Towards Continuous Improvement based on Management Execution Systems: the human side of Information Technology

The contribution of a Management Execution System to Operational Excellence, at Coca-Cola Enterprises

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Name
L.J. Valk (1309919)

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Graduation Committee:
Chair: Prof.dr.ir. M.P.C. Weijnen
First Supervisor: Dr.ir. Z. Lukszo
Second Supervisor: MA. H.J.G. Warmelink
External Supervisor: F. van Mossel

Academic information:
Delft University of Technology
Faculty of Technology, Policy and Management
Section Energy & Infrastructure

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i. Management summary

The manufacturing sector is one of the most important pillars of developed and emerging economies. But, markets have become highly competitive, volatile, and unpredictable. This behavior is driven by faster innovation, reduced product life cycles, and globalization of industry.

Coca-Cola Enterprises (CCE) is one of many companies that operates in this environment. CCE is a bottling company of the Coca-Cola Company (CCC). CCC has ownership of all the brands and the recipes of the beverages. To best the competition CCE has adopted a Operational Excellence as a business strategy. OE has three core principles: customer satisfaction, employee involvement, and process improvement.

Recently CCE changed their IT environment to be able to build the desired information that is needed to support the core principles of OE. Two major IT systems have been implemented. Firstly they adopted an Enterprise Resource Planning (ERP) system, that covers a very wide range of an enterprise by integrating information from finance, accounting, human resources, operations, supply chains, and customer relations. Secondly a Management Execution System (MES) has been implemented, this IT system enables the organization to gather specific data and information about the manufacturing process of a plant.

The MES connects the shop floor (operational level of the organization) with the ERP system (strategic level of the organization). This results in two main capabilities of the MES. Firstly, it presents real time information about the processes, leading to immediate efficiency gains. Secondly, the information about the processes are stored. On a longer term managers at the tactical level build knowledge about the processes based on this information; this knowledge will lead to improvement projects that can structurally and continuously improve the efficiency of an industrial production plant. The MES of CCE has three main modules that can improve the production, quality, and CRS (Corporate Responsibility and Sustainably) efficiency of their industrial production plant in Dongen.

Yet, the MES of CCE has only recently been implemented and it is facing challenges regarding all three modules of MES. The environmental department of CCE requested research on how their MES should be further integrated with the organization in order improve the energy and water efficiency in the CCE production plant in Dongen based on MES. However, before the environmental department can be assisted with this request, the MES as a system must be successful in contributing to the overall strategy of the plant. This led to the main research question:

*How can the implementation of a Management Execution System contribute to the strategy of Operational Excellence in an industrial production plant?*

Framework for a successful MES contribution to Operational Excellence generally applied to CCE

Working with the CRS module of MES to improve the energy and water efficiency of the plant gave the insight that two aspects regarding the system are most important for its success. Firstly the technical aspect, basically meaning that the system must be able to present accurate information about the desired processes in the plant and that it meets a minimum set of technical specifications needed for successful continuous improvement. Secondly the organizational aspect, meaning basically that all relevant employees need to use the system and must be able to improve the intended efficiency based on the information that the system presents.

This led to a literature research on technical and organizational success factors for a MES within an industrial plant based on the experiences gained at CCE. Based on the relation between the factors a framework for a successful MES contribution to OE was developed, Figure 1. Subsequently the framework is applied. This part of the
research finishes with an integrated advice to the management team of the organization as a whole. The next part the framework is applied to the CRS module of the MES to answer the question of the environmental department.

Before the individual success factors are discussed the framework is put in the context of how it can be used by the management of an industrial production plant. Simultaneously with the explanation of the success factors the recommendations for the management team will be given. Thereafter the application to the CRS module and the recommendations for the environmental department will be discussed.

As can be seen in Figure 2 the success factors need to be improvement continuously to keep MES successful in a changing market and organization. The framework is applied to the MES of the CCE which results in challenges per success factor that can be improved. They are combined to an integrated approach to solve the challenge.

As Figure 2 states, first a dedicated 'MES champion' must be appointed. The MES champion often has a senior function because he must be able to influence all the success factors.

Currently the CCE MES champion only has eight hours a week for MES. We advise CCE to make this a full time job. The MES champion is advised to intensify the relationship with the CCE MES project leader in Paris, since this actor is often needed for systems adaptions and troubleshooting.

Secondly, the situation has to be mapped out. This is done by investigating the engagement of the organization with MES, which is defined as follows:

An organization is engaged when all relevant employees use a system and all relevant employees have the knowhow to use the system in order to continuously improve.

Engagement is the most important success factors and is influenced directly by four other success factors: data accuracy, user friendliness, clear responsibilities, and education and training.
Of these four success factors **data accuracy** appeared to be of great importance when it comes to engagement and should therefore be adequately taken care of as soon as possible. The MES champion needs to find out if the MES produces accurate data and if necessary he needs to correct errors. The relevance of this factor is illustrated when you imagine an organization that is engaged but makes decisions based on wrongful information; MES might work counterproductive. Furthermore, the way in which the MES is integrated with the IT environment must ensure **adequate functionalities** to provide accurate and complete data and information that is required for the continuous improvement strategy. This can be done using the ‘ISA-95’ guideline, though this is mainly the responsibility of the MES supplier. In case the MES is not well integrated by the supplier a third party might be able to assist. In the case of CCE the IT integration is adequate, but since the system has only recently been implemented not all relevant actors are engaged yet. This might well be because of the fact that the system still experiences some teething problems, which sometimes results in inaccurate data.

The third step states that the user experience must be reviewed: in case the **user-friendliness** of a MES is not adequate employees will use it less, which has a negative influence on engagement, subsequently making the MES less successful. For CCE this means that the software in the production halls needs to be updated to improve the user-friendliness for the operators. Furthermore the functionalities of the system must be adequately aligned with the goals of the organization concerning their MES. This last part should be done in good consultation with the MES supplier for which a good **MES supplier relationship** is necessary. For the CRS module of the MES owned by CCE, this means adding the steam boilers, adding a main gas gauge, and adding a main Low Pressure air gauge.
Fourthly the MES champion will have to review the **KPI tree** of the industrial production plant and align this with the functionality of MES and the goals of the organization. When the KPI tree is decomposed over the organization, employees or departments can and must be made **responsible** for certain KPI’s in order for people to be committed in reaching the target for their KPI, leading again to a greater engagement.

Finally the MES champion has to push the ‘training center’ to give **education and training** to all relevant employees, where they learn how to use MES and how to improve the efficiency of the plant based on the information MES presents to them. Of all forms of **leadership**, relational leadership is considered to be the style that aims at enabling employees by educating them and making them responsible, not only for using the MES in the right way but also for acting on information the MES provides them with.

When this is all executed the cycle starts over again.

**Energy and water efficiency improvement based on MES, the framework applied to the CRS Module**

The previously presented recommendations will contribute to the successfullness of MES, which is a condition when increasing the energy and water efficiency of the plant in Dongen based on the CRS module. Now let us return to the request of the environmental department: the next step is applying the developed framework to the CRS module of MES specifically by using all inherently gathered knowledge on the processes of the production plant gathered whilst performing the research.

First the situation for CRS module was mapped out. Since the MES is recently implemented, the engagement was low and some variation in the data accuracy was found. In cooperation with the environmental department a way was found to engage the relevant employees in the area of energy and water. Yet first we had to find out who were relevant in the first place. This depended on the relevant processes: all processes significantly contributing to energy and water usage were identified, and subsequently the processes with room for improvement on these subjects were selected. This resulted in the following three processes:

1. Bottle washer
2. Water treatment process
3. Bottle blowing process

To engage the employees that work with those processes we ‘stepped’ so to say into the factor (relational) leadership and basically took the role of ‘MES vice champion’ in the CRS module. From this position we:

1. … experienced a low engagement overall (see interviews in appendices) and tried to identify (framework) success factors that held potential for improvement;
2. … reviewed data accuracy as much as possible, indeed finding some errors which were communicated and corrected, and by this restoring potential engagement;
3. … used the ISA 95 guidelines were relevant for the CRS module to asses IT integration and functionalities (see appendix iii);
4. … improved user-friendliness of processing MES information by making more efficient, clearer and easier to use spreadsheets in excel;
5. … assessed the current KPI mechanism and assigned new or more clear responsibilities based on this;
6. … aimed at educated employees ourselves by exercising relational leadership; this means in this specific case talking to employees, asking them questions and explaining them the goals and relevancies of them using of MES. On top of that the training center of CCE is looking into ways of providing the (relevant) employees with actual trainings.
To give you a short example of one of the experiences leading to above said: When applying the KPI tree success factor it was found that there is already a KPI mechanism in place at CCE. This is called the ‘dashboard meeting’ in this meeting the most important KPI’s are discussed by the management team. Since it is hard to change any part of an hierarchically structured organization on the short term, it was decided to use those KPI’s in the most valuable way as possible. On top of that those meeting hold a lot of decision power, which makes that the KPI’s discussed in those meetings are thought of as very relevant making it even more suitable for our research. The environmental department has the responsibility to produce key figures for the KPI’s for energy and water. We found that the energy KPI \( \text{[kWh/1000l product]} \) is influenced by some external factors. These external factors can significantly influence the KPI while the plant performance does not change at all. Therefore an excel tool was made that can correct for the energy KPI given the change in those external factors. Two examples are correcting for temperature and correcting for the water usage of line 3. When it is cold during winter a lot of energy is used to heat the plant, which means the energy KPI should be higher during winter. Volume line 3 is the line were the glass bottles are washed and the bottle washer used for this uses a lot of energy. The original KPI did not take this into account. Because the new excel tool accounts for those factors the dashboard meeting is able to make decision based on the actual performance of the plant.

This all resulted in two pillars where we engaged people with MES that has already led to efficiency improvements in the area of energy and water. First we engaged employees that work with significant processes in the area of energy and water. They are mainly using the real time functionality of MES to continuously improvement the efficiency of their process. An example of a result of this in the water treatment: an unnecessarily opened valve was found and closed based on the information from MES. This valve would have been leaking for hours if the operator would not have been engaged with MES and checked the KPI for the water treatment. By removing the cause of the waste the efficiency was improved. In case this valve has problems often the operational excellence team will structurally improve the situation and thus the efficiency.

Secondly we further engaged the management team with MES and improved the information they receive from MES. Based on this information the managment team will initiate improvement projects that can structurally improve the energy and water efficiency of their plant. An example of such a project could be the replacing the of bottle washer by a more efficient process.

When reflecting on this research in hindsight we determined that the main difficulty was the structure of the research. Due to the tension between the scientific relevance, a successfully contributing MES to the Operational Excellence strategy of an industrial plant, and practical relevance, improving energy and water efficiency based on MES information, a heterogynous feeling arises between the second and third part. In hindsight the practical experience should have been embraced and used as input for the scientific research, and the other way around, from the very beginning of the research.

Future research can contribute to the framework in two ways. Firstly the reach of the framework can be extended over the entire life cycle of MES, taking to account the design and acquisition phases as well. Secondly the success factors can be extended with tools and techniques that give the user of the framework clear action to take when trying to improve a factor.
Preface

This report is written by Rens Valk a student of The Delft University of Technology. This document is my master thesis with which I aim to graduate from the faculty of Technology, Policy and Management.

For my thesis I was able to take a look into the world of Coca-Cola. I thought I might find the secret/hidden/original Coke recipe, but; I did not. This probably answers the main question you wanted to ask me about my thesis.

During seven months I studied and worked in Dongen where the Dutch production plant of Coca-Cola is located. I would like to thank all the people at Coca-Cola that accepted me with ‘Brabantse gemoedelijkheid’ and helped me understand everything that happens in a production plant. I am fascinated by all the aspects involved to deliver that cold can or bottle of coke to all their customers.

In special I would like to thank Frank, my supervisor from Coca-Cola, whose door was always open for questions and feedback.

For this thesis to become as it is today I had to overcome many challenges, from traveling three hours every day to writing an academic, over 100 pages, report. I could not have done this without the help of Zofia and Harald, my supervisors from the Delft University of Technology. They provided feedback, helped me structuring the problems and solutions that were often present in my mind but not on paper, and they even visited me and Frank in Dongen. Also the input, during the official sessions, from my professor Margot helped me greatly.

During the process of writing this thesis my interests in the interface between IT and people has strongly increased giving me an idea what to do for career, which was one of my goals while graduating.

Finally I would like to thank those people for whom no question was too mad. Firstly my parents; who supported me through my entire life getting me here. And secondly Clementien who corrected many parts of my writing (except the preface); whom I could always consult; and most importantly, told me once every while that ‘everything would be alright’.

With pride I present to all of you;

my master thesis(!)

Regards,
Rens
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Part I

Introduction to the challenge: MES and CCE

In the first part the scientific and practical context is illustrated from which the need for this research is originated. The research questions and approach will be presented in the first chapter as well. Management Execution Systems and their relation with operational excellence are presented in the second chapter. In the third chapter Coca-Cola Enterprises and their MES will be introduced.

1. Introduction
2. Management Execution Systems
3. The Management Execution system of Coca-Cola Enterprise
1 Introduction

The manufacturing sector is one of the most important pillars of developed and emerging economies. In Europe, 22% of the gross domestic product (GDP) is represented by the manufacturing sector, and it is estimated that 75% of the GDP, and 70% of employment is, to some extent, related to manufacturing (Unver, 2012). Over time, these markets have become highly competitive, volatile, and unpredictable. This behavior is driven by faster innovation, reduced product life cycles, and globalization of industry (Reinert, 2012). Also the cost of raw materials has risen, and scarcity is forecasted (Kolesnikova, 2011). This led to an accelerated information technology (IT) which triggered the manufacturing industries to continuously improve process efficiency and decrease production costs, thereby trying to best their competitors.

There exists a wide range of theories focused on enterprise strategies concerned with keeping a competitive advantage by improving their process efficiencies. These theories range from quantity and statistical focused tools (hard tools) to more quality, and organizational focused tools (soft tools). IT innovation usually fits well within the strategies that enterprises adopt to improve their process efficiencies. Examples of these strategies are Total Quality Management (TQM), Organization Wide Optimization, Lean, and Six Sigma, or a combination which all share the common goal of continuous improvement (Gonzalez, Alonso, & Fernandez, 2011; Kwak & Anbari, 2006; McManus, 1999).

These theories in general evolved from being hard focused to more hybrid forms of hard and soft focused elements. During the early 1940’s the first notions of quality control emerged (Gupta & Valarmathi, 2009). W. Edwards Deming is considered to be one of the founders of the early notions of quality control. He taught Japanese engineers about quality management based on Statistical Quality Control, which was mainly quantity focused. After the rapid growth of the Japanese economy that followed, the quality strategy that Japanese companies adopted, called Total Quality Management (TQM), emerged, as the world started looking for strategies to compete with the Japanese products. The current generation of TQM concepts is based on the quality theory, and approaches suggested by (Demming, 1982), (Feigenbaum, 1983), and (Garvin, 1988). This has led to three central principles in TQM: customer satisfaction, employee involvement, and process improvement (Ling, 2008). TQM is also referred to as the first ‘wave’ of quality management (Basu, 2004).

