Energy Management Framework

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October 2016

Abstract

Energy management has become crucial for organizations seeking to reduce energy costs, improve their public image and conform to legal requirements.

Despite the introduction of some energy management standards and guides, organizations still confront major challenges in the actual energy management implementation. This is mainly due to the fact that an understandable and comprehensive energy management reference model does not yet exist.

In order to resolve those problems, we propose the Energy Management Framework, a reference model and implementation road-map for organizational energy management. The Energy Management Framework is based on ISO 50001 and inspired by the structure of COBIT 5, IT governance and management framework. It follows principles of management frameworks and covers detailed energy management processes, activities, best practices, inputs, outputs and roles within an intuitive structure.

The evaluation of our framework was done by mapping its processes with ISO 50001 requirements as well as thorough validation by an energy management professional.

Keywords: Energy Management, ISO 50001, Management Framework, Plan-Do-Check-Act

1. Introduction

Energy presents a crucial resource for daily operations of every organization. It has recently become one of the key aspects that companies should improve and keep monitoring, due to the related economic costs and the significant environmental impacts, to which todays society is paying more and more attention [10]. To confront those challenges, the concept of energy management has been recognized by organizations across different business domains.

According to the definition, energy management is the systematic use of management and technology to improve organizational energy performance [5]. In the academia it has also been defined as the control, monitoring and improvement activities for energy efficiency [4]. But the real issue is that energy management and its associated practices vary greatly mainly because there is no well-understood energy management model [1].

In other words, a complete, detailed and understandable energy management guide does not yet exist. The interpretation of profoundly abstract energy management activities is left to organizations themselves which is generally a daunting task and leads to only partial results. This paper will focus on creating a reference model that is comprehensible yet intuitive to follow. The goal is to provide a complete support to organizations in their energy management implementation as well as to improve their energy efficiency.

2. Related Work

An inspiration for creating the Energy Management Framework came from two distinguished domains of energy management and management frameworks. We identified the opportunity of their combination and how they can work together. This section covers the relevant energy management standard, energy management guides and industry best practices as well as scientific articles that are currently active within the energy management domain.

2.1. ISO 50001

The ISO 50001:2011, Energy management systems - requirements with guidance for use, is an international standard developed by ISO with the main purpose to establish the systems and processes necessary to improve energy performance, including energy efficiency, use and consumption. Implementation of this International Standard is intended to lead to reductions in greenhouse gas emissions and other related environmental impacts and energy cost through systematic management of energy [15]. Large organizations, from health care, aerospace, automotive and transportation product manufacturers, energy generation companies, and others have adopted continuous energy and quality improvement principles based on ISO 50001 [17].
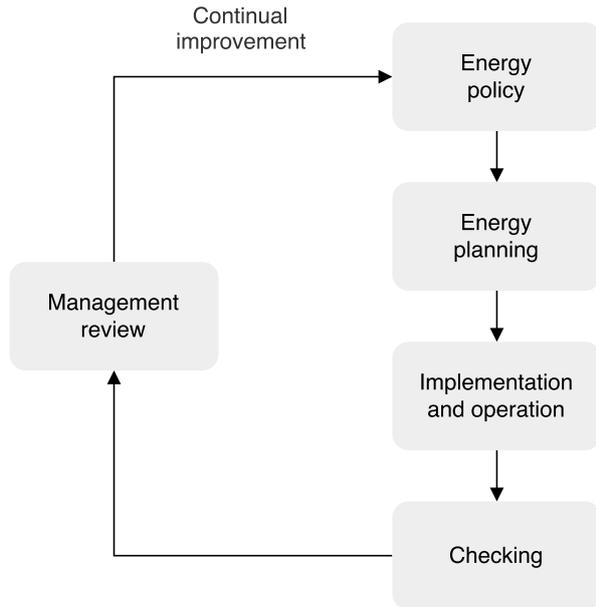
Figure 1: Representation of the ISO 50001 Energy Management System model with its core parts. Each part presents a stage of the cycle which is based on the Plan-Do-Check-Act (PDCA) continual improvement framework. The model should incorporate energy management into everyday organizational practice. Adapted from [15].

Further on, 75% of Turkish industrial organizations welcome ISO 50001 as the new energy management standard and 20% state that a standard is necessary for energy management [2].

