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Institutionalizing Energy Efficiency Within the Manufacturing Industry: a Computer-Aided Framework for ISO50001

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Abstract. This paper discusses one of the key issues related to the institutionalization of best practice in energy efficiency within the manufacturing industries. It presents the structure and functionality of an integrated and computer-aided framework that logically supports the complete cycle of continuous energy efficiency improvement, and the requirements of ISO50001. The paper also discusses the case of a multi-national manufacturing organization, and how the framework is being adopted to help its global-wide energy efficiency initiatives.

Keywords: Energy efficiency, Continuous improvement, Computer-aided energy audit, ISO50001

1. Introduction

Previous works have described a cycle required to help an industrial organization to institutionalize best practices in energy efficiency [1-3]. From strategic planning and implementation, to performance monitoring and continuous improvement, the conceptual framework follows a closed-loop that is designed to help companies elevate energy efficiency importance as a key part of the organization's strategic matrix, identify and adapt best practices, develop standardized operational procedures, implement the strategic and operational plans, establish monitoring mechanisms, and achieve continuous improvements. To support the framework, an integrated, web-based tool was developed to establish a platform to provide training and to help actual application in industrial energy efficiency analysis. It integrates all necessary materials, such as teaching materials, task flowcharts, data sheets and specific tools for technical and financial analysis, in a task-centered way. This framework can be adapted and developed for each company's specific needs, and is available at: http://iac.missouri.edu/webtool/flowchart/flowchart.html

This framework has now been expanded to support the complete cycle of continuous energy efficiency improvement, providing a computer-aided tool to help satisfy the organizational, technical and documenting requirements of the recently released ISO50001 standard. ISO50001 represents one of the world's major efforts to help the industries become energy efficiency. According to some prediction: it could have a positive impact on some 60% of the world's energy use [4].

In addition to outlining the structure and functionality of this complete framework, the paper also presents the case of a multi-national manufacturing organization, which is in the process of adapting the framework and its web-based tool, to institutionalize best practices within its global network of hundreds of manufacturing organizations.

2. Computer-Aided Framework of Continuous Energy Efficiency Improvement

2.1. Industrial Assessment Center and Industrial Energy Efficiency

The work reported here are the results of collaboration between the Missouri Industrial Assessment Center (MoIAC), University of Missouri, USA, and the ABB Inc. They are based on a computer-aided training and application tool for energy efficiency analysis within the manufacturing industries, originally developed by the first author and his MoIAC team. MoIAC is one of the 24 university-based centers across the United States supported by the U.S. Department of Energy's Industrial Assessment Centers (IAC) Program. This program provides university students with training to conduct energy assessments in a broad range of facilities, while producing real cost savings for small to mid-size manufacturers. Its achievements to date have been recently highlighted by the President of the United States [5]. To date, these assessments have helped save over 530 trillion BTUs of energy – enough to meet the energy needs of 5.5 million American homes – and have helped participating manufacturers save more than $5.6 billion in energy costs.

2.2. Cycle of Continuous Improvement of Industrial Energy Efficiency

Regarding continuous system improvement of industrial performance, it is a well understood fact that a complete cycle is required to achieve the goals: setting strategy and goals – analysis and design – implementation and operation, performance monitoring and setting of new goals [3]. However, when it comes to the improvement of energy efficiency, practical experiences have shown that despite the potentials and the increasing level of awareness, in reality the industrial organizations are still faced with barriers such as [6]:

- Lack of in-house expertise, know-how, and resources to initiate and implement energy program
- Lack of effective methodology to help industrial organizations to plan, adopt and institutionalize energy efficiency solutions in their facilities
- Lack of user-friendly tools
- Lack of institutionalized operational procedures to set the energy efficiency program in the facilities

To overcome the obstacles, a systematic approach is needed to help the industrial sectors to effectively initiate and implement an energy efficiency programs in a logical manner. Approaches and tools are needed by the industrial organizations to help tasks in the key areas:

- Education and training of personnel
- Planning and execution of energy efficiency projects: planning, data collection and analysis, identification of opportunities, detailing and justification of recommendations, implementation tasks
- Institutionalization of best practices in the organizational and operational structure: analysis and investigation of a organization's specific needs, identification of best practices guides and operational procedures, documentation