From the evolution of Total Quality Management, the Six Sigma theory emerged, which represents the second wave. Like TQM, Six Sigma was developed as a purely statistical an quantity focused concept (Hahn, Hill, Hoerl, & Zinkgraf, 1999; Hoerl & Snee, 2002; Montgomery, 2001). Though, in the business world, the Six Sigma concept later developed to the idea that improving the effectiveness and efficiency of all operations was the way to meet or exceed customer’s needs and expectations (Antony & Banuelas, 2001). Anbari (2002) implies that Six Sigma is even more comprehensive than other quality focused theories. He states that: Six Sigma is the sum of TQM, a stronger customer focus, additional data analysis tools, financial results, and project management. These theories all hold enormous potential benefits, which was magnificently proven by the Motorola savings of almost 1.4 billion dollars from 1987 to 1994 by implementing the Six Sigma strategy (Motorola, 2002).

Continuing with the wave-theory on the quality management evolution of Basu (2004) we are currently in the third wave: from Six Sigma to Lean Sigma (combining the Six Sigma precision with the agility of Lean) to Fit Sigma. Basu (2004) considers Fit Sigma as the current ultimate combination of building blocks from Lean Sigma and other operational excellence best practices.
Operational excellence means striving for business excellence and practices of operational excellence form holistic approaches of many forms of quality management. Combining several statements on the concept of Operational Excellence (OE) we define OE as:

‘An integrated effort designed to sustainably improve key performance indicators at every level of the organization, so that results are achieved in less time and with less resources’ (Furterer & Elshennawy, 2005; Grossmann, 2009; Mauch, 2009a; Oakland, 2011; Zakuan, Yusof, Laosirihongthong, & Shaharoun, 2010)

Continuous improvement and step changes are ‘integral ingredients’ in the strategy of Operational Excellence (Basu, 2004). An organization that adopts a continuous improvement strategy must be willing and able to make big changes to the organization, the way of thinking, and the production process.

Now, let us go back to the fact that a lot of quality management strategies make use of IT systems to support a form of continuous improvement, because they hold enormous potential to gather data and provide information on which improvement strategies can be based. Sadly, fifty percent of all implementations of such big IT systems fail (Nutt, 2002). Anbari (2002) suggests that the reason for this failure is the sum of many factors. He explains this with the concept of continuous improvement: challenges are not only found within all elements of a project, but mostly arise from friction between the different elements, if not aligned correctly. To explain this more concretely the concepts of data gathering and information derived from this data should be clear.

In an industrial production plant data is often gathered by gauges throughout the plant. From data information is built by understanding the relations in the data. This is called ‘connecting the parts’. An example of information building is the following: an IT system that counts the number of products that leave the plant minus number of products that enter. The outcome, all the products that are missing, is the waste (or scrap). The percentage of scrap shown in an IT system is information built from data. We can continue our information building by understanding the patterns in the information, which is called ‘a formation of a whole’ or knowledge building. A pattern could be that items only disappear when a certain operator is working. Knowledge is necessary for improvement. Analyzing patterns and improvement reveals principles, which builds up to wisdom in a certain area. Educating the concerned operator could for example lead to less waste. The relation between data, information, knowledge, and wisdom is presented by Figure 3.

[Figure 3 Data, Information, Knowledge, Wisdom (Ackoff, 1989)]

MSc Thesis Rens Valk
One of the most famous and most used IT systems are enterprise resource planning (ERP) systems, that are supplied by companies such as SAP and Oracle. ERP systems provide information about the entire process of an enterprise, from quotation to costumer delivery. But ERP systems lack the specific detail level that is required in industrial production plants for continuous improvement (Albert & Fuchs, 2007). Therefore Management Execution Systems (MES) are introduced; they are able to combine data from the shop floor and data form ERP systems. From the combined data information is built about the processes in an industrial production plant.

The first type of information is used by the operators at the line, who receive real time information about their processes from MES. This enables them to improve straight away. The second type of information is used by managers on a tactical level to gain more insight in the performance of many processes, related to production, quality, utilities, inventory planning, and many more (MESA, 2008). Many enterprises are acquiring IT systems to get more information about their processes. This information should be used by their employees to continuously improve, all aspects of the industrial production plant covered by MES, and best the competition.

1.1 Research Challenge: a holistic Operational Excellence approach for MES implementation in industrial plants

Gathering data in itself is a challenging process within all mentioned continuous improvement strategies (Mauch, 2009b, pp. 45-46). Though literature findings agree on the fact that Information Technology can boost plant performance by the increased and enlarged availability of information and data, potential benefits will not be reached when there is no consensus about how they should be used, which unfortunately happens frequently (Houy, 2005). This results in difficulties during implementation of a MES and, later on, during the life cycle, thereby vaporizing potential benefits.

An organization needs to get three things right in order for a MES to succeed. The first is that the Management Execution System must gather data and analyze this data in order to derive information. This is a challenge in itself; many factors need to be right in order for the system to deliver the right information at the right time to the right person. Secondly a well-defined continuous improvement strategy needs to be in place. The mindset of the employees must be set to removing waste and inefficiency from the process in order to deliver products at a low cost, but with high reliability and quality (Nieuwenhuis, 2010). Thirdly the interface between the Management Execution System and the continuous improvement strategy is of importance. The employees of the plant need the information from the MES as input for continuous improvement, but often they stick to information gathering, not making the final step to actual improvements as was explained by means of figure 2.

In the academic world a lot of research exists on approaches for quality management. Most of this research focuses on one or a few aspects of TQM – for example the importance of leadership (Chopra & Kanji, 2010; Oakland, 2011), culture (Haffar, 2012), or education (Thandapani & Gopalakrishnan, 2013) – or describes a more holistic approach of Operational Excellence (Furterer & Elshennawy, 2005; Gupta & Valarmathi, 2009; Mauch, 2009b; Miguel & Santiago, 2010). Practically all holistic approaches mention the importance of IT system alignment and quality data to the success of a quality management strategy and all of them try to identify other relevant or critical factors of the OE approach. Yet, every approach seems to be sector or industry specific and even though aiming for generalization, exceptions are always held up as a cover to prevent ‘blind’ adaptation of the approach.

This research is aimed at doing precisely the same: finding a holistic Operational Excellence approach. The contribution lies in the fact that there is no existing literature yet on a holistic Operational Excellence approach for the implementation of Management Execution Systems in industrial plants. A bottom up approach will contribute
to finding critical factors that define successful implementation of this specific IT system in this specific manufacturing sector.

1.2 Problem statement: adequate contribution of MES to energy and water efficiency improvement at Coca-Cola Enterprises in Dongen

The Coca-Cola Company (CCC) is the biggest player in the non-alcoholic beverages industry worldwide, with an operating revenue of 11.1 billion dollars in the first quarter of 2012 alone (Forbes, 2012). Besides that, CCC has the world’s most famous brand name (BusinessWeek, 2011; Interbrand, 2012). The Coca Cola Company does not produce the soft drinks itself; in 1986 Coca-Cola Enterprises (CCE) was established to produce the various soft drinks of CCC. The syrup, which has an unknown recipe, is bought from CCC by CCE. With this syrup CCE produces the end product. CCE is still partly owned by CCC and the two companies work together very closely (The Coca-Cola Enterprises, 2012b). CCE is responsible for the activities, the bottling, marketing, and selling of the CCC products in the area where CCE is active, which is roughly West-Europe.

CCE has recently started implementing a Management Execution System, which was operable from the beginning of 2012 onwards, to help the organization strive for continuous improvement. CCE is now looking for ways to adapt the MES within their continuous improvement strategy, to meet their goals as stated in their Global Operating Framework (Appendix v), and to keep their competitive advantage. They would like their MES to exploit all the theoretical benefits, that Management Execution Systems offer, with respect to continuous improvement. This sentence holds a few definition dependent terms: what is, for example, meant by theoretical benefits? And how should those be measured when found?

The organization of The Coca-Cola Enterprises in Dongen consists of amongst other departments, the environmental department. The environmental department is mainly commissioned with the challenge to improve the energy and water efficiency of their production processes. Their recently implemented MES gathers an enormous quantity of data on that subject. As explained before, this does not necessarily lead to improvements: first information should be ‘built’, then knowledge should be formed on which improvement is possible so that finally wisdom is acquired on the subject. CCE indicated that their MES is not successful contributing to the envisioned improvements. This led to a following problem statement:

How can the MES of CCE adequately contribute to the improvement of the energy and water efficiency in the CCE plant in Dongen, without new investments?

The research on the improvement approach is constrained to the fact that the system is already viral and all the design choices have already been made. Since no new investments will be made, the CCE MES functionalities are set. They might be changed when a business case is made that can show that new functionality will recoup the investment of that functionality. That is why this research, when defining an improvement strategy for the CCE in Dongen, will focus on how to make the current system successful under the constraints posed by the current design.

1.3 Research questions

After the introduction of the research challenge and the presentation of the problem statement, a clear main research question can be formed. From this main research question, sub questions are derived, that function as guidance for the outline of this report. The main research question is the following:
How can the implementation of a Management Execution System contribute to the strategy of the Operational Excellence in the industrial production plant of Coca-Cola Enterprises in Dongen?

To answer the research question five sub questions are defined:

1. **What technical factors are essential for a Management Execution System to be successful in contributing to an Operational Excellence strategy?**

2. **How can an industrial production plant and its Management Execution System be organized in order to successfully add to an Operational Excellence strategy?**

3. **How can the identified success factors be framed in such a way that a well-defined method is developed to support an industrial production plant in successfully implementing a Management Execution System?**

4. **Based on the framework, what changes can Coca-Cola Enterprises make to improve the success of their Management Execution System?**

5. **How can the environmental department of Coca-Cola Enterprises in Dongen use the Management Execution System to reduce the energy and water consumption?**

6. **To what extent can the developed framework be applied to other enterprises?**

How those questions will be answered, will be discussed in the following paragraph.

### 1.4 Research approach

As mentioned before, the environment in which this research is conducted is Coca-Cola Enterprises. Working with the Coca-Cola Enterprise environment, helping the environmental department understand MES, and the interrelations of MES with departments of CCE, is part of the research experience. The overarching research method for this research is therefore Participatory Action Research (PAR), which is a form of Action Research.

In the course of the research, two more specific approaches will be used to answer the sub questions, that were filtered from the main research question: (1) a literature research on MES and OE, and the technical and organizational success factors; and (2) interview studies amongst CCE employees and MES experts, to map the current CCE situation, concerning MES and identification and validation of success factors.

This paragraph elaborates on the principles of the overarching research method of PAR and then presents a more detailed approach for answering each sub question.

#### 1.4.1 Overarching research approach: Participatory Action Research

Action research is an interactive inquiry process, that balances problem solving actions implemented in a collaborative context, with data-driven analysis, or research to understand underlying causes, enabling future predictions about personal and organizational change (Reason & Bradbury, 2001). This definition can be brought down into; (1) extending or augmenting knowledge by (2) working with the surroundings on (3) data-driven information in order to (4) say something useful about future performances related to (5) either personal or...
organizational change. Translating this to our specific subject we are (1) aiming to improve (our knowledge on) the MES contribution to the OE of CCE by (2) working with the environmental department – and possibly other departments – on (3) data and information provided by MES in order to (4) create a framework that supports an industrial production plant in successfully implementing a MES with respect to (5) technical as well as organizational characteristics.

Participatory action research (PAR) is a category of action research that is developed over recent years as a significant methodology for intervention, development, and change within an organization. PAR practitioners make a concerted effort to integrate three basic aspects of their work: participation (life in society), action (engagement with experience and history), and research (soundness in thought and the growth of knowledge) (Chevalier & Buckles, 2013, p. 10). PAR is by definition an iterative learning process.

In hindsight this perfectly fits the way this research was conducted. The Participatory part is the researcher working at CCE in the environmental department. The Research part consisted of a literature research and interviews held at CCE and with an expert. The Action is the way participated of the researcher in the CCE environment influenced his research through experience, trying to reduce the energy and water use based on MES. This is schematically shown in Figure 4.

So, how is PAR further applied to this research? Already in the early seventies, (French & Bell, 1973, p. 18) defined something called Organization Development (OD) as “improvement of an organization through action research”, which then was based on action research as conceptualized by (Lewin, 1958), who believed the motivation for people to change was strongly related to action. Lewin (1958) developed a framework with the process steps of planned change through action research.
During this research the MES of CCE is used to reduce the energy and water consumption of the industrial CCE production plant. When organizational changes are required for this approach, the framework for action research defined by Lewin (1958) will be used.

Lewin (1958) defines a loop that can make behavioural changes to stick. The first step is to unfreeze the organization by showing it how they are working and what might be improved. This is done by diagnostics about what is inefficient in the current situation, based on supportive data. The second step is to let people learn from what is found by the conducted research. In this step the behaviour is changed. The third step is refreezing, in this step the changes in behaviour need to be freezed, thereby preventing people to revert to their old behaviour. This is done by monitoring the behaviour and giving feedback on the changes by gathered data, to make in the improvement insightful. This is a never ending cycle, as now again a new an analysis will be planned.

1.4.2 Research approach for answering separate sub questions

Every sub question demands a certain research approach. Important to realize, is, that for every sub question, input is provided by the chosen approach, and by feedback loops of the general Participatory Action Research approach. Sometimes this happens consciously, but more often it is a subconsciously process, which is always validated by the research approach itself. The overall research approach as such is represented Figure 6.

The first two sub questions are answered by means of a literature research. Experience on the work floor (PAR), and interviews with CCE employees on the current MES experience provide input for a search direction. When both technical and organizational success factors are identified, they are framed in a method to support good implementation of a MES in an industrial plant, resulting in a framework. After the development of the framework, it is validated by means of interviews with, again, CCE employees and by means of an expert opinion validation. After the development and validation of the framework, a case study will be performed: the framework is applied to the Coca-Cola Enterprise and their MES. From this case study recommendations are derived for CCE to improve their MES implementation. It is important that we acknowledge a difference between an improvement approach for the entire CCE organization based on the framework and improvements for the environmental department of CCE Dongen. Finally, all discussed issues provide input for the reflection and discussion necessary to answer the final sub question, see Figure 6.
1.5 Report outline

Based on the research approach as introduced before, the second chapter will introduce the Management Execution Systems (MES) and their relation to OE principles, as found in literature. In this chapter, MES is put in the context of a broader view on improvement strategies. Chapter 3 is an introduction of The Coca-Cola Enterprise as a company, and elaborates on the current experiences CCE has with their MES. This chapter provides a guideline for the conducted literature research in the subsequent chapters, which aims to answer the main research question, and more specifically the sub questions that are derived from it. These two chapters form together with this chapter Part I of the report: ‘Introduction to the challenge: MES and CCE’.

Part 2 will then elaborate on the entire research concerned with answering the main research question which was derived from the research challenge, leading to ‘MES success factors and the framework’. Chapter 4 and 5 respectively focus is on the technical requirements that the essential for a functional usage of MES, and the factors that contribute to a good organization of MES in order to add successfully to OE. The next step is to frame the identified success factors and their relation with each other to filter a well-defined support method for an industrial production plant in their process to successfully implement a MES. Therefore, in chapter 6 a framework is developed and validated, by means of an expert validation on Management Execution Systems. Chapter 7 deducts an integrated approach for the organization of CCE leading to a successful implementation of their MES.