As shown in Figure 1, ISO 50001 is based on the Plan-Do-Check-Act (PDCA) continual improvement framework and incorporates energy management into everyday organizational practices.

2.2. Energy Management Guides

Energy management guides and frameworks have intention to provide a complete structure of an energy management inside an organization. There are several published guides and frameworks that are trying to establish industry best practices and organize processes and activities. Several energy management guides and scientific articles are analyzed in detail such as Energy Management Maturity Model [1]; Ecova SEM framework [8]; Virtous Cycle framework [9]; Van Gorp [19]; Coppinger [6]; Dusi and Schultz [7]. However, all the references have more or less the same context of energy management processes and activities. Some references are more complete and have better structure while the others have significant lack of important energy management steps. The analyzed articles also provide some consistency with ISO 50001 requirements as well as some redundancy.

2.3. Management Frameworks

A framework is a real or conceptual structure intended to serve as a support or guide for creating something more specific. Management frameworks are conceptual structures in the management domain. They are usually made by collecting industry best practices and putting them all together in model(s). Simply said, management frameworks try to provide graphical models that consists of connected processes and activities, their descriptions and guidelines how to use them. The purpose of a management framework is to serve and help managers to run a successful business. To point out the benefits of management frameworks, some of the best management frameworks from other domains were compared with current management guides and frameworks from energy domain. In other works, we compared IT management frameworks COBIT 5 [12] and ITIL [3] with respectful energy management guides CarbonTrust [5] and SEI [18].

2.4. COBIT 5

COBIT 5 (Control Objectives for Information and Related Technology) provides a comprehensive framework that assists enterprises in achieving their objectives for the governance and management of enterprise IT [12]. It enables information and related technology to be governed and managed in a holistic manner for the entire enterprise. In other words, this framework is a set of best practices focused on the governance and management of IT. The main elements of the COIT 5 framework are:

COBIT 5 Process Reference Model (PRM) defines a number of governance and management processes. PRM represents all of the processes normally found in an enterprise relating to IT activities, providing a common reference model understandable to operational IT and business managers [12].

COBIT 5 Enabling Processes enabler guide complements COBIT 5 and contains a detailed reference guide to the processes that are defined in the COBIT 5 Process Reference Model [13].

COBIT 5 Process Assessment model (PAM) describes a process assessment model based on COBIT 5 and its compliant with ISO/IEC 15504 International Standard [16]. In other words, this assessment model helps to assess all the COBIT 5 processes and provides a guideline to improve them [14].

In total COBIT 5 Process Reference Model is structured within 2 areas, 5 domains and 37 processes that are industry best practices and have purpose to guide managers into governance and management of enterprise IT.

Going further, each process is explained in details in COBIT 5 Enabling Processes [13] and contains its identification, description, purpose, goals and metrics. Each process is also divided into process practices and activities and contains inputs and outputs. Those inputs and outputs can be from other CO-BIT 5 activities or some external activities. Also, each process practice and activity is assigned to organizational roles.

Finally, each process is then assessed through the COBIT 5 Process Assessment Model (PAM) [14]. The PAM is based on ISO 15504 scale [16] where each process gets assessed to determine the appropriate maturity level. In this way organization gets a valuable overview on how well it executes its IT processes.

To conclude, COBIT 5 provides a complete and well formed structure of all the processes for governance and management of IT. To justify the benefits of this framework, business outcomes show that COBIT 5 provided 40% of improved communication and relationships between business and IT and 38% of lower IT costs [11]. This provides a trustful reference and a good starting point on building a good energy management framework structure.

3. Proposal

Herein we propose the Energy Management Framework (EMF) that aims to provide organizations an intuitive guide to adopt their energy management. It provides an easy-to-understand models that enable organizations to adopt energy management practices, guiding them along a clearly defined road-map and helping them to comply with energy management standards.

3.1. Energy Management Framework

The Energy Management Framework is based on ISO 50001 International Standard for Energy Management System requirements and inspired by management frameworks from other domains. The framework covers detailed energy management processes, easy-to-understand structure and best energy management practices.

In particular, the EMF consists of the two main components:

EMF Process Reference Model (PRM) - a management reference model that defines and groups energy management processes. It represent a base structure for the entire energy management cycle.