2.3. Task-centered Framework

A task-centered approach provides an ideal framework to help achieving the above. Initially, task-centered methodology was used to introduce the manufacturing system design and management (MSM) workbook with a systemic approach for industrial manufacturers [7]. The concept is based on the integration of all tasks to accomplish the work. These tasks may include tasks descriptions, instructions, processes, drawings, tools, data, etc. All elements, with the task-centered methodology, are integrated into one single platform. A web-based implementation of this task-centered framework has been developed. Closely supporting the ISO50001 standard, it represents a knowledge base and project tool, in the form of a computer-aided "workbook", providing a guide to the processes, tasks and outcomes of the complete cycle of continuous improvement, as shown in Figure 1. From the initial planning to the final recommendation and follow-up, the workbook utilizes a front-end flowchart to specify the steps and tasks involved, and then logically integrate all the relevant entities such as training materials and instructions, data collecting tools, procedures of analysis and calculation, and worksheets to support task execution, project management and documentation. In essence, it is a unified project tool that organizes and links instructional materials, worksheets, analytical tools, and resources in a logical and task-centered manner.

For example, the collection of computer-aided tasks for "II. Plan" stage (Figure 1) are illustrated in Figure 2. This implementation has proven to be effective as an integrated computer-aided training/application tool for industrial energy efficiency, because following locally through the complete cycle of the energy improvement, it is structured in a user-friendly and practical way to support:

- Interactive learning and training, by providing learning materials and best practice guides and resources in a focused way, for instance, see Figure 3. Each of the recommendations in the best practice list is supported by a task document that provides both theoretical details and tools.
- Application in actual energy improvement project through the provision of a collection of "task documents" that: (a) aid diagnosis and solution identification by providing on-line and up-to-date on-line checklist, and (b) help with the problem-solving tasks required through live tools for data collection, calculation and justification.