Part 3 constitutes of the ‘Energy and Water efficiency improvement approach’. Here the problem statement is separately tackled: what improvements can the environmental department apply and what realizations are made during the research.

Figure 6 Overall research approach
Finally Part 4 is concerned with discussion on the framework, the reflection on the research and general conclusions and recommendations. The research will be finished by giving some direction to potential future research.

**Figure 7 Report outline**
## 2 Management Execution Systems

In this chapter, Management Execution Systems will be further introduced. The relation between Operational Excellence (OE) and MES will be explained to provide a context on how a MES relates to a business strategy. This is followed by an analysis of which steps need to be taken, when a company is thinking about acquiring a MES.

### 2.1 Introduction in MES

Within industrial production plants, information technology (IT) is becoming more apparent. Machines, supported by IT, have taken over parts of the production process, and managers request more information to improve the processes. One of those IT systems that can provide information about the operations of a plant, is a ‘management execution system’ (MES). ‘A MES is a powerful production management tool supporting production optimization from the process initiation to the final shipment. It not only transmits the production information to production planning systems, like ERP (Enterprise Resource Planning) and SCM (Supply Chain Management) in real-time, but also orders the planned production data to the production site’ (Lee, Nam, & Lee, 2012).

A MES fits in the operational and tactical layer of a production organization. Operationally it has the ability to show real-time information about the plant performance to the operator, who can instantly react based on the information that is presented to him. In Figure 9 an example of this is shown. Here, the layout of a production line can be seen. The block indicates important machines, and information about the machines is presented. Hereby, an operator is able to see if a machine is producing, if its energy and water KPI are met, what the waste (scrap) of this machine is, and so on.

**Figure 8** Representation of a production line in MES
On a tactical level, MES is used to identify processes, that do not perform as they are supposed to, with the goal to improve those processes. This can, for example, be done by requesting standard reports from MES, as is shown in Figure 9. This specific report gives information about the water usage of the CCE plant in Dongen over a selected interval of time. The amount of incoming water can be seen, as well as the loss of the water treatment, the water used for Cleaning In Place (CIP), and so on.

![Figure 9 Standard reports: the water report](image)

It is important to understand the implication of the fact that a MES connects the shop floor with the strategic IT layer of an organization. This in combination with the way most MESs are built basically means that MES can improve the efficiency of an industrial production plant in two ways. Firstly; on the shop floor (operational level of the organization) MES presents real time information about processes that help the employees to improve efficiency. Think about a signal that goes off when the a energy KPI is not met, an operator will be able to solve the problem right away. Secondly, on a tactical level of the organization. The standard reports about the processes give insight to tactical managers, when a machine brakes down often an improvement project can be initiated based on the information from MES. When replacing the machine is cheaper than fixing the problem every time the efficiency of the industrial production plant increases.

![Figure 10 The two ways MES can increase efficiency](image)

Management Execution Systems exist in various forms, depending on the supplier, and the functionality that is demanded by an industrial production plant. Later in this chapter, the functionalities that a MES can have, will be explained. The design and implementation of MES are often not as evolved as the implementation of ‘Enterprise Resource Planning’ (ERP). Most MES are supplied by local organizations, that are responsible for the equipment of the industrial production plant as well. The suppliers have developed MES from the knowledge they acquired in automation, which is good, but often those suppliers lack the knowledge to integrate the MES with other IT systems. In this sense, the market for ERP systems is more mature. Here, it is more common for the supplier, or a third party consultant, to look at the integration aspects of the MES as well (Scholten, 2013).
However, when a MES is successfully implemented, it can be beneficial for an industrial production plant to integrate information into a continuous flow, that can lead to process improvement (Grossmann, 2009). Also employees can become more involved in the production process. MES enables operators to have more detailed information on the performance of ‘their’ machine, which can be a trigger for action. Managers can use MES at a tactical level to get more insight in the bottlenecks of production process, which can lead to a more accurate improvement.

These benefits cannot be realized by only implementing a MES, as, although IT systems have become quite powerful, they do not provide comprehensive decision making capabilities, that account for complex trade-offs and interactions across the various functions, subsystems and levels of decision making (Grossmann, 2009). Therefore MES must be placed within broader philosophy of the entire plant, because to make MES a success people are needed to actually make the improvements and remove the waste from the process.

A MES can fit within several enterprise wide philosophies, that all have a focus on continuous improvement in common. One of those philosophies is Operational Excellence (OE). OE is adopted by many companies as overarching business strategy. As this research focusses on how the benefits of a MES can be realized, it must be placed in context with the overarching philosophy of a plant. Because OE is used in many enterprises, and this research has the possibility to do a case study in an industrial production with OE as strategy, it will focus on how MES can contribute to enterprises that strive for OE.

Therefore, the relation between OE and MES will be discussed more elaborated below, after an explanation of the general goals of MES.

When an enterprise decides to implement a MES, it has many goals it wants to achieve with a MES. From research at Coca-Cola Enterprises we found multiple goals. Some were related to the corporate responsibility goals of the organization, like water and energy reduction. Other goals were positioned in the field of quality. But CCE also hopes to reduce IT redundancy, by documenting all information in one place. This reduces the time spend on documenting information and finding it later on. This goal is also found in the literature, as many CIO’s expect MES to replace the various excel sheets that are often built and maintained by departments themselves (Scholten, 2009). Also the production departments of production plants expect MES to improve throughput, reduce the use of raw materials, and so on. All those goals are captured in the functionalities as defined by the (MESA, 2008). These goals can also be found in the ISA-95 standard, made by the ISA.

As illustrated in the introduction not only the functionalities and technical features of the system determine its success. Success depends on many factors, which always have an organizational side as well. Employees will have to use the information that the system presents to them, in order to improve. This is why it is important to place the MES in a broader philosophy. This strategy strives to improve three major things: customer satisfaction, employee involvement, and process improvement. MES can contribute to those goals, when it is implemented successfully.

Nearly always, MES is implemented to continuously improve an organization, thereby realizing cost reduction in industrial production plants. MES does this in two ways. Firstly, MES presents real time information to operators about the performance of their machines. When MES is implemented all relevant machines and processes will get a target or KPI. In case the machines do not reach the targets or KPI, the operator can act on this information by adjusting the settings of the machine, or informing a manager on how to get the machine back within the target line. Because this is done in real time, defects that cause waste, can be removed immediately. Secondly, managers can use the information from MES at a tactical level for all kinds of analysis, which provides them with knowledge on which machines or processes cause waste. This identification is the basis for future improvement projects. The
real time and longer term improvement possibilities that MES enables, will lead to production improvements and waste reduction, and thus to cost reduction.

Besides the fact that MES enables continuous improvement, it also enables enterprises to compare processes and machines between different plants. This way, an enterprise can analyze which plants perform well in which areas. This information can be used to increase the mutual learning between production plants of an enterprise, thereby enabling further cost reduction (Schmidt, Otto, & Kussmaul, 2009).

Finally, MES can reduce IT redundancy (Schmidt et al., 2009; Scholten, 2007b). Industrial production plants often have many procedures, that need to be followed and documented to guarantee quality, and to get insight in the performance of the plant. In some cases, where MES is not is not implemented, the different procedures have to be documented in different systems in different places. This can be labor intensive, and it is vulnerable to the loss of data. Besides, it can be hard for managers to find the data for analysis, when these data are spread among different systems and programs. MES improves this, by providing one location for all data, making these data online accessible and reshaping some of the data into useful information for improvements.

2.2 The relation of MES with Operational Excellence

In this paragraph the relation between MES and OE will be explained. OE is defined as follows; ‘An integrated effort designed to sustainably improve key performance indicators at every level of the organization, so that results are achieved in less time and with less resources’ (Furterer & Elshennawy, 2005; Grossmann, 2009; Mauch, 2009a; Oakland, 2011; Zakuan et al., 2010)

Operational Excellence is considered one of the upcoming strategies, with lean operation, supply chain management, and technology management, to remain competitive as an enterprise. Indirectly, a successful, MES can contribute to the central principles of OE (Zakuan et al., 2010). The three central principles of OC are customer satisfaction, employee involvement, and process improvement. Now will be discussed how MES can contribute to these central principles.

2.2.1 Customer satisfaction

OE considers the idea that ‘quality’ is determined based on the needs and expectations of the customer (Berry, 1991). Whenever a customer is not satisfied, this means that insufficient quality was delivered. This leads to extra work for an enterprise, because it needs to restore the faith of the consumer by sending a new product, or fixing the product, to prevent the loss of a consumer. All those extra costs, that would not have expended if quality was perfect, are called the ‘cost of quality’ (Yasin, 1999). The determination of the cost of quality is very difficult, as it depends on the behavior of the consumer, which can vary per consumer (Mauch, 2009a). Fortunately, OE presents tools that can help determining this cost, by identifying which processes cause losses and which are profitable. To identify the cost of quality in an industrial production plant, five key principles need to be taken into account: specify value, identify value streams, make value flow without disruption, allow customers to pull value, and pursue perfection. The ultimate goal of executing these principles is to eliminate the seven deadly wastes: overproduction, waiting, transportation, extra processing, inventory, motion, and defects (Unver, 2012).

MES can produce information about the production process, that is needed to execute the principles mentioned above. For example, MES can produce information about the quality of a product. When the quality is not of a sufficient level, the production process will produce a lot scrap. Scrap is a product that is produced but does not meet the quality requirements and therefore has to be destroyed or reworked. MES will notice this and give feedback to an operator who can then change certain parameters of the production process in order to reduce the scrap.
2.2.2 **Employee involvement**

Employee involvement is the second important factor in OE. The idea is that a philosophy needs to be adapted by the entire organization of an industrial plant, from operational manager to the operators. When the philosophy is not carried out throughout the organization, OE will not lead to improved business results (Oakland, 2011). MES can help motivating the tactical and operational layer of an industrial production plant, assumed that MES is implemented successfully. Due to the fact that this principle is driven almost solely organizational, it will be further discussed in the next chapter.

2.2.3 **Process improvement**

The third central principle defined is process improvement. ‘Process improvement can be realized with handful of powerful statistical tools in order to reduce variation, measuring defects, and improving the quality through continuous process improvement’ (Gonzalez et al., 2011). The statistical tools Gonzales (2011) refers to, need input, which can be gathered by various measuring systems. However, the data needs to be reliable for the statistical analyses to be valuable. When a MES is successfully implemented, managers are able to extract the data for these analyses from the system.

In the next paragraph, it will be discussed how MES can successfully fit in the IT structure of an industrial production plant.

2.3 **The road to MES implementation**

As is explained in the introduction, this research focuses on making MES a success once implemented. This must be seen in the context of the entire life cycle of the system. Therefore, this paragraph discusses the applicability of MES, and an example of an investment decision will be given. Later in this report, the context of MES will be used to show how the framework developed by this research, relates to the life cycle of a MES.

2.3.1 **MES application area**

In the previous paragraphs, Management Execution Systems were further introduced by discussing their goals and explaining their position within organizations. This raises the question whether a MES can be successful in every enterprise.

When the goals that a MES has, are used to determine the applicability of a MES in an organization, it is clear that the enterprise has to produce something, since the goals of MES all try improve a production process (Osorio, 2012).

In general, it is assumed that three main types of manufacturing can be defined: continuous, discreet and batch-wise manufacturing. All three types can benefit from MES (Scholten, 2013), although in recent decades, it was not always clear how MES could be adapted to fit with those different manufacturing processes. Therefore, the International Society of Automation (ISA) developed a guideline for MES. Later on in this report, this guideline will be discussed more elaborately. Based on the functionalities of MES, as described in the guideline, and goals of MES, it can be concluded that basically all manufacturing organizations, service related or goods related, can benefit from MES (Scholten, 2007a).

Therefore, we conclude, that when considering acquiring a MES, first a condition has to be satisfied: the enterprise should have a manufacturing process. When this condition is not present, the implementation of a MES will not be useful.

2.3.2 **MES implementation decision & design**

The next step that should be taken, is the investment decision. When the previously mentioned condition is fulfilled, an enterprise has to decide whether a MES will increase the value of company. This investment decision in
itself is a very complex topic. Because it is mostly outside the scope of this research, the complexity of this decision will be only be sketched.

To illustrate how such a decision is made, the study by Schmidt (2009) will be taken as an example. This investment decision is based on a MES implementation in the automotive industry in Germany.

The approach of Schmidt is based on getting all the potential benefits of the MES clear in various steps, shown in the figure above. Those benefits are monetized through the Key Performance Indicators (KPI’s). Those steps are taken in collaboration with the MES supplier and the buying parties to prevent the benefits from being over or under estimated.

In the first step the process of the location, where the MES might be implemented, is roughly defined. Then, the general benefits of MES are applied to business. This information is used to make a questionnaire that will be held under various employees to estimate the benefits.

In the second step, the data that are gathered with the questionnaire, are assessed with the buyer and supplier of the system, thereby establishing the potential savings of the system.

This information is taken to the next step, where the potential savings are translated to the KPI’s, to see what they can save there. Thereafter, the saving on the KPI’s is transferred to a monetary unit that can help executing the business case.

This will be done in last step, where the results will be presented. The costs of the system will weight with the monetary benefits. When the business case is concludes that MES is a profitable investment, the buyer can decide to start implementing the system. Schmidt (2009) advises, to take the best practices of the supplier into account, to improve the system.

When the decision is made to implement a MES, it is clear which functionalities need to be built into the system, to realize the defined savings. When a MES realizes the defined changes we call it successful. The technical design of IT system itself is quite complicated, and needs to be done properly to let MES function successfully. Challenges with the technical implementation lay in the integration of MES with the meters and the other IT systems, that might be required to let MES function. This will be discussed in the chapter ‘Management Execution System form a Technical perspective’.

The investment decision and design phase require various disciplines such as, project management, process management, economics, and engineering, to make MES successful later on in the life cycle. Since this research is not able to take the entire MES life cycle into account, it needs to be scoped. In the introduction, it was explained why its focus is on technical and organizational success factors. From this perspective, it is clear that an investigation of the entire life cycle of a MES does not fall within the scope of this research. Therefore, the life cycle is divided in four basic steps, (1) defining whether a MES is suited for the type of organization, (2) making design choices and making the investment decision, then (3) implementing the design, after which (4) continuous improvement can be applied and monitored.

Figure 11 Life cycle for MES with research application area
CCE has already made all the design choices and the investment decision, and is momentarily coping with the final steps of implementing its MES. In this research, the choices CCE made with respect to the first two steps in a MES lifecycle, will be mentioned in chapter 3, but the goal of this research is to help CCE with the actual implementation of the MES, as it has been designed. From this, recommendations for the fourth phase will follow. Therefore, this research is restricted to a well-integrated MES design in the CCE plant in Dongen. From this assignment, it is clear that there is initially no extra investment required.