EMF Process Reference Guide(PRG) - a detailed management guide for energy management processes defined in the PRM. Each process is supported with the relevant information, guidelines for the process implementation, re-
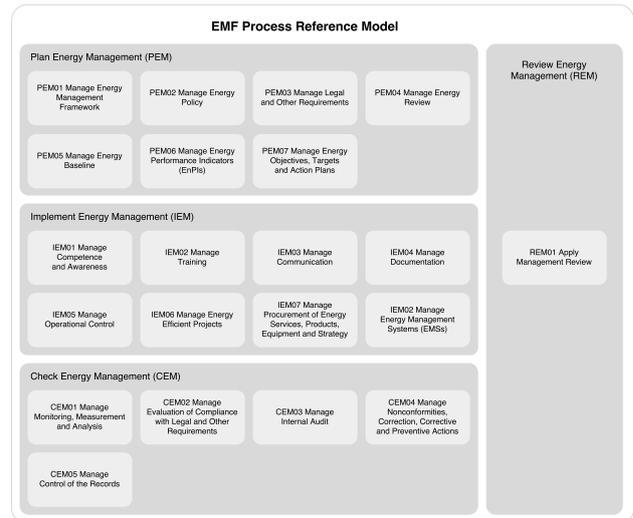

Figure 2: EMF Process Reference Model with its four domains which represent planning, implementation, checking and reviewing stage of the energy management cycle. The domains group defined 21 EMF processes for the respective stages.

lationship with other processes as well as responsible organizational roles.

3.2. EMF Process Reference Model (PRM)

The EMF Process Reference Model (PRM) is a management reference model that includes all the energy management processes. The processes are based on the ISO 50001 requirements and the industry best practices while the structure follows the PDCA (Plan-Do-Check-Act) cycle extensively used in other management frameworks.

In total, there are 21 EMF processes grouped within 4 domains:

Plan Energy Management - refers to the stage where an organization commits to an energy management cycle. The domain combines 7 processes which cover establishing an energy management commitment, creating an energy management team, energy policy, baseline, objectives, targets and action plans, consolidation with legal and other requirements, processing energy performance indicators and conducting an initial energy planning review.

Implement Energy Management - refers to the actual implementation stage where an organization is implementing the energy management and undertakes processes of competence, training, communication and documentation management as well as managing operational control, procurement and energy efficient projects and systems. The domain contains 8 processes in total.

Check Energy Management - refers to the monitoring and checking stage. There are 5 processes that include monitoring, measurement and analysis of organizational energy performance, compliance with legal requirements, internal audit, manage nonconformities and other corrective actions and managing the control of the records.

Review Energy Management - refers to the review stage. The domain contains 1 process that applies an overall management review of which ensures continuous adequacy and effectiveness the entire energy management cycle.

The EMF PRM presents only a high-abstract representation of processes. To fully incorporate the energy management road-map, each process requires a detailed explanation and implementation steps. Following section defines the reference guide that supports the PRM and clarifies each process.

3.3. EMF Process Reference Guide (PRG)
The EMF PRG represents detailed descriptions of the EMF processes defined in the PRM. Therefore, each process is detailed with the following information:

Process label - the domain prefix (PEM, IEM, CEM, REM) and the process number.

Process name - indicating the main context of the process.

Process description - an overview of what the process actually does.

Process purpose - an overall purpose of the process.

Process inputs - each process usually has some kind of inputs (e.g. document, deliverable). The inputs can be from the other EMF processes and activities or from the outside of the EMF (e.g. ISO 50001 document). Each input is defined with the source, description and which activities require that input.

Process outputs - each process produces some kind of outputs (e.g. document, deliverable). The outputs are usually used in the other EMF processes and activities or outside of the EMF (e.g. organizational structure). Each output is defined with the producing activities, description and destination.

Process activities - specific activities/tasks that construct the process. Each activity consists of the activity label and description that explains what specifically needs to be done.

Process model - a model representation of an EMF process. It consists of defined activities, inputs and outputs that are produced within the process. This representation ensures that each process is understandable and easier to manage.

RACI chart - a responsibility assignment table that connects each process activity with the appropriate organizational role. The different levels of involvement are as follows:

R (responsible) - who is doing the activity? Roles that are actually fulfilling the listed activity and creating the intended outcome.

A (accountable) - who is accountable for the success of the activity? This assigns the overall accountability for getting the activity done. As a principle, accountability cannot be shared.