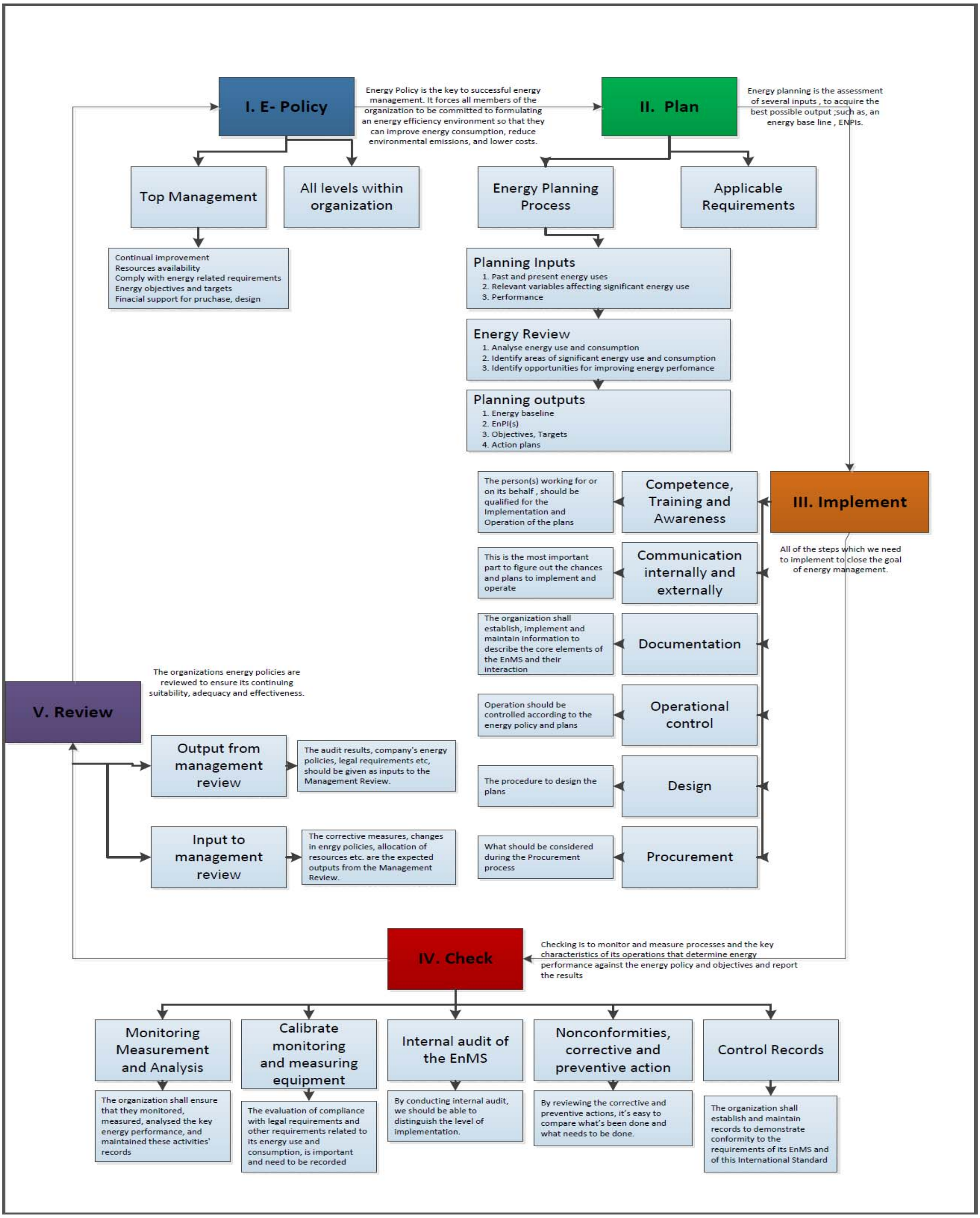

Fig. 1: Cycle of continuous improvement

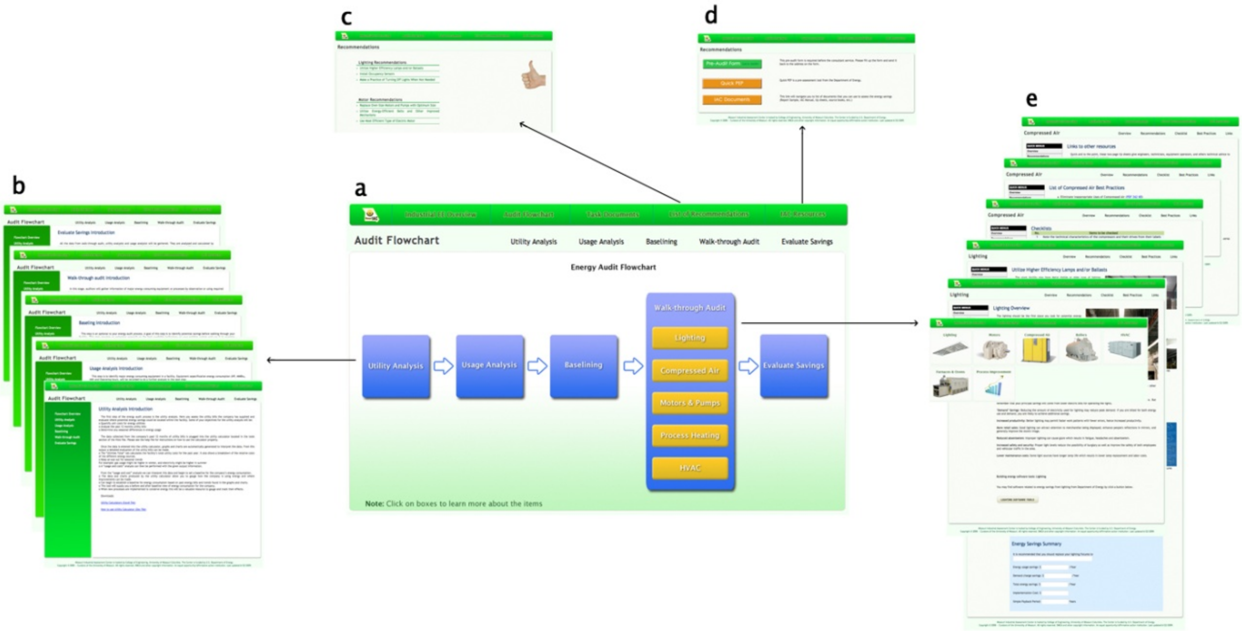

Fig. 2: Task-centered workbook: collections of "task documents" supporting the Plan state of the cycle