In the previous paragraph, it is explained why the relation of MES with OE is researched. Three aspects of the MES systems are relevant to the implementation of MES: the data acquisition and the analysis of the system itself, and the alignment of the MES with the continuous improvement strategy of the company, which fits OE principles.

Finally, an application area within the company structure is chosen. The MES of CCE has various so-called modules that are active within different ‘pillars’ of the company. This research is conducted for the Environmental department. This means, that the research will focus on all features of MES that are relevant for the Environment department. How MES and the Environment department are aligned is further elaborated upon in chapter 3.

2.4 Conclusion

In this chapter MES is further introduced, and the goals of MES and the relation it has with other systems is explained. Thereafter the relation of MES with Operational Excellence is explained. It is shown, that MES can contribute to all three core principles of OC: customer satisfaction, employee involvement, and process improvement.

In this chapter is also shown that not all organizations benefit from a MES. This fact led to a condition that needs to be satisfied to make the implementation of a MES successful. We conclude, that when considering acquiring a MES, first a condition has to be satisfied: the enterprise should have a manufacturing process. When this condition is not present, the implementation of a MES will not be useful.

Then, it is mentioned, that before making a MES successful after the implementation, there are very complex business cases and design processes that need to be executed. An example on how this can be done, is given based on existing research. Thereafter was concluded that the different phases of implementing such a system cannot be seen completely separately, choices made in the design phase, will influence the functionality of the system. Therefore, sometimes the framework will have external conditions it has to accept, or will have a small overlap with other steps. Those steps will be further explained in chapter 3. This research did not dig into this part of the life cycle, because Coca-Cola Enterprises has already implemented the system. From the implementation phase to the end of the life cycle, many challenges need to be overcome to make MES successful. Before this research will investigate which factors are important to make MES successful, Coca-Cola Enterprises will be introduced, because this is where the action research is held.
3 The Management Execution System of Coca-Cola Enterprises

In this chapter The Coca-Cola Enterprises (CCE) will be introduced, for whom this research is held. The focus will be on their MES since that is what this research is about, but this can only be done first introducing the company by giving a short history and then explaining about the manufacturing process. Then the MES of CCE will be introduced, here the focus will be on the part of MES that the environmental department uses. Finally the current situation with the MES will be described according to the interviews that were held and the experiences of the researcher.

3.1 General overview of the plant Dongen

The production plant of CCE in Dongen makes various soft drinks, such as Fanta, Coca Cola, Coca Cola light, Coca Cola zero, and so on. In total CCE produces approximately thirty-five different soft drinks, which are delivered in different bottle sizes and bottle materials. The total output of the plant on a yearly basis, is approximately 850,000 m³ of product (Coca-Cola Enterprises, 2012a).

Four raw materials enter the factory: syrup, CO₂, sugar and water. First, in the upstream department, the water, that comes partly from the wells and partly from the water network is being treated. The syrup, sugar and CO₂ are being stored. Also cans, glass bottles and plastic preforms enter the factory.

The soft drinks are produced at seven different lines. Line 3, 4, 5, 6 and 8 are the biggest productions lines. Line 3 is the only line that produces glass bottles of the various soft drinks. This process is special, because on this line the recycled bottles and crates are being cleaned, which is very energy and water intensive. At line 4, 5 and 6 the plastic preforms are being blown into bottles and then filled and packaged. Line 8 produces cans: empty cans enter the process and leave the line filled and packaged. The other lines are being used to repack orders and fill boxes with pure syrup, which is being sold to big coke retailers.

All the products that leave the lines, are being stored in the warehouse, which is partly automated and partly operated.

CCE in Dongen striving for Operational Excellence (Coca-Cola Enterprises, 2011), which is makes sense when the tree overall manufacturing strategies are taken; product leadership; customer intimacy; and operational excellence (Nieuwenhuis, 2010).

Product leadership is a strategy used, for example by apple, that focusses on technological innovation and a superior brand name. The Coca Company who owns the brands that are bottle at by CCE might have product leadership as strategy as well.

Customer intimacy is a strategy used, for example by Lexus, that focusses on high customer satisfaction and a lot of support.

Operational excellence is use by CCE and is explained earlier in this research. Basically it focuses on low cost, and reliability of delivery by continuously improvement.
3.1.1 Departments

Within CCE, there are multiple departments. In this paragraph, the departments will be discussed, because different departments are responsible for the different processes within the plant. The departments within CCE might have different goals and it is therefore important to know which process ‘belongs’ to which department. Besides, when the selected processes will be analyzed this will be done in collaboration with the responsible departments. The department can therefore be seen as actors within the plant.

Not all the departments within CCE in Dongen are responsible for energy or water consuming processes, think about administrative departments. Four departments have a significant influence on the energy and water consumption of the factory. These are: upstream, production, utilities and logistics. In Figure 12 a concise overview of the production process is given. Within the process the departments are shown, beneath the figure they are explained further.

![Concise overview production process CCE plant Dongen](image-url)
3.1.2 Upstream

The upstream department is responsible for the preparation of all the raw products that enter the factory. There are three main processes that are their responsibility, water treatment, syrup preparation and the central warehouse (Tilburg, 2012). Below those processes will be explained.

Water treatment

The water that is used in the factory has 2 different origins. Firstly well water is extracted, this is done by four wells that are spread out over the terrain of plant, and one well is placed on the ground of another company nearby. Secondly the water is extracted from the freshwater network of the municipality Dongen. When the water is enters the company from one of the wells or the freshwater network the quality is not sufficient to make a soft drink. Therefore the water is treated to get the desired quality. How this process exactly works will be elaborated on later in this report.

Syrup preparation

There are quite some products produced in Dongen and the preparation of the syrup is different for every product, therefore this is an intensive process. The exact ingredients of the syrup are a well-kept secret of the Coca Cola Company. Therefore syrup is bought from CCC. The syrup enters the syrup room where it is prepared to go to production. Incase this research will conclude that this process is relevant from an energy and water waste point of view, further elaboration will take place.

Central warehouse

In the central warehouse all the goods that are needed to produce the soft drinks are stored. These are almost all incoming products except for equipment and other occasional deliveries.

3.1.3 Production

The production department is responsible for the processes that are directly linked to the production lines. This are all processes that happen on lines, from the empty bottles trough the filler into the packs and finally onto the pallets. Production also arranges the CIP’s (cleaning in place). A CIP cleans the filler and the pipes from the syrup room to the filler and is needed when a different product will be produced on a line. As can be imagined the pipes have to be cleaned when a production line changes from one product to another, from Fanta to Coke light for example. The production department is also responsible for the bottle blowing process. In this process the tubes that enter the factory are blown to the desired size bottle. The bottle will then be transported by air conveyor to the filler. This is only the case for the plastic bottles. The glass bottles are partly new and partly recycled, but they are all washed on the line to ensure that they are clean when they are filled with product. The cans are delivered by an external company, they are checked on quality on the line before they are filled.

3.1.4 Logistics

The logistics department is responsible for the all the processes an entity passes from the end of the production line until it leaves the plant by truck (Kroes, 2012). A part of the factory’s warehouse is automated; the pallets with soft drink are placed on a conveyer by a fork-lift truck. The automated system stores the pallets and delivers the pallets to the truck docking station when the pallets leave the plant. In the other part of the warehouse the fork-lift trucks bring the pallet from the end of the production line to a destination in the warehouse. When a pallet is needed at the truck docking station a fork-lift truck delivers the pallet from the warehouse. The fork-lift truck fleet is partly electric and partly diesel fueled. The automated warehouse also uses electricity. The heating of the halls were the warehouses are placed is facilitated by utilities as well as the lighting in this part of the plant.
3.1.5 Utilities
The Utility department is responsible for all processes that are not primarily used for production but support or facilitate production, upstream and logistics (Suylekom, 2012). The utility department has many processes that use a significant amount of energy and water, for example; the steam boilers that provide steam for many processes in the plant, the low pressure compressors and lighting of the plant.

3.2 MES for the environmental department
In this paragraph the MES of CCE will be described. The MES will be explained by first elaborating on the goals CCE has with the system, in particular the environmental department. Next, the experience the company has with their MES is discussed.

3.2.1 Three main modules of the MES of CCE
Before the goals the environmental department has with MES are presented, it is useful to give a little more information on the structure of the MES of CCE, which consists of three main modules.

The first module is the quality module. In this model, all information about the quality of the products made in Dongen can be found. This part of the system is very extensive, mainly because The Coca Cola Company demands high standards in documentation and quality from CCE. Information about the average filler height, sugar or aspartame levels of every single batch of product made in Dongen is stored.

The second module is the production module, which focusses on the production efficiency of the plant. The yield of the products is calculated in this module, in throughput times, change overtimes, and so on. To illustrate this a short example is given; for every in Dongen possible changeover, the time is known. The changeover time can differ a lot, because changing a line from 0.5 liters 6 six packs Fanta to 0.5 liters 6 six pack of Coke is easier than changing to 2 liters 4 pack Kingly Bitter Lemon. First of all, there can be a difference in the cleaning of the pipes between changeovers. Secondly, the settings of all the machines on the line can be changed for different bottle sizes and the way the bottles are packed. The production manager keeps track of the changeover times and therefore he has insight in which teams perform better during changeover and which changeovers are harder and therefore take longer than expected, which might lead to a different planning.

The third module is the CRS (corporate responsibility and sustainability) module. This module is used by the environmental department of CCE. In this model, a lot of information about the energy and water usage of the plant can be found. Processes such as the water treatment, bottle washer, heating of the plant, and so on can be found in this module. The water treatment for example, is where the well and fresh water are processed to a high quality, so they can be used in the soft drinks. The losses of water in this process can be monitored. This module is the most valuable for this research because the research is executed for the environmental department of CCE how is responsible for the energy and water efficiency of the plant. Therefore the focus will be mainly on this module.

3.2.2 Goals of CCE with MES regarding environment
CCE has many goals they want to achieve with their recently implemented MES. They are comparable with the goals that were found in the literature in chapter 2. For this report the focus will be on the corporate responsibility and sustainability goals of MES. This angle is chosen because this report is written for the environmental department.

The most important goal environment aims to achieve with MES is to reduce the water and energy use of the plant further. Two KPI’s exist to target and monitor the energy and water use of the plant, energy is expressed in kWh/1000 liters of product that is produced. Water usage is expressed in the amount of water that is being used to
produce one liter of product [l/l]. Before the MES of CCE was introduced these KPI’s were monitored on a weekly basis, on a yearly basis the performance of the plant, in the field of energy and water, was asset.

CCE is striving for OE by continuously improving all KPI’s. Before MES was implemented the insight needed for continuous improvement was based on various measuring systems that delivered the data that was used to analyze the plant to try and find improvement areas.

The improvement areas lead to improvement projects that are being executed by changing teams that are built from different layers and expertise throughout the plant.

Now MES is implemented CCE wants it to replace the existing measuring systems to reduce IT redundancy. Besides that CCE want to use MES to;

1. Detect defects in real time in order for them to be removed immediately, reducing the waste of energy and water
2. Identify reoccurring defects, improvement teams will be initiated to find a long term solutions and remove the reoccurring wastes
3. Identify improvement areas; improvement teams will be initiated to restructure the improvement areas to reduce the energy and water use of the plant

At the moment this report is written the MES of CCE is still in the implementation phase. To get a better understanding of the system and investigate the current situation interviews are conducted, supported by own experiences this will present the experience CCE currently has with MES.

3.3 MES experience at CCE
reaching all goals, we will search for technical and organizational factors in the literature that need to be satisfied in order for MES to be work and in order for it to contribute to OE.

3.4 Conclusion

In this chapter the MES of CCE is introduced. To do this in the first paragraph the company was introduced, thereafter the production process was shown, and a short elaboration on the MES implementation was given to provide some context of the MES. Then we zoomed in on the goals the environmental department has with MES;

1. Detect defects in real time in order for them to be removed immediately, reducing the waste of energy and water
2. Identify reoccurring defects, improvement teams will be initiated to find a long term solutions and remove the reoccurring wastes
3. Identify improvement areas; improvement teams will be initiated to restructure the improvement areas to reduce the energy and water use of the plant

This is all done to positively affect the two main KPI’s of environment, the energy ratio and water ratio, they are defined by the amount of kilo watt hours that are used to make a thousand liter of product and the amount of water that is needed to make one liter of product.

At the moment those goals are not reached in the way the environmental department would have hoped. Therefore in the next two chapters a literature research will take place.

This literature research will identify success factors that are need to be in place for MES to be successful in reaching its goals. First the technical success factors will be discussed in chapter four, then the organizational ones will be discussed in the fifth chapter. Those success factors will be placed in a framework that will be used to let CCE in reaching their MES goals.
Part II

MES success factors and the framework

In this part the framework for a successful contribution of Management Execution Systems to operational excellence will be presented. An successful MES is a condition for the reduction of energy and water in the plant in Dongen. Based on the framework recommendations to CCE will be done on how their MES can be improved.

4. Management Execution Systems from an Technical perspective
5. Management Execution Systems from an Organizational perspective
6. Framework for a successful Management Execution System
7. The framework applied to Coca-Cola Enterprises
4 Management Execution Systems from a technical perspective

In this chapter the technical perspective of the literature research will be presented. Based on the experience CCE has with their MES and factors that are discussed in chapter two that are important a desk research will be conducted into success factors, which have a technical character, for MES in order to contribute to TQM. We also investigated the guidelines of the International Society of Automation (ISA), who are about the implementation and integration of IT systems in manufacturing environments. This will be done by answering the following sub question;

What technical factors are essential for a ‘Management Execution System’ to be successful in contributing to ‘Total Quality Management’?

To be able to do this we investigate the IT integration of MES with the IT environment of an industrial production plant in the first paragraph. In the second paragraph the functionalities a MES should have to be successful will be discussed, in the third chapter the capabilities and relationship an enterprise should have with their MES supplier will be discussed. In the conclusion the sub question will be answered.

4.1 MES integration in a plants ‘Information Technology’ environment

In this paragraph will be explained how MES relates to other IT systems within industrial production plants. The goal of this paragraph is to investigate if the IT integration is success factor for a successful implementation of MES and if so, how this can be realized.

MES implementations are much like ERP implementations, they both operate in the field of production and information technology (IT) the issue of integration between the infrastructures used by production and IT is therefore, unavoidable (Greenfield, 2012). Beside that the benefits are greater because other IT systems can use the information produced by MES, which makes their information more valuable. For example, the financial department that uses their own accounting IT system has access to related information in MES such as, resources used per product, throughput times, etc. (Siemens, 2012). This information can help them determine which products are profitable and where the production need to allocated to.

On the other hand can the MES benefit as well, for example operators that do not have to insert order information because this is already available in other IT systems (Scholten, 2013).

But this also increases the complexity of the whole IT structure of the industrial production plant. Not all IT systems speak the same ‘language’ which creates the need for transducers that allow the IT systems to communicate, this requires skill of supplier and creates complexity (Karapetrovic & Jonker, 2003; Scholten, 2007b; Unver, 2012). Therefore it is important to have a competent MES supplier or consultant that is able to integrate MES with the rest of IT systems, the role of the supplier and relationship with the supplier will be explained in more detail in chapter 4.3.