C (consulted) - who is providing the consultation? Those are the key roles that provide information inputs to the listed activity.

I (informed) - who is receiving the information? Those are the roles who are informed of the achievements and/or deliverables of the activity.

Each of the 21 EMF processes comes with the relevant PRG charts that provide understandable as well as comprehensive processes descriptions. The PRG is aligned with the ISO 50001 International Standard which leads to the closed cycle of the entire organizational energy management. By following the EMF PRG, organizations are always be sure what has been done and what needs to be done to ensure an efficient energy management. Moreover, the guide is adaptable and can be used across industries and organizational preferences. The complete Energy Management Framework with all of its processes and details can be found at www.energymanagementframework.com as well as in the Appendix A of the Thesis document.

4. Demonstration
Demonstration of the work that was conducted with the energy efficiency and management assessor of Instituto Superior Tcnico. The EMF was demonstrated and compared with the real-world practices, both from the industry and the University. This was a crucial step in validating our work where we got significant knowledge on how energy management actually works in practice and where we can implement our EMF processes.

The energy management expert who evaluated EMF has been working in the industry for more

than a decade and is currently an energy efficiency and management assessor of Instituto Superior Tcnico. This acknowledgment puts our work in a valid and affirmed context.

The demonstration sessions were done in two occasions and they included following elements:

- General demonstration of EMF processes - each EMF process was assessed regarding its utility and difficulty of implementation. The assessor compared processes with real-world implementation both from the industry and the University. Processes are mainly analyzed concerning their main description, purpose and structure. At the end, the assessor gave some general comments about each process.

- Detailed demonstration of EMF processes - following the first part, each EMF process was then assessed in detail, point on each activity within processes, their connections, utility and necessity. In other words, each process activity was discussed and analyzed followed by its final approval. The approval means if the activity is actually aligned with real-world practices and has a practical value to be implemented as-is.

- General demonstration of entire EMF framework - final assessment covered construction of the EMF PRM and PRG, their utility as well as some general comments on how it can be aligned with the real-world implementation. The assessor provided some important pros and cons of our framework, how it can be aligned and implemented in various examples as well as some improvement measures that should be produced in forthcoming framework iterations.

4.1. General EMF processes demonstration

As mentioned, first part of the demonstration included just the overall assessment and alignment of EMF processes with real-world practices. The assessor compared our processes with industries processes giving some critical notes. Main scale that was used to assess the processes is shown in Table 1. Each process was classified regarding its two characteristic:

- Utility - how useful a particular EMF processes actually is for a real-world organization. In other words, would this processes contribute in overall energy efficiency and management improvement of an organization.

- Difficulty of implementation - how big of an obstacle a particular EMF processes would be to implement. Namely, how much time and resources in average would an organization use to implement a particular processes.

Value	Utility	Difficulty of implementation
0	No utility	No difficulty
1	Low utility	Low difficulty
2	Mid-low utility	Mid-low difficulty
3	Mid-high utility	Mid-high difficulty
4	High utility	High difficulty

Table 1: Utility and difficulty of implementation scale used to assess EMF processes. This scale was presented to the assessor before the demonstration.

Even though EMF tries to provide a general energy management solution, the assessor pointed on some important parameters that influenced the overall scoring of each EMF processes. They are tight to a specific organization as follows:

- Energy management experience - if an organization has already implemented some sort of an energy management, the difficulty of implementing EMF processes is highly reduced.

- Type of the industry - significantly influences how EMF would be implemented. For example, energy management of an university, hospital or power plant are approached from different angles which influences utility and difficulty of implementation scores.

- Top management commitment - since energy management is quite a new area, executives and top management are yet to understand the full potential of its implementation.

- ISO 50001 knowledge and certification - referring to the first chapter, it is clear that many European countries and businesses still have to recognize the importance of this Standard which is the EMF baseline.

- Organization size - overall, energy management is more significant to larger organizations than the smaller ones since it usually requires more complex approach.

- Current personnel energy management expertise - even though EMF tends to simplify energy management, some expertise is welcoming to speed up the cycle.

- Budget - most of the EMF processes do not require significant investments, but some of them such as IEM06 Managing Energy Efficient Projects require long term budget plannings.

