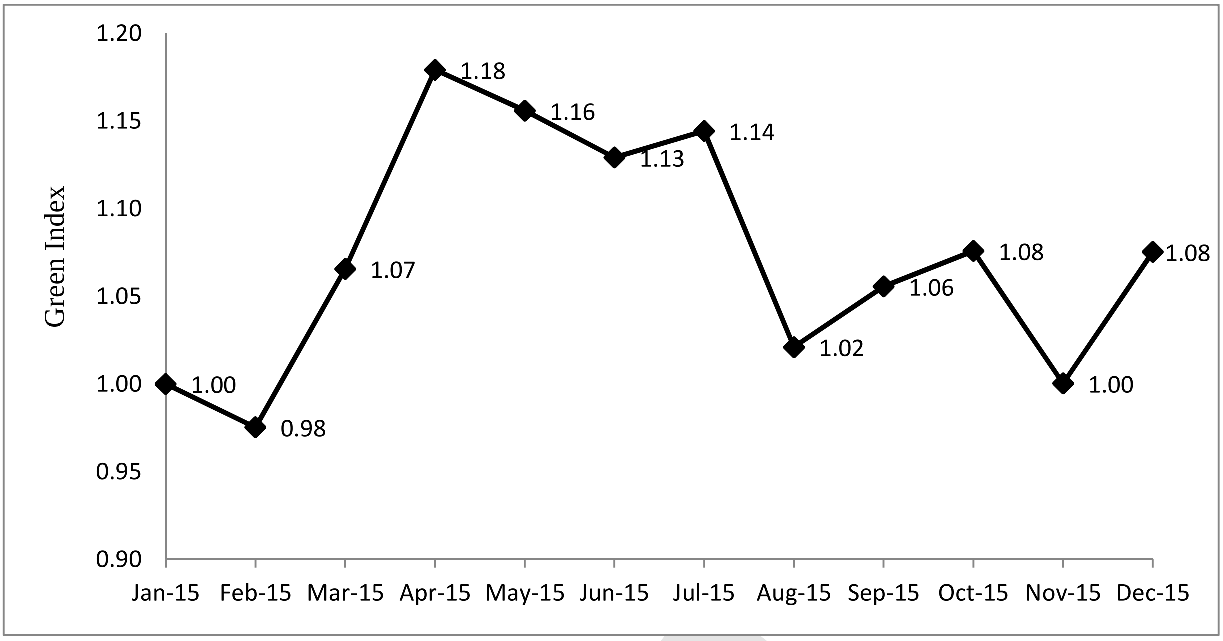

Figure 5: Green Index Trend