In an ideal situation all IT systems are connected, share information forming a closed loop where all information is consistent and supported by other systems if needed. The International Society of Automation (ISA) noticed the increased complexity when the ERP and automation system are connected using MES. Therefore they decided in the 1990s to develop the ISA-95 standard for integrating enterprise and control systems in order to reduce the risks, costs, and errors that go hand in hand with implementing manufacturing control system and
integrating them with ERP systems (Scholten, 2007b). This guideline is used in this research for the IT integration of MES and the functionalities in the next paragraph; therefore we will first elaborate on the ISA-95 guideline.

### 4.1.1 ISA-95 guideline

The ISA-95 guideline is a very extensive and detailed document with over a thousand pages, although it is very useful it is also very complex. This has led to various interpretations and simplifications made by academic studies and IT consultants. We will also give a more conceptual view on the guideline in this paragraph, this also how the guideline will be used in this research. Basically the guideline presents a terminology and conceptual models on how to implement and integrate automation systems, MES and ERP systems, throughout a manufacturing enterprise. The definitions and models assist in organizing application requirements in an application framework. The models and definitions are based on best practice methods and technical applications.

The guideline can be divided in five parts, for this research the first part, about models and terminology is relevant and will therefore be explained. The other parts are about more detailed on actual program code and therefore more relevant in the design phase which is outside the scope of this project.

In Figure 13 the context of the guideline is shown. In the figure ISA-S88 guideline is mentioned, this guideline is for the level under MES and focuses on batch-wise production processes.

![Functional hierarchy model](image)

**Figure 13** Functional hierarchy model (ANSI/ISA, 2000; Scholten, 2007a)

The first part of the guideline focuses on standard terminology and object models, describing the relevant functions in the business and the control domain, which in Figure 13 is shown as level 4 and respectively level 3. The functions described in level 4 will be used in the next paragraph functionalities. This part will also be used in the next chapter where governance and metrics as success factor will be discussed, because it can answer questions as, which information must be exchanged from where to where? And which tasks are executed by which function?

The models presented in the ISA-95 guideline can be seen from a functional view point, which will be done in the next paragraph, but also from an organization and systems view. In the next part of this paragraph will use this view to explain how successful IT integration can be realized.
4.1.2 IT systems integration

As discussed earlier in this chapter, (Greenfield, 2012) concluded that IT integration is unavoidable and therefore it needs to be done adequately for MES to be successful. In Figure 14 is shown how ERP, MES and shop floor are connected.

![Figure 14 MES as connector between ERP and shop floor (Albert & Fuchs, 2007)](image)

In the second chapter MES explained extensively, before we continue we also shortly introduce ERP system and production/automation systems.

4.1.3 ERP (Enterprise Resource Planning)

Enterprise resource planning (ERP) is an often used IT system that can coordinate with the different functions of enterprises and improves the information flow. This system exists in many shapes; some ERP systems are developed by enterprises in house. But most enterprises use one of the big two suppliers of ERP systems, ORACLE or SAP.

ERP systems cover a very wide part of a organize by integrating information from; finance, accounting, human resources, operations, supply chains, and customers (Wang, Shih, Jiang, & Klein, 2008). Therefore ERP systems have become very complex and can become very costly, a modest budget for ERP implementation in a small company can range from 2 million USD to 4 million USD. But a full-blown implementation in a large organization can easily exceed 100 million USD (Markus, Tannis, & Van Fenems, 2000).

But ERP systems do not have specific information about single equipment, that MES has. Therefore it is useful to combine the systems, for example the material management system (MMS) that is often part of MES can be
integrated with the sales and distribution model (SDM) that can often be found in ERP systems. Combining the two systems can make MES more effective (Kuo, Chen, & Lin, 2012).

4.1.4 Production and automations systems
The shop floor is the place where the products are produced. The hardware that is needed to gather the data for the ERP systems and MES is gathered by the counters that are installed on various places throughout the production process; the counters gather information for the production and automation systems. An SCADA system is an example of a production system. Operators also enter data in those systems on shop floor level. Recent developments have made it possible that this information can also be acquired automatically, but this not a mainstream possibility within MES (Lee et al., 2012).

4.1.5 Relation between systems
As can be seen MES is directly connect to production and automation systems, and an Enterprise Resource Planning (ERP) system. The connection between automation/production systems and the MES is a people to software one. The operators on the shop floor enter data into the MES directly; the MES will use this data in combination with the data from the other IT system to create information. To illustrate what kind of data an operator enters an example is used; when a product change is executed in an industrial production plant, the operator needs to communicate this to the MES in order for the system to know at what time the changeover started, ended and what the new product is that is being created.

These connections show the interdependence of the IT systems, the results in the fact that when one of the systems fail all might fail. Since MES is on those systems it is essential that the systems are integrated adequately for MES to be successful. Often the IT integration is handled by the MES supplier or a third party between the supplier and the industrial production plant. Their competency with integrating the systems is also essential therefore we will elaborate more on that in paragraph 4.3.

4.2 MES required functionalities
In this paragraph the functionalities of MES are discussed, for MES to be successful in contributing to TQM it must have the right functionalities depending on the goals that an enterprise has with MES. To describe the functionalities of a MES the ISA guidelines are used. They are explained in the previous paragraph. To measure the functionalities of a MES the functional Enterprise Control Model can be used, this model is shown in Figure 15.
In the model ten main functionalities are described and the relation that functionalities have with each other are shown as well.

Centralized in the model the production control functionality can be found, these functionalities main functions are process support engineering, operations control, and short-time operations scheduling. This function is mainly used by the production unit of an enterprise.

Around production control, quality assurance, maintenance management, material and energy control, product scheduling and product cost accounting are positioned. As can be seen in the model they are linked to each other. These links exist out of information that is transferred between the functions.

When a MES designed it is important that the desired functionalities are determined carefully, it is advised to do this using the model from the ISA guideline. Using this model might show what functions an enterprise desires, but in every single enterprise and plant is different, therefore the process must mapped using SADT and UML to determine where counters should be placed and what connections with other systems should be made to deliver the desired functionality. This part is also described in the first part of the ISA guideline 95.

Ideally all the functionalities are already determined when deciding to acquire a MES or not. Also the way in which the functionalities will be brought to system will have to be determined before the MES is implemented. However desired functionalities or the process might change, in this case the functionalities might have to be adapted. Also when the system is operational the desire might areas for more functionalities than initially were required. The ISA guideline can then also be used investigate how to implement the extra functionalities.

Because this research focuses on already implemented MES we will not elaborate further on the functionalities a MES can have and how that can be realized, but we will take this factor into account in the framework to investigate if the all required functionalities are met of the implemented system and to investigate if essential functionalities are present that are needed to make MES successful.
In the next paragraph another aspect that came forward from the paragraph IT integration will be discussed: The supplier relationship and capability.

### 4.3 MES supplier capability and relationship

In the previous paragraphs is explained why the functionalities of MES and a successful integration in the IT environment are crucial to realize the benefits of MES. When looking at the technical aspect of MES, there is a third factor that is crucial for a successful implementation in an industrial plant. Wang (2008) defined a couple of success factors for the implementation of ERP systems. One of his success factors, regarding the system supplier, is also applicable to the implementation of MES. He defined it as the capability of the supplier and/or the consultant; and the support the vendor of the system provides after the systems is implemented (Wang et al., 2008).

During the research at CCE the importance of the capabilities and the relationship with the supplier is quite often noticed. As the research progressed, a few of the standard reports that MES produces needed to be changed. In the standard reports, information about certain processes are put together. An example is the ‘water report’, which shows all relevant water processes of the plant on one page, enabling CCE to get a quick overview of the plant performance in the area of water.

Without going into too much detail, technically the supplier is not able to change the KPI’s that are shown in the report, because some calculations are already made in the PLC (a data acquiring server) and not in MES. This decreases the flexibility of the MES, which had as result that a desired KPI could not be added to the ‘water report’.

Next to this, the supplier is physically located in Italy, which causes a geographical and cultural gap, making it more difficult to communicate about requirements of and desires for the system.

Wang, 2008 refers to these factors in his paper. He finds that it is very important that the party who supplies the MES, can properly execute such a project. Because is mentioned before half of all big project decisions as implementing a MES are not successful (Nutt, 2002). This is partly caused by the fact that the supplier is unable to deliver the correct methodology to implement an IT system. This happens more often with MES than ERP systems, due to the fact that ERP systems are often supplied by very experienced companies, while MES is often supplied by local and less experienced companies (Scholten, 2013).

Therefore, an enterprise should be very careful in selecting a supplier to implement the system. The expertise of a supplier can be investigated by letting it provide evidence of the value of the methodology, by investigating whether the supplier has a complete understanding of the methodology, and if the supplier is able to transmit knowledge about the methodology that will affect roles and responsibilities for personnel that is involved (Wang et al., 2008).

The second aspect of the supplier success factor is based on the relationship an enterprise maintains with the supplier after the implementation phase. This aspect is researched by (Thong, Yap, & Raman, 1994). He concluded that the desired information supplied by IT systems changes over time. This happens because the production process might change; because products that are produced on a site will change. Next to this, the organization will develop more knowledge about their plant when using a MES. Therefore, they might develop the need for information that the systems delivers. The vendor must be able to realize those changes. The flexibility a supplier will show in changing the a system and costs that come with it are influenced by the relationship that an enterprise has with its supplier (Theodorakioglou, 2006). A good relationship will give the enterprise a better negotiation position when changes to initial requirements are desired, as over time the desires will change. A good relationship with the supplier can be built by executing good project and process management. This starts from the pre-study where miscommunication might cause problems; in this phase close interaction is required to prevent
problems. Because MES has different functionalities that can be acquired (see paragraph 2) it would be wise to have the purchasing discussions simultaneously to the development, when a supplier has been selected (Ronnberg-Sjodin, 2013). In this stage uncertainty is a problem. It is important to get feedback from the end user and the commitment of the end user throughout all stages of the project. Information sharing and educating the end user in an early phase will commit all parties to the system in an early stage which will increase the successfulness. This is project management that is also needed in the acquiring phase of system as a MES. Because this report focuses on making MES a success when it is already implemented, the lesson that will be taken from project management is the importance of a strong relationship with the supplier, to be able to negotiate well and be flexible when future desires might lead to changing requirements. The relationship can be built by exchanging information between buyer and supplier, and involving employees of the buying party in the project team.

Based on the above, it can be concluded that that a sustainable relationship with a capable supplier is essential to let a MES succeed. This can be achieved by excellent project and process management in the early stages of the project, which is outside the scope of this research. This shows that after implementation an enterprise must keep on or start investing in the relationship with the MES supplier to have a good negotiation position, when the requirements change due to changing desires. An enterprise can invest in the relationship by having information exchange between the companies and keeping employees of both organizations in the project team.

4.4 Conclusions: technical success factors

The goal of this chapter is to answer one of the sub questions that is presented in the introduction;

*What technical factors are essential for a ‘Management Execution System’ to be successful in contributing to ‘Total Quality Management’?*

In this chapter we identified three factors that are essential to get right in order for MES to be successful in contributing to TQM. Adequate IT integration, adequate functionality and competent supplier capabilities combined with a good relationship with the supplier.

In the first paragraph the success factor IT integration was identified. MES is often integrated with other IT systems that operate in an industrial production plants to increase the functionalities and decrease IT redundancy. The increased functionalities can result in bigger benefits because a bigger range of waste can be identified and removed. The decreased redundancy increases the benefits because the information is more consistent between the different IT systems within the plant which will prevent confusion and increase the reliability, besides it will be less time consuming for employees to enter and extract the desired information because it is available in one place and only needs to be inserted once.

A pitfall for IT systems integration lays in the increased complexity of the whole infrastructure and of MES itself. To cope with that complexity, a competent MES supplier and relationship with this supplier is needed.

This was experienced during the research, the cultural and geographical distance between CCE and supplier sometimes made it more difficult to communicate the desired improvements to the system. Besides the way the MES is designed by the supplier sometimes results in inflexibility making it impossible to incorporate certain functionalities.

When selecting a supplier the credentials of the supplier and the reputation need to be taken into account. The actual selection of a MES supplier is outside the scope of this report. Therefore the focuses will be
more on the relationship with the chosen supplier. When the investment decision is positive and the MES will be implemented the acquiring company needs to invest in a solid relationship with the supplier. During the implementation this relation is needed to smoothly implement the system, but also on the longer term to keep the system updated to future desires the supplier is needed. A solid relation needs to be built from day one, information sharing and combining employees of the supplier and buyer in the project team both improve this relationship.

Finally is found that the MES needs ‘adequate functionality’ to become successful. A good representation of an industrial production plant is required to let a MES succeed. The ISA guideline gives an excellent grip to investigate if the desired functionality of a MES is met and how that functionally can be reached.

The three factors explained and elaborated on above are marked by this research for a successful MES, but these are only the technical success factors. In the next paragraph the organizational success factors will be identified and explained.
5 Management Execution Systems from an organizational perspective

In the previous chapter the technical success factors are introduced. In the introduction of this report we explain that investigating only the technical aspect is not enough to make MES a success in contributing to TQM. Therefore this chapter will identify the organizational factors that need to be in place for the MES to be successful. This will be done by answering the following sub question:

How can an industrial production plant and its Management Execution System be organized in order for them to successfully add to Total Quality Management?

This question will be answered by execution a desk research based on the experiences and challenges encountered during this research. Besides that books and articles will be studied that are acquired by; a search on Scopus; the Delft University of Technology library; recommended by Z. Lukszo a Delft University of Technology Assistant Professor in the field of Energy, Water and Industry; Bianca Scholten a consultant at Accenture specialized in IT manufacturing; and Harald Warmelink a University of Technology Assistant Professor in the field of Policy, Organization, Law, and Gaming.

In the first paragraph engagement is discussed, this is done first because this is the most important success factor and we will argue why. Thereafter the other success factors from an organizational perspective will be introduced.

5.1 Engagement

During this research we spoke to employees of CCE. Many of them have various opinions about the MES and what is needed to make it better of what needs to change. But we also spoke to employees that do not have an opinion about the system at all or employees that are not even using the system due to various reasons. Those conversations and the interviews led to a factor that we call engagement, which is defined by the Oxford Dictionary as:

The action of engaging or being engaged: Britain’s continued engagement in open trading (Oxford, 2013)

This only party covers what we want to define by engagement. Before we will define engagement in this research a finding of Noble (2000) is given to help illustrate our definition.

The most valuable source of information is formed by the operators of an industrial production plant: they know 100% of the problems. When you move up through your organization this percentage declines until the General Manager, who is only aware of 4% of the problems. Yet, people on the shop floor might not be aware of the possibilities that MES brings, the team leader takes this knowledge to the table. Both are important to succeed in reducing the amount of failures.