4.2. Detailed EMF processes demonstration

The second part of demonstration included detailed assessment of EMF processes. The assessor went through each process and its respective activities and marked their acceptance. As a reminder, each activity represents a specific task that organization should implement within a process to ensure its successful management. The assessor stated this is certainly beneficial for organizations because it removes the abstraction of processes and produces simple tasks that usually don't require specific domain knowledge. In other words, most of the activities can be implemented without extensive training in energy management. Since this is a first version of the framework, it was expected to have some activities that don't align with the real-world situations but the results are truly promising. Most of the processes have 70-80% of acceptable activities and are commented as good and ready for implementation. The most relevant critiques are as follows:

- IEM08 Manage Energy Management Systems process requires major improvement - the assessor stated that it is not clear enough how this process should evolve around energy management systems as software tools. It should be more precise and detailed how software tools should be used in the context of energy management cycle. However, as shown in previous results, utility of the process is high so it just needs more clarification in implementation itself.

- CEM05 Manage Control of the Records - the assessor stated that its activities could be mitigated in other processes. The process itself is useful, just the amount of activities and their description don't contain required necessity for implementation.

- CEM04 Manage Nonconformities, Correction, Corrective and Preventive Action - as mentioned before, another important comment was regarding CEM04 where organizations have to deal with non-fulfillments for their specific case which is usually very complex to simplify.

4.3. General EMF demonstration

Finally, the last part of evaluation by the assessor gave the overall conclusions regarding the entire EMF itself, its PRM and PRG. Some of the comments are as follows:

- Less responsibility assignment for Top management in RACI charts - in practice top management don't have that much responsibility regarding energy management. Tasks should be mostly transferred to energy management team and top management is just occasionally informed and consulted about most important energy management decisions.

- Increased importance of energy audit - even though energy audit is mentioned several times through certain activities within EMF, there should be an increased importance of this procedure. The assessor event suggested to create another process called Manage Energy Audit to precisely determine required steps. Energy audit should be included as one of the first steps of the energy management cycle.

- Separation of ISO 50001 document from EMF processes - several EMF processes and activities explicitly involve ISO 50001 document but this should not be necessary. The framework should be completely standalone document and guideline for organizations and they should not be required to obtain the Standard as well. EMF completely covers all the ISO 50001 requirements so having two documents would be ambiguous. Of course, organizations could acquire both, side-by-side to ensure they are on the right path.

As we can see from this demonstration, Energy Management Framework still needs some minor improvements for real-world implementation. Nevertheless, demonstrating its value by comparing to current energy management practices within few industries has shown that is very close to how energy management is actually conducted. On the other hand, it brings this fresh engineering approach of coupling concepts and tasks as specific processes and activities which would significantly reduce complexity of organizational energy management.

5. Evaluation

Since the Energy Management Framework is based on ISO 50001, the main evaluation was conducted by mapping EMF processes with ISO 50001 requirements. This was a crucial step to confirm the proper alignment and minimum baseline for our framework.

5.1. ISO 50001 mapping

The ISO 50001 mapping was implemented by aligning its requirements with our Energy Management Framework. Each of the Standard's requirements had been analyzed with its content completely covered. Since EMF is based on ISO 50001, significant number of processes followed the flow of Standard's requirements, both by including them through activities and covering end-to-end.

Some of the requirements such as Top management and Management representative has been aggregated within one EMF process (PEM01) while

others like Communication, training and awareness divided into more processes (IEM01 and IEM02) This decisions were made after concluding that it makes more sense in real-world implementation to construct those processes as shown.

Another example is IEM08 process which was included on top of the requirements which deals with managing energy management software solutions. Since more businesses have already implemented software tools to track their energy consumption, EMF supports and includes managing of those in its cycle. This is crucial because the tools can provide significant improvements by providing data for other processes like IEM01. Management review can be more efficient and thorough which brings better understanding of the entire cycle.

5.2. Discussion

Obtained evaluation results are certainly positive. The Energy Management Framework is completely mapped with ISO 50001 requirements which ensures the compliance. Moreover, it simplifies the energy management implementation over the Standard by providing explicit steps and complete cycle as a whole.

On the other hand, the demonstration and assessment from the energy management professional gave us even better conclusion that EMF can actually be applied as-is in organizations. Some of the processes and activities would require iterations to make them more explicit, clear and closer to what organizations actually need. As seen from the graphs, around three quarters of entire EMF is acceptable and ready to be applied. Those inspiring results show that this could be a right path to follow in future energy management implementation.