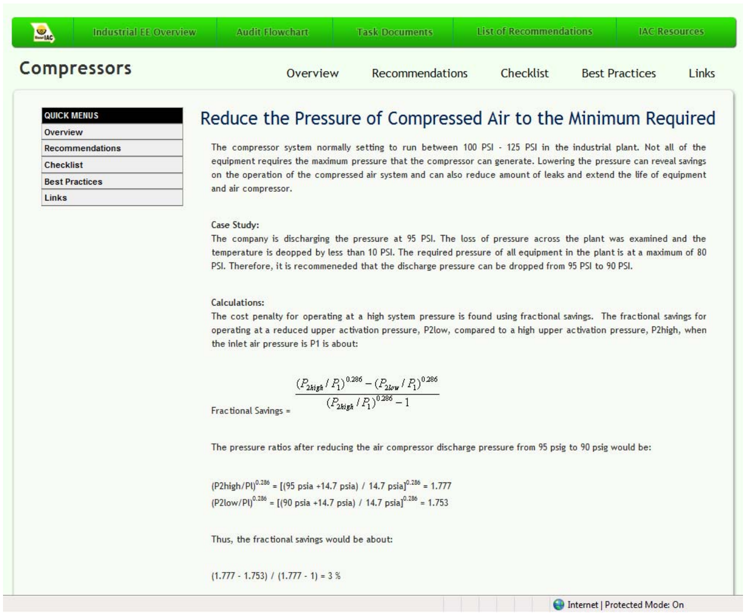

Fig. 3: Web-based task-centered workbook: sample training materials and task document providing details to specific best practice measures

3. Adaptation Within the Global Manufacturing Network of an Industrial Organization

As an example to illustrate the framework's potential as an effective means to help overcome the obstacles as previously identified, this case study outlines how the framework's structure and contents are being adopted by a manufacturing organization, and institutionalized within the organization to help the organization's global wide initiative of energy efficiency. The industrial organization involved is one of the largest manufacturers in power and automation that employs approximately 117,000 people in over many factories located in over 100 countries. It was realized that a key to improve the organization's energy efficiency situation is to have best practices institutionalized within its organizational and operational structures, and the structure and contents of the task-centered framework provides an ideal platform to help the organization achieve this. It was therefore decided by the organization's leadership to adapt this framework and implement it within its global network of manufacturing companies as part of its standard operational procedures.

Starting with a couple of comprehensive IAC assessments, the leadership of the organization decided to expand the scope, making it a organization-wide effort. This means firstly implementing industrial efficiency standards and best practices as a pilot in their one business unit which includes 62 sites worldwide, and later expand to other business units and divisions. Organization-wide adaptation and implementation of recommendations identified through the original assessments, such as energy-efficient lighting, occupational sensors, insulation for old equipment, and recovery of waste heat, are expected to lead to immense energy cost savings—to the tune of $50 to 100 million every single year.

4. Conclusion

According to the leadership in this initiative from this organization: "We're going to make energy-efficiency a part of the culture. It's going to be a challenge but it's so much better to work on something that is worthwhile." Up-to-date, the organization's global steering committee has used a top down approach to the framework's adaptation and implementation. Essentially the steering committee shall nominate the division Environmental Officers whom will roll out the initiative to the different factories worldwide. Once the improvements are proven in terms of less carbon emissions and energy savings for one division, the same model will then be copied, improved and implemented on other divisions of the corporation. Eventually the division level instructions (adopted task documents) regarding energy efficiency can then be elevated to become the global standard and operational procedures for the organization. It is also decided that the institutionalization of the framework shall follow the ISO 50001 Energy Management Standard, which gives a complete framework for a continuous improvement process as shown previously. Focus will be given to the Planning Stage where the framework will be adapted. The current status and results of the project, together with the lessons learnt, will be reported in detail elsewhere [8].

5. Acknowledgements

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