In general team managers, according to Noble, are only aware of 9% of the problems, whilst line managers (on the shop floor of industrial plants) are aware of 74% of the problem in their field (Noble, 2000). Knowledge on MES and thus solutions for the problems at hand work exactly the other way around, thus good communication between the different managers is needed.
This can be illustrated by an example at CCE. The operators on lines monitor the energy and water KPI for their line. But when the KPI is not met they are not always able to take an action that can influence the KPI positively. This might be caused by the fact that a lack knowledge about external factors that influence the KPI is missing. When they often face themselves not being able to improve based on the information presented to them by MES or their own ability to interpret that information, they will give it less interest. On the other hand managers might not know where energy and water efficiency on the lines can be improved, or at least not as good as an operator who works on the lines with the machine every day, causing opportunities to improve the energy and water efficiency of the plant to be unused. This is where we talk about asymmetrical knowledge between the management layers and the operational layers of the organization.

![Figure 16 Illustration of asymmetrical knowledge between management and operational layers of Coca-Cola Enterprises Dongen](image)

In our opinion this illustrates that all employees need to firstly understand what continuous improvement is and how they need to use it to reach the goals of the organization. Secondly all people, for whom it is relevant, should use the MES as a tool for continuous improvement. In case one of the two conditions mentioned is not met, MES will not be successful in contributing to OE. Imagine that all employees use MES, but are unable to use the information to improve, the system will not be successful. On the other hand, when everybody strives for OE and has the knowhow to do so, but is not using the system, no matter the reason, this will not result in a successful contribution of MES to OE. Therefore this research defines engagement of an organization with MES as:

*An organization is engaged when all relevant employees use a system and all relevant employees have the knowhow to use the system in order to continuously improve.*

In this definition relevant employees are employees whose functions can benefit from the use of MES. When the success factor responsibilities is defined it will become clear which functions these are. This is the most important factor to let MES succeed in contribution to OE.
5.2 Responsibilities

The first factor that influences the engagement has to do with responsibilities. A wider term for this regarding IT systems is governance (Scholten, 2013). With the case of MES the responsibilities need to be clear both on MES as a system and the responsibilities of employees regarding the tasks of MES. In the next two paragraphs they will both be discussed.

5.2.1 Responsibilities IT systems

In industrial production plants often various IT systems are implemented. Those systems can be found within various levels of the organization. Think about the third chapter where IT systems integrating was mentioned: we disused enterprise resource planning (ERP) system at enterprise/strategic level, and we discussed MES which is in between ERP and control systems such as SCADA that measure individual processes and machines. Those systems are connected and overlap each other and speak different 'languages' which results in a complex IT environment.

When this complex IT environment is not managed adequately the whole environment can become instable resulting in wrong information in all areas of the enterprise (Morel, Valckenaers, Faure, Pereira, & Diedrich, 2007; Scholten, 2007b). A very important aspect in preventing this from happening is assigning clear responsibilities per IT system within an industrial production plant (Scholten, 2010). This way, employees know whom to ask when problems occur. The person or department that is responsible for the system will also benefit, because they carry the responsibility they will invest in knowhow about the system to be able to solve problems.

5.2.2 Responsibilities MES modules & Tasks

The other aspect of governance that is taken into account in this research is about the responsibility that is given to employees of CCE regarding MES. Those responsibilities differ per layer of the organization and per function. MES is divided in modules and those models are further decomposed in reports and specific machine details. How those responsibilities must be divided will be discussed in the paragraph KPI tree. In this part of responsibilities we want to explain that it needs to clear who is responsible for what and that this needs to be communicated throughout the organization. In case it is unclear who is responsible for which module or report in MES there is a big chance that the report will not be used. When this is the case the potential benefits of this part of the system will not be reached resulting in a less successful MES.

This can be illustrated by an example of from CCE. The environmental manager is responsible for the main KPI of energy and water, when the function is evaluated those KPI are also considered. Therefore this function is committed with those KPI’s. In CRS (corporate responsibility and sustainability) module of MES those KPI can be found and monitored, it makes sense that the environmental manager uses this module and is responsible for this module to get more insight in the KPI’s that are his responsibility.

Therefore it needs to be clear who is responsible for which part of MES. The management needs to make sure that the responsibilities are clear and well distributed throughout the organization.

5.3 KPI tree

In the previous paragraph we discussed responsibilities, which in itself is important. For this to be clearly and successfully implemented the organizational structure needs to allow this.

This can be realized by aligning key performance indicators (KPIs) with the goals and strategy of the organization (Locascio, 2009). How this can be done successfully will be explained based on the paper of Locascio (2009) and the experiences gained at CCE.
5.3.1 Alignment with strategy
The first step that needs to be taken in order to get a functioning KPI tree is to ensure that the measurement are clearly focused on the right behavior, this need to be done by establishing what the business and department goals are. The highest KPI should be decomposed to departments and they will then need to decompose them even further until a daily work level is reached. All KPI’s need to reflect the goals of the company that together are the strategy of the company, in this research the overarching goals of TQM need to be reflected in the KPI’s. It is useful to first decompose the goals of the organization using a goal tree, Thereafter for all the goals KPI’s need to be made. A KPI needs to be an indicator that can be measured and measures the goal in an effective way. A few moments of brainstorming might be needed to establish good KPI’s for all goals. When the KPI’s are made they needed to reviewed every year to keep them up to date to the changes in the production process.

5.3.2 Ownership of the KPI
Another important organizational aspect of an effective KPI tree is the fact that an employee has to be made responsible for the KPI. Here we find an overlap with the success factor responsibilities where is concluded that for every module/report in MES an employee needs to be responsible. In fact in those modules and reports the KPI’s can be found. Therefore we recommend making a same person responsible for a report that has ownership over the KPI.

Before determining who should be responsible for a KPI, the organizational structure should be aligned with the KPI tree, this way it will make perfect sense who is responsible for which goal and which KPI’s he has to follow up to reach the goals.

For example a goals of CCE is reducing the water and energy use to become more environmental friendly. The environmental manager is responsible to make this happen; this can be done by influencing two main KPI’s. Which are; for water the amount of water that is needed to produce one liter of product and for energy the amount of energy that is needed to make one cubic meter of product. His task is to decompose those KPI’s to KPI’s that can be followed on a day to day basis to continuously improve. The ownership over the KPI will create the priority and urgency with the employee responsible, when this is done for all KPI’s the main KPI will improve.

5.3.3 Comprehensive
The functions that get ownership over the KPI’s must be involved in the process in order for them to be content with the KPI’s they get assigned. In the process they must feel the KPI’s for their field are relevant and measure at the right level and frequency, to allow the owner to use the KPI to actually improve by the information the KPI presents to him. A pitfall is swamping employees with work by giving them KPI’s that cost a lot of time to follow up, this will result in bureaucracy. The employees will only make the KPI but will not use them to improve.

5.3.4 Refreeze KPI’s
When the KPI’s are defined and an owner has been made responsible, the KPI’s and the way in which they are followed up need to institutionalized. How fast this can be done depends on the commitment of the employees regarding the KPI’s. The senior management of an organization can influence this commitment as described in the paragraph about leadership.

This part of implementing a KPI tree is very important; the result of actually improving is based on engagement as defined in the first paragraph of this chapter. To contribute to engagement an adequate frequency of communication about all the KPI’s needs to be defined. This means that routines need to build in order for the organization to adapt to the KPI structure. When this happens the information will flow up through the institutionalized KPI’s and accurate decisions can be made upon the change in KPI’s.
In a later stage when the KPI tree is institutionalized in the organization, target can be set on the KPI’s that push employees to keep on improving in their field.

The KPI structure needs to be revised approximately every year in order for it to remain up to date with the ever changing production process (Mauch, 2009b)

5.3.5 Apply KPIs in MES
Once the KPI’s have been established they must be incorporated in MES and the responsible employees for the KPI must know how to access this KPI in the system. To be able incorporate possible changing KPI’s, the factor relationship with the MES supplier needs to be satisfied, because in most cases companies are not able to change all the KPI’s in the dashboards of the MES themselves.

5.3.6 Communication and training
The final aspect for successful execution of a KPI tree is training and communication of the KPI’s. Communication and training is an important pillar of OE as strategy as well. Therefore this aspect is taken as an individual success factor that will be discussed in paragraph 5.4.

5.3.7 Concluding on KPI trees
For MES to be successful the organizational goals need to be aligned with the functions that organization has. Then KPI’s need to be made that need to be followed up by the functions using MES to reach the goals to do this an adequate KPI tree is needed and the KPI’s need to be available in MES.

Finally must be noted that this is not a onetime event. Every year the organizational strategy, goals and KPI’s should be reviewed in order to ensure the organization remains adapted to the organic changes an organization goes through (Mauch, 2009b, pp. 13-32).

5.4 Education & training: employee empowerment
Talking to one of the operators on the shop floor the success factor of Education and Training developed. The operator had received no information about the MES except for his username and password. Trying to decipher the user interface of the MES his motivation to use it disappeared, and note that he was one of the few actually trying, and after understanding to some extent how to use the MES, he still did not know what KPI’s were relevant to keep track of. Note that for example water usage is related to the size of the bottles that are filled; understanding the relation between these KPI’s is essential to draw valid conclusions and act on them.

Two aspects of this success factor should be noted. Firstly, on the operational level not a lot of support existed to use the MES in the first place. Secondly, when there was support for the system a lack of understanding of the system demotivated and subsequently undermined potential engagement. Thus, when reinforcing engagement, knowledge about the MES is essential to operators. Knowledge about the system is achieved by education and training; teaching employees what the information provided by MES encompasses so they can draw valid conclusions and act on them, and training employees in using the interface of the system getting them the information they need.

Literature supports the importance of employee training in quality management. Cheng and Choy (2013) investigates the relation between certain quality management practices and organizational performance. One of the measurement indications of organizational performance identified by Cheng and Choy is operational performance, referring to the quality of products and processes directly related to developing the products. ‘Employee training and empowerment’ is found to be significantly related to generating greater operational performance.
Employee empowerment not only refers to the fact that employees are well educated; it also encompasses the idea that employees are motivated to work according to the principles of the company’s philosophy. Proper training includes the explanation of overall company operations and product quality specifications (Motwani, 2001). Employee empowerment in this sense has been recognized as a critical factor to quality management by many researchers over the past few decades (Ahire, Golhar, & Waller, 1996; Powell, 1995; Saraph, Benson, & Schroeder, 1989; Zeitz, Johannesson, & Ritchie, 1997). This is where good leadership comes in; good leadership, as defined in the next paragraph, endorses the concept of employee empowerment to reach a greater engagement.

5.5 Leadership

We have now identified three essential factors: clear responsibilities are necessary to structure the efficiency of tasks concerned with using MES, a clear KPI-tree supports this identification and division of responsibilities, and education and training is essential to engage employees to use the system effectively. When reflecting on what drives the progress of these factors the term leadership rises: some form of supervision needs to initiate and control these factors. More importantly: leadership should be executed in the right manner, for there are many forms of leadership.

In the introduction the definition of OE was found and described as ‘an integrated effort designed to improve quality performance at every level of the organization, so that results are achieved in less time and with less resources’. A strategy like this needs to leek through the mindset of the entire organization, which requires a management that executes leadership in such a way that it triggers good communication between the management layers of the organization and the operational layers (see again figure 15).

Quoting from Duff (2011) and based on Oldman and Hackman (2010): ‘the nature of work in the developed world tends to shift away from the traditional manufacturing roles that are typified by clearly defined objectives and requirements to knowledge-based roles where the nature of work itself involves a much greater degree of variation and interpretation based on changing role, client, or environmental needs’. This is exactly what happens with Coca-Cola Enterprises in Dongen as well when trying to implement an ‘integrated effort’, in our case by means of their MES: more professional communication and integration is required to make sure problems and solutions existing between management layers find each other. Duff argues that these structural changes in organizations have increased the importance of effective leader ‘coaching’ and refers to the answer of the question of good leadership as ‘relational leadership’, in which positive working relations amongst team members and organization layers are essential.

Good leadership therefore should implement some form of relational leadership and as such be able to make the right decisions about education and training, and the structure of the KPI-tree.

At Coca-Cola Enterprises a sense of negativity surrounds the implementation of MES. This was a new and ‘external’ event (a management choice that was implemented top-down) that needs to earn its credits by proof of concept. Yet, as we already mentioned, proof of concept is only realizable when the organization is successfully aligned with the system. Here we touch upon the concept of change management as spoken of by Oakland (2007). The culture of an organization is shaped by believe, behaviors, norms, dominant values, rules. The success of an organization depends on the extent to which people preform their role and move towards the common goals and objectives. Duff presents different styles of relational leadership that respect that idea and incorporate it in the leadership style. An interesting form of leadership is provided by transformational leadership. Transformational leadership aims at developing self-motivated workers through the alignment of personal goals with organizational
goals (Avolio, Walumbwa, & Weber, 2009). This can be operationalized as leadership that inspires rather than directs. This is exactly what the implementation of the MES of Coca-Cola Enterprises needs: inspiration and a positive attitude towards the system. When exercising such a form of leadership a clear and especially broadly accepted KPI tree is more likely to be successfully constructed and education and training is more likely to be set up in such a way it contributes to the empowerment of employees.

5.6 User friendliness

In this research we also found that the user-friendliness of the MES influences the engagement. Imagine an operator during a product changeover from ‘Fanta Pomelo light half liters packed in a twenty-four pack’ to ‘Coke regular two liters packed in a six pack’. The operators need to change the settings of all the machines, for example; they need to mechanically change the width of conveyor belts in order for the six packs two liter to fit through. Many actions need to be completed in approximate thirty minutes, depending on the changeover type. A new task the operators got with the introduction of MES is that they need to close the production order when they stop a batch. Then, when they start producing the new batch, the production order has to be opened in MES again. In case the loading takes long or when it is difficult to find the correct screen in the MES, the engagement with the system bound to decrease. In many cases an operator postpones the closing of production order, but does not notice the impacts. The system thinks that line is still in the production mode and keeps adding energy use and water use to the production batch while there are no units being produced. The energy KPI and water KPI, expressed in energy per 1000l respectively liters of product per liter of incoming water, will give a worst representation of the batch. Managers review this information from MES and since it is not accurate they might make wrong decisions making MES less successful.

Now let us return to the concept of user-friendliness regarding IT systems, which is defined differently over time. A concept that is related to user-friendliness and used often regarding IT systems it usability, the ISO (International Organization of Standardization) made a standard, ISO 9241-11, where they provide a definition of usability. But this concept is too wide for the application it has regarding this research, since it incorporates the all ergonomics of human-computer interaction (Jokela, 2003).

Therefore user-friendliness is more appropriate as success factor in this research. An adequate definition was found by doing a literature research on Google scholar and academic search engine Scopus. The latter provided an article of Wei, Chien, and Wang (2005) using the search term ‘User-friendliness IT systems’. Wei (2005) breaks user-friendliness down into two factors:

- Ease of operation:
  - Graphic interface
  - Step by step command
- Ease of learning:
  - Provision of a guidebook
  - Online learning
  - Online help

Those two factors are used in in this research to define user-friendliness. When the framework is applied those factors will be investigated to conclude if the user-friendliness of a MES is adequate and to see where this factor can be improved.
5.7 Data accuracy

Strictly speaking is data accuracy a factor that belongs to the technical aspects of MES. Yet, this research identified data accuracy as a very important factor that directly influences engagement. This is why it is discussed in this chapter as a fourth and final factor that is essential to establish a successful MES from an organizational perspective.