Lastly, an even better step would be to apply the EMF in the organizations and get some field measurements. That would require more time and commitment of the testing organizations but, nevertheless, it is highly possible in near future.

6. Conclusions

Energy management has become one of the upcoming areas which organizations yet have to tackle. Despite some proposed solutions and guides that tried to provide energy management solutions, none of them produced a complete and understandable framework. From analyzing, both, scientific and industry literature we have seen that organizations still struggle to actually implement energy management in their daily work.

Current energy management activities are too abstract and descriptive, not detailed enough and there is, generally, a lack of an intuitive and easy-to-follow structure. There is still lots of work left to organizations themselves to figure out how to approach this problem.

6.1. Impact

The Energy Management Framework aims to provide a complete guidance for organizational energy management implementation. It will help organizations to improve their energy performance, reduce energy related costs, help complying with regulations and improve their public image.

Throughout the related work, we identified ISO 50001 International Standard as the basis to extract all the steps that an organization needs implement for a successful energy management. The obstacle was that this Standard only provides set of requirements that have to be accomplished. But it does not structure them in context of processes and activities to explicitly present what an organization needs to do. In other words, an organization gets the requirements and it is left on its own to deal with them.

Moving forward through related work, we pointed on the idea to analyze some already established management frameworks that are used in practice and that produce great results. We decided to take COBIT 5, IT governance and management framework as the basis for structuring our framework. It is already used by many IT managers across the industry and has great results within managing IT and reducing IT-related costs. It provides sets of processes and activities structured in logical domains as well as their comprehensive description and purpose. Moreover, it connects them throughout inputs and outputs so entire framework works as an organic unit. Finally, it sets the roles for each and every process so it is clear who is responsible for them.

Inspired by the management frameworks from other domains, our final idea was to create one for the energy management domain. Therefore, the Energy Management Framework takes ISO 50001 energy management requirements and other industry best practices as a content basis and COBIT 5, IT management framework as a structure basis. The result is a management framework adaptable to organizations of any industry. The Energy Management Framework consists of the EMF Process Reference Model (PMF) that defines the energy management processes and their domains and the EMF Process Reference Guide which describes each process in details, adds their connection and responsible organizational roles.

Finally, proposed Energy Management Framework was evaluated both by mapping with ISO 50001 International Standard for Energy Management Systems and thorough validation by an energy management professional. The results were more than positive showing that EMF can already be put in practice and be applied in real-world organizations. Moreover, it is on the right research path to

solve the upcoming problem that organizations yet have to face which is how to conform legislations and efficiently manage energy.

6.2. Lessons Learned

Throughout this work, specially during the evaluation stage, we have tried to align our processes with real-world practices. From the energy manager assessor we learned some valuable insights how can this framework be used in a real organization. Some of the most important suggestions were in creating one more process for energy audit, separate ISO 50001 from EMF as well as including energy management software tools in a more clear and understandable way. Other than that, we have received more than positive feedback confirming that EMF processes and activities can be already applied as-is. Most importantly, we learned how energy management works in big organizations such as Instituto Superior Tcnico, and how our EMF could possibly be applied in their every-day work.

6.3. Future Work

For the future work, we have identified following:

- The proposed Energy Management Framework could be further developed to align with the evaluation feedback. It needs few more iterations over the processes as well as refined structure.

- Each of the 21 EMF processes could be modeled like the PEM01 example. As the assessor suggested, those model are extremely helpful to provide clear picture of every process, its activities, inputs and outputs.

- The framework could pass few more evaluations from other energy management professionals to establish its value.

- From the academic perspective, the proposed framework could be used in a scientific article.

- Finally, the best proposition would be to fully demonstrate EMF within an organization. It needs to be implemented for some months to get concrete results but, as stated already, majority of the processes are already prepared.

Implementing EMF in a real organization is suggested path to take as soon as possible. In that way we could test the very core idea of EMF as an unique guideline for organizational energy management. Even though energy management is quite a new area and still needs to be discovered, we believe that its crucial for future of organizations. Our approach was mainly supported with engineering principles by dividing concepts within processes and activities and connecting them with inputs and outputs. We believe this is the most clear and understandable way for a successful management and we are sure this will be recognized.

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