The fact that is essential to engagement is confirmed by the interviews held at CCE (Appendix ii). This can simply be explained by the fact, that even when your organization in fully engaged with MES, when the information presented by the system is not accurate, the wrong conclusions will be drawn. This might even have a counterproductive effect on continuous improvement.

Think for example about the water KPI; in case the water KPI is not met the environmental department will thoroughly investigate the plant to find out what the causes of the inefficiency are. This can be very time consuming and when the data is not accurate, it might result in no actual causes found. A mistake in data accuracy is easily made and should therefore be well guarded. When working with the MES of Coca Cola a conversion factor to calculate the liters Coca Cola produced is used. This conversion factor provided by SAP, the volume of a Coca Cola can, is multiplied with the number of cans a line processes. After a few weeks we discovered the conversion factor was 3 L, instead of 0.33 L. This made all previous calculations and information based on that production line invalid.

Next to the notion that mistakes in data accuracy like this undermine quality management in itself, a strong feedback between engagement and data accuracy was found, especially when talking with managers (Appendix ii). They argue that when the information they receive from MES is, or appears to be, inaccurate they will use the MES less. This effect leads to less engagement with the system, causing jet another side effect. Operators who insert information in the system notice that their managers are not using the system and therefore their effort goes to waste. They therefore tent to prioritize MES related tasks lower causing a further decrease of engagement and also making the information less accurate because they enter less information in to the system. This negative spiral should be prevented at all times.

However when is discovered that the data presented by the system is not accurate (which can be done by comparing it to other measuring systems, such as SCADA, SAP, or manual measuring), the following steps can be taken. Firstly the feedback between engagement and data accuracy needs to be removed by adequate leadership, in this case this means; making sure that the operators feel valued and feel the pressure so that they will execute their MES tasks. Secondly the IT integration needs to be checked to see if the data from other systems is accurate to find out if the problem is with MES or has other causes that lay with other IT systems. Thirdly the functionalities need to be investigate, the data inaccuracy might be caused by a broken meter or a miscalculation by MES. This can be done by determining which processes is represented inaccurate in MES, then investigate what causes the inaccuracy.

5.8 Conclusion: organizational success factors

In this chapter Management Execution System are reviewed from an organizational perspective. This is done to answer the following sub question;

*How can an industrial production plant and its Management Execution System be organized in order for them to successfully add to Operational Excellence?*
Based on the experiences at Coca-Cola Enterprises and a literature review seven organizational success factors are identified that are necessary to align the MES and the organization in such a way that MES successfully contributes to the organization strategy of Operational Excellence.

The first and most important factor from an organizational perspective is engagement, which is defined in this research as;

An organization is engaged when; all relevant employees use a system, and all relevant employees have the knowhow to use the system in order to continuously improve.

This basically means that a MES can be perfect but when the relevant employees are not working with the system, nothing will happen, since MES does not act on its own. When the relevant employees are engaged the information presented by MES will assist the operational layer and tactical layer of an industrial production plant in continuously improving the efficiency of the plant based on real time efficiency gains and longer term improvement projects. In this chapter organizational factors are identified which are essential in determining who and where relevant employees to a successful MES implementation are and how they can be engaged with MES.

Clear responsibilities is one of the factors that is needed to reach engagement.

First of all it needs to be clear which actor is responsible for MES as a system, especially when MES is integrated with other IT systems in the industrial production plant. When problems arise it needs to be clear which people need to be contacted to solve the problems. This is essential for all IT systems within a plant; even more because they are all connected which can lead to downtimes in MES caused by other IT systems.

Secondly it needs to be clear which party is responsible per functionality of MES. When making the investment decision of implementing MES the efficiency improvements are identified in various parts of the plant, they are translated in functionalities that are incorporated into MES. For employees it must be clear who is responsible for what functionality to reach the efficiency improvement based on MES. When this is not the case certain functionalities will not be used, resulting in the fact that not all potential improvements can be realized, making MES less successful. The employees who have to enter data into the system also need to be aware what their responsibilities are in order to collect all data needed to get reliable information from the system.

An organizational success factor linked to clear responsibilities is an adequate KPI tree. An adequate KPI allows information to flow from the shop floor to the management (bottom up). Based on this information the management takes decisions that are communicated downward (top down). Every important KPI is discussed in a dashboard meeting; every department lays down the results for a certain KPI’s that are part of a main KPI and which are the responsibility of that specific department. This way control over the factory is guaranteed. The KPI’s need to be aligned with the goals and organizational structure, when this is done they need be institutionalized. Approximately every year they need to be reviewed to keep them up to date with the ever changing production process.

Education and training is necessary to have employees work effectively with MES; employees that have to work with the system must be able to understand how they can use the information presented by MES to continuously improve. Literature supports the idea of training mainly in the field of employee empowerment. Employee empowerment not only refers to the fact that employees are well educated; it also encompasses the idea that
employees are motivated to work according to the principles of the company’s philosophy. Proper training includes the explanation of overall company operations and product quality specifications. This is where good leadership comes in; good leadership endorses the concept of employee empowerment to reach a greater engagement.

Thus, to secure the right implementation of these factors a form of supervision or leadership that guarantees the right execution of these factors should be exercised. Transformational leadership is suggested as a way to inspire employees to align their goals with the goals of the organization. This way, a clear and especially broadly accepted KPI tree is more likely to be successfully constructed and education and training is more likely to be set up in such a way it contributes to the empowerment of employees.

User friendliness of the system also influences the engagement with the MES. User-friendliness is assessed by two criteria, the ease of use and the ease of learning. Basically this means that a person is able to quickly use the system and once the person understands the system it will be easy to operate it in the future. Both criteria are taken into account when the user-friendliness of a MES is reviewed. When one those factors or bother are not satisfying the willingness of somebody to work with the system will decrease, diminishing the engagement with the MES.

Finally a very important factor determining the engagement with MES is the data accuracy of the system. At CCE is experienced that there is a feedback between engagement and data accuracy. A simplified example illustrates this; managers start using MES less when they perceive the information from the system as unreliable, since they make wrong decisions when the data is wrong. Operators will prioritize their MES tasks lower since there managers are not using the system, this has a negative effect on the data accuracy and completeness of the system, staring the cycle again. Therefore it is essential that system is accurate. The actor responsible for the MES must monitor the data accuracy of the system, when ether the managers or the operators start using it less the actor must act by stimulating employees to use the system, to do this leadership and education are needed. In case the data accuracy has a different cause then engagement the actor must contact the MES supplier and fix the problem.

In the next chapter the success factors that are defined and explained above will be discussed to review their validity. Thereafter they will be used to create a framework for a successful MES.
In the previous chapters the technical and organizational success factors were identified. In this chapter the success factors will be discussed according to interviews that were held at CCE, regarding the identified success factors. Once established that all success factors are relevant at CCE, they will be made into a framework answering the following research question:

*How can the identified success factors be framed in such a way that a well-defined method is developed to support an industrial production plant in successfully implementing a Management Execution System?*

Then, an expert in the field of MES will assess the framework on its relevance.

### 6.1 Discussion on the success factors based on the interviews

Fifteen employees of CCE were interviewed for this part of the research. The interviewees were asked to rate and rank the success factors that were found in this research. The interviewees were asked to rate the success factors in order to analyze whether CCE employees find the success factors important, then they were asked to rank them. This was done to find out which factor would be found to be more important for success than another.

The intention of this paragraph is to investigate if the success factors we found are relevant at CCE. At first we thought of this paragraph as validation for the success factors, but we must conclude that the employees of CCE alone are not authority enough on the topic to use the results as validation. Therefore was chosen to discuss the results per factor to determine their relevance, and to find out how they are prioritized at CCE. In appendix i & ii the interview method, interviewees, results and questions lists can be found.

Subsequently we concluded in the refaction of the interviews that some of the questions that were asked pointed to engagement while others asked for somebodies opinion. Therefore, with some of the discussed factors, it is concluded whether they are relevant or not for a successful MES, as defined in the introduction, or whether a factor contributes to higher engagement with the MES, or not. When the success factors were ranked, this problem did not occur because all factors were placed in order of importance for success.

#### 6.1.1 Data Accuracy and Engagement

Both operators and managers agree on the fact that data accuracy is the most important factor for a successful MES. They reason that, when the information in the system is wrong, due to wrong data or a wrong handling of the data, they will build incorrect knowledge from MES. Therefore, wrong decisions will be made, regarding both improvement projects, and real time influence of the operator on the process.

But data accuracy it not a switch that can be switched on to reach success, as many factors influence data accuracy. However, data accuracy is mare a success factor, because it needs special care. The interviews showed that especially managers will use the system less when they have no faith in data accuracy of the system, leading to lower engagement and less success. Operators indicate that they will keep the using system regardless of data accuracy. because the explanation for this difference may be, that operators get rewarded for the degree of tasks completed in MES, thereby having another incentive for using the system than mangers.

Besides the fact that a manager who is not engaged will not improve, the operators working for this manager, will give less priority to their MES tasks, further undermining the data accuracy of the system (which party relays on the entering of data by the operators tasks). The manager will notice that the data accuracy diminished and will become less engaged, completing the negative cycle. This must be prevented at any cost, by
motivating managers who will have to motivate the operators. This will be further discussed in the success factor leadership.

6.1.2 Competencies MES supplier & relationship MES supplier
Managers were only asked to rank the competencies of MES supplier, regarding the success of a MES. This was done, because most operators are not aware of this factor. All managers find this the most important factor together with data accuracy. Research suggests this is mainly caused by the fact that often an industrial production plant is greatly depended on the MES supplier for the success of the system. Often knowledge to build the hardware and program the software is not available in the plant, making the activities of the MES supplier like a black box they cannot control nor influence. Therefore it is important to use a very thorough selecting process to find a competent MES supplier.

At CCE, the relationship with the MES supplier is rated less important for success than for example data accuracy and competencies of the MES supplier. But managers do agree that is a factor that influences the success of the system. This is not surprising, since we experienced that there is need to adapt the functionality of MES based on changes to production process, and improving insight in what is needed to continuously improve. Next to this, it is expensive and time consuming to change the system.

6.1.3 Leadership important for operators and managers
Both managers and operators ranked leadership above average. Both groups agree on the fact that managers should have a constructive attitude towards to system to make it succeed. While this might look like stating the obvious, in reality it often happens that mangers lack the abilities to embrace the changes needed to make MES a success. At CCE most employees agree that this factor is important.

We chose a few questions to give the term leadership some context. This resulted in interesting conclusions: both groups agree on the fact that time should be allocated specially to learn to work with MES, and that set routines in communicating about the system increase the success of the system. Those conclusions will be presented as recommendations to CCE.

6.1.4 Responsibilities rated high but ranked low
Operators and managers agree on the fact that MES will be more successful when it is completely clear what responsibility lays with the employees, which tasks are related to MES, and who is responsible for the system itself. They even agree on the fact that one central point of contact for all IT systems will increase the success of all IT systems, but when they have to rank the factors, both responsibilities score low with both groups.

This might be explained by the fact that, at this moment, it not completely clear who is responsible for what regarding the MES modules, for the main topics like energy and water, production, quality, and so on. This is done, but not all reports are used, partly because there is nobody responsible for those reports or parts. This will also be discussed further in the next chapter.

6.1.5 Training and education rated higher by operators than managers
Training and education is ranked by both groups as average important on making MES a success. Managers rank it higher than operators, which is interesting, because when managers were asked if they would be able to function better with the system, they indicated mostly neutral on this question, while almost all operators would like more education, to be able to work better with the system. From this we conclude that training and education is important for operators and managers, but managers are less reluctant to accept the training. This will also be taken to recommendations for CCE when possible training for managers will be discussed.
6.1.6 Functionalities not essential for managers

When ‘functionalities’ as success factor was investigated, many interesting findings were done. Managers are not convinced that the functionalities of a MES are of large influence on the success of the MES. They argue that, when all functions that are incorporated in the system is being used in a good way, the system can be a success. But operators approach this differently: they argue that all the processes and machines should be incorporated in the system, because processes and machines that work prefect now, might change in the future. A MES will be able to warn you when this happens, so you can solve the problem and prevent extra cost from happening. This indicates that the amount of functionalities is definitely a point of discussion, and therefore important to correctly take into account when making MES a success.

But the conversations with the operators gave us a better understanding of how the maintenance mode in MES works. When all machines are monitored, and one of those starts using more resources than before, probably something is wrong, although the machine will not fail at once, thereby giving the operator time to fix the machine. Before a MES implementation the machine would just have broken down at an inconvenient time. The continuous monitoring of machines and processes with MES has other advantages as well: this explains not only the process with a clear room for improvement need to be incorporated in MES, but the whole of relevant production processes.

6.1.7 User-friendliness has small influence on engagement

We found that user-friendliness has only a small influence on operators, which seemed odd, since they work with the system regularly, and more than often complain about the user-friendliness. They explained that their incentive to execute the MES tasks in the form of a ‘punishment’, when they fail to do so is bigger than the user-friendliness of the system is withholding them to use the system. Managers did confess to use the system less often due to the low user-friendliness. Therefore, we conclude that user-friendliness is a success factor for MES.

6.1.8 IT integration vague concept for managers

Managers at CCE think, that integrating IT systems is valuable. Systems will have the same information, so everybody is informed consistently. Also they expect less work pressure for operators, because they only have to insert certain information once, instead of multiple times in different systems. But managers also expect the complexity of the whole IT environment to increase. They do not see this as a problem, as long as the MES supplier capabilities are adequate. Managers see data accuracy and the capabilities of the MES supplier, and relation with the MES supplier as the most important things to make MES work. Operators were not questioned on the MES supplier, because they have nothing to do with this and therefore lack a well-developed opinion, but they do agree on the fact that data accuracy is the most important thing in determining success.

From this research it did not become clear whether they find the increased functionalities and lower work pressure more or less important than the increased functionality and possibilities based on IT integration.

6.1.9 Conclusion: relevance success factors

In this chapter all success factors acknowledged by the operators and managers of CCE were mentioned. This makes sense, because various success factors are inspired by the experiences we had at CCE. During the interviews we did gain new insights on some of factors, and we also did get a better understanding of the factor functionalities. In the next chapter the results of interviews will be used to support the recommendation for CCE.
6.2 The Framework for a successful contribution of MES to OE

In this paragraph, the framework will be made. As is explained in the introduction, the framework must be able to make MES a contribution to the Total Quality Management. Researching the entire life-cycle of a MES is too extensive for this research, as we were able to study the MES of CCE, which was at the end of the implementation phase. Therefore we chose to research how to make MES a success during and after the implementation.

In the previous chapters we identified the success factors that can be found in the framework. In this chapter we already discussed the factors in the context of CCE, to see if people that work with the system every day agree with the success factors. This gives confidence that the selected success factors represent all the important aspects, and when they are continuously stratified and improved, MES will become more and more successful within an organization.

Wang (2008) warns that only defining critical success factors is not enough, as the relation between the success factors needs to be defined as well, in order for a framework to work. In this case, the success factors are closely related to each other, and some of them even influence other factors. Therefore, the success factors will be presented schematically in Figure 17. How the success factors relate to each other in this framework will be explained below.

![Figure 17 The Framework for a successful contribution of MES to OE | Relations between factors](image)

As is explained in the second chapter of this report, this framework can be applied from the end of the implementation phase, until it will be disposed or replaced on the long term Figure . When all the hardware and software are built, engagement needs to be built too.
As mentioned before, in this research we defined engagement as:

*An organization is engaged when all relevant employees use a system, and all relevant employees have the knowhow to use the system in order to continuously improve.*

We found that User-friendliness, Education & Training, Clear Responsibly, and Data Accuracy have a direct impact on how engaged an organization is with a MES. This direct link is discussed in the fifth chapter, and the first paragraph of this chapter. The other factors eventually contribute to a more successful MES.

The relationship an organization has with the supplier of the system can have an effect on the functionalities, because the desires of the organization might change due to a changing manufacturing process. The supplier needs to adapt the system to those changes, which will only work when the suppliers have the right competences and motivation. To ensure a good MES supplier is chosen, and a beneficial relationship with the supplier is maintained, good leadership is required.

Leadership also ensures that the employees who work with MES, receive adequate training and education, to be able to use the system. In order to retrieve the information from the system, education of the workforce is important. This must enable them to transform this information to knowledge that leads to continuous improvement based on MES. Leadership is connected with the KPI tree, because through leadership the KPI has be established. Decomposed managers must be made responsible for the KPI’s. When this has happened, the information will flow through the KPI’s up to the management and decisions based on the KPI will be communicated down through the KPI tree.

Leadership is also connected with IT integration. As we discussed in the fourth chapter, it must be clear who is responsible for a certain IT system, to guarantee a successful integration. The management needs to make clear choices when assigning the responsibilities. Good leadership must make sure that those responsibilities are accepted and complied with.

When these factors are satisfied, a supplier will be able to deliver the desired functionalities, and changes can be made easier. The functionality might also improve when the IT integration with other systems is successful, because a MES also retrieves information from other IT systems.

Finally, the factor KPI tree and responsibilities are interconnected. Without a good KPI tree, it will be very hard to determine who is responsible for which functionality in MES. On the other hand, having a KPI tree in which nobody feels responsible for the KPI, is completely useless.

Having discussed the relationship between the factors leaves the question how the framework need to be used. Where to start and in which order should the framework be used and by whom? Those questions will be taken into account in the next paragraph.

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**Figure 18** Framework application area in the MES life cycle
6.3 How to use the framework

In the previous paragraphs is elaborated on the value of the success factors based on the interviews with CCE and is elaborated on the relationship between the factors. This has led to a framework of success factors that all need to be in satisfied for MES to have a successful contribution to operational excellence, in the Figure 18 the relationship between the factors is displayed.

In this paragraph is explained which steps should be taken when the framework is applied. Before the stepwise approach on how to use the framework is presented it must be noted that the situation can be differ between organizations. This might lead to changes in the order in which the steps should be taken, however we are convinced that all factors are relevant in all organizations. On the below presented stepwise approach on how to use the framework will be reflected in chapter 12. The stepwise approach is made for the management team of an industrial production plant that recently started implement a MES and would like to let it be successful in contribution to Operational Excellence.

![Stepwise approach for using the framework](image)

The first step in making IT systems a success is always having one responsible person or department (Scholten, 2010). This actors is often referred to as the MES champion, which is title deduced from the champion belt used in
the meso structure of six sigma (Schroeder, Linderman, Liedtke, & Choo, 2008). As might be expected this actor is often a senior manager of the industrial production plant, since managing such a system can be complex and decision power is needed to influence the success factors presented. This actor will use the framework to continuously improve the successfulness of the system.

This actor will enter an ongoing process in which the relation with the MES supplier need to be maintained, by communication with the supplier and having clear agreements. Besides leadership has to be shown continuously. This can be done by being a relational leader that stimulates employees by being positive about the system, and by educating the employees. This way they are enabled to start improving the efficiency based on MES on more and more on their own.

Simultaneously the first step needs to be taken; map out the current situation. This is done by assessing the two main factors; engagement, are all relevant actors using the system and do they have the knowhow to improve based on the information from MES; and data accuracy, is the information for the system correct? This will give the MES champion an overview of situation.

From this point the IT integrating, functionalities, and user-friendliness needs to be assessed. In case of those factors causes problems they need to be solved, think about the example of CCE where the steam boilers are currently not incorporated in the system making potential improvements based on MES impossible while gains are ogle. Solution can be starting a project to reorganize the IT environment of a plant, adding functionalities that are required, and ensuring a fast and easy to use system.

Thereafter a KPI three has to be build that reflects the goals of the organization, other actors need to be made responsible for the KPI’s.

The final step is to educate the organization, this way employees will know how to use the MES and what actions they need to preform based on the information presented by MES. Some organizations, like CCE, have a designate training center that can provide the training to the employees but often they first have to be familiar with the system. Therefore the MES champion needs to take the initiative.

It might be hard for organizations to see the actual contribution of MES to Operational Excellence. When the second chapter is taken into mind, this research found that MES contributes in two ways to Operational Excellence. Firstly, on an operational level where it presents real time information about the processes to the operators who can take imitate action to remove waste improving the efficiency. Secondly, the defects that cause the waste are stored, this builds knowledge about the system on which later improvement projects can based.

The first efficiency improvement based on MES is extremely difficult to quantify, imagine an operator fixing a leaking pipe which he found based on MES, when did the leak occur, how much water is wasted, when would it have been found if not for MES? Here an organization has to decide to try and quantify every improvement made by an operator based on MES, or just estimate the benefits.

The second efficiency improvement can be monitored easier, for every improvement project that will be executed a business case will be made to calculate the expected savings. The number of savings and improvement project based on MES together with the estimated savings based on the real time functionality of MES will give an estimate to the MES champion how the system is functioning within the organization.

Concluding, when an industrial production plant is in the end of the implementation phase this stepwise approach to the framework can be initiated to make MES a success in contributing to OE. It makes sense to choice the MES champion among the employees involved in the implementation and who is senior. This stepwise approach might not be only correct way of satisfying all the success factors, different organizations might needed a different order in the steps, this will be further discussed in reflection chapter 11.
6.4 Assessment of the framework by a MES expert

The framework has emerged from experiences at CCE founded by the relevant literature. However, there is not one correct answer on the question how to create a successful MES. Therefore, an expert in the field is interviewed, to see whether the framework is comparable with the expert’s experiences in the field of MES. Bianca Scholten is employed by Accenture (Accenture is a global management consulting, technology services and outsourcing company, with approximately 261,000 people serving clients in more than 120 countries (Accenture, 2013)), where she is one of the authorities on MES. Besides that, she has published many papers and books on the topic, that are also recommended by the ISA and MESA. This makes her an authority in the field of MES, and her opinion on the framework is definitely valuable.

We held two interviews: the first one was halfway through this research. In this interview, the expert gave advice on missing factors and completeness. In the second interview we discussed the outcomes of the conducted research. Now the two interviews will shortly be discussed.

In the first meeting, we mainly discussed the completeness of the framework and the formulation of the factors that are important in the framework.

During our conversion, we found that, next to the factors mentioned above, the cost effectiveness of the system itself is an important factor, when it comes to the management evaluation of a MES. It was hard to give this factor a place in the developed framework, as we concluded that this factor is more a condition that a management needs to get right, than a success factor, like the earlier mentioned success factors, that have a direct contribution to operational excellence. Therefore, this factor will be mentioned in the reflection (chapter 7.4) and we will incorporate it in the success factor ‘capability and relationship MES supplier’.

Secondly, the formulation of the factors was discussed. We found that responsibility is nowadays referred to as governance. Because governance is a more comprehensive definition than what we mend by using responsibility, we decided not to change the name of the factor.

Institutions were changed into KPI tree, because institutions as definition is more comprehensive than how it is used as success factor in this research. The term KPI tree was chosen because it entails the alignment of the goals of the organization with the KPI’s that are decomposed over the functions. This way, all the goals are represented in KPI’s and all KPI’s are owned by a function in the organization, making them responsible, and giving the KPI’s a bigger chance of improving.

Data accuracy is a term that is often used regarding IT systems. This represents better what we mean, than reliability which we used to use.

Furthermore, we agreed that more context to framework would increase the value of the framework. We hope that it is now clear that MES can be applied to all types of manufacturing enterprises, instead of only batch-wise production processes. Besides that, we hope it is clear that the framework will help an organization engaging with a MES, thereby realizing improvement. Although the phases before the implementation phase are just as critical for a successful MES, these phases are left out of the scope of the conducted research.

The second interview was built around the question whether the framework would be of added value to somebody in the field, working with a MES and trying to make it successful. Fortunately, the expert assessed this as being the case. The completeness of the framework was discussed, only the ‘cost effectiveness’ might have been added, but, as explained above, we chose to leave this out. Elaboration on that choice can be found in chapter eight. The application area of the framework is was also assessed as wide, since it might be useful for not only the MES of CCE. Concluding the expert was satisfied with the framework. She thinks, it can be useful for every organization in the implementation phase of a MES and beyond.
6.5 Conclusion: The framework

In this chapter the following sub-question is answered:

_How can the identified success factors be framed in such a way that a well-defined method is developed to support an industrial production plant in successfully implementing a Management Execution System?_

In the first paragraph of this chapter, we concluded that the success factors found in this research are acknowledged by the CCE employees that are interviewed for this research. The factors are made into framework, because the relation between the factors is important in determining the success of MES. In Figure 17 the framework is presented with the relations between the success factors. In Figure 19 (pd. 52) a stepwise approach on how the framework can be used when applying it to an organization is presented.

Fortunately, we had the opportunity to assess the framework with an MES expert, with whom a few meetings were held. Valuable input for the framework was given based on better formulations of success factors and the suggestion of other factors. Besides in the final interview was concluded that the framework is useful for every organization that is in the implementation phase of a MES, or beyond.

In the next chapter the presented framework will be applied to MES of CCE to find challenges and solutions for those challenges in a structured way.
7 The framework applied to Coca-Cola Enterprises

In this chapter the framework is applied to Coca-Cola Enterprises to analyze with which factors improvements can be made to increase the successfulness of their MES. In this chapter the following sub research question will be answered:

*Based on the framework, what changes can Coca-Cola Enterprises make to improve the successfulness of their Management Execution System?*

This will be done by identifying the challenges per success factor in the first paragraph, we will also present solutions for the specific challenges based on our knowledge of CCE and the literature. For those challenges an integrated approach specifically for CCE will be presented.

7.1 Challenges and solutions identified with the framework

In this paragraph the framework will be applied to the MES of CCE. In this first paragraph the MES will be disused per success factor, later on in this chapter an integrated approach will be presented to solve the issues and challenges that come forward in this paragraph.

7.1.1 Engagement

In this research was found that engagement is the most important factor that CCE needs to get right in order for MES to be successful. We defined engagement as;

> An organization is engaged when; all relevant employees use a system, and all relevant employees have the knowhow to use the system in order to continuously improve.

While the interviews were taken regarding the success factors and experience CCE employees have with the MES an illustrative conversion was held with one of the senior managers. He draw a spot on conclusion, in our opinion;

> ‘The group that is working with the MES and has the knowhow to realize the potential saving is too small at the moment’ (senior manager)

During the interview we discussed what the causes of low engagement are at CCE, the first thing that was established is that this manager and many others still see the MES in the implementation phase, thus is argued it make sense that CCE is not at level of engagement it would like to be in the end. But we must also conclude that engagement is lower than CCE would have hoped to have at this moment. This is one of reasons why this research is conducted, after all.

The framework that was made in the previous chapter presents us will all kinds to factors that CCE can improve to increase the engagement with MES and eventually reaching their goals with MES. Besides identifying and applying the success factors, a goal of this research was also to help the environmental department to specially use all possible MES functionalities to reduce the energy and water usage of the plant. Therefore we provide recommendations based on the framework but we also use the framework to increase the engagement with MES regarding all energy and water modules.
In order to do this we made an approach to ‘bring’ MES to all relevant actors, whom can be identified by the frameworks success factor KPI tree. The environmental department acted as an initiator for MES use and improvements based on this usage of MES. In the paragraph 7.3 we will elaborated on how we did this and what we learned from that in respect to the engagement with MES. But we will first apply all success factors to CCE to see what challenges can be identified to improve the MES as system.

7.1.2 User-friendliness
As can be seen in the framework user-friendliness contribute directly to the engagement of employees with MES. Simply put, when you have to wait very long for a response of the system and it hard to find the information you are looking for, you are less likely to go through the hassle for you information and might prioritize your time differently.

From the interviews came forward that user-friendliness of the current system is not appreciated by all employees of CCE. Managers and operators indicate that the reaction time of the system is not adequate. Other small difficulties occurs, this quote is illustrative for that;

‘*When a changeover takes place, the parameters of machines has to be changed manually, this is very busy moment. Also during the changeover the MES order has to be closed and the new one needs to be opened, when this action takes me over three minutes I will do it after the changeover*’ (filler operator)

Because the operator does this the data accuracy of the system will decrease, we elaborate on this later in this chapter. The response time issue is also mentioned by some of the managers. Interestingly the operators indicate that will not use MES less if is not user-friendly. We found that is occurs because there is an incentive for them to do their tasks in MES. For this managers this incentive is not present resulting in lower use of the system when the user-friendliness is lower.

There are two things that can be improved to increase the user-friendliness of the system, the ease of use and the ease of learning.

The ease of use can be increased by updating the hardware the MES runs on, the computers the MES runs on and the connect they have slows the system down. This is especially relevant to increase the user-friendliness for operators. For Managers it is harder to improve the user-friendliness, they sometimes find the information in the standard reports of MES inadequate, but it is very hard to change the standard reports. This forces mangers to use the KPI viewer, see Figure 20.
However extracting information from the KPI viewer is very time intensive because all data needs to be exported to Excel, manual calculations need to be executed to get the right data.

Therefore the ability to change and add standard reports needs to be possible, how this might be possible will be discussed in the factor capability and relationship with the MES supplier.

7.1.3 Training and education at CCE

Another factor that directly influences engagement is training and education. CCE has its own ‘training center’ where two people train, operators and managers all core values of CCE, for example about safety. Before an operator is allowed to use a machine a training has to be completed in order for the operator to be able to operate the machine safely.

In the trainings package the MES is only recently added, thus when the system was implemented not all employees did get any training. Besides still not all relevant employees got a training, illustrated by this quote;

‘When MES was implemented I got a username and password to log on the MES, which is all. I think MES would be useful my function but I need more explanation to be able to use it’ (operator)

In the current situation not all operators have a sufficient understanding of MES which is required for them assess the system. Because this is the case they will also not be able to improve based on the system. The operators who know how have the system work are confronted with the challenge that they do not know how to improve based on the information. This is illustrate by this quote;

‘We (filler operators) mainly focus on scrape and filler height, energy and water parameters are ignored because it is not clear what causes the diversion, therefore we don’t know what to change in case a target is not met’ (production operator)
This illustrates that it is important that employees are trained on how to assess the system and learn where all relevant models for them can be found. And more importantly what they can do based on the information from MES to improve.

In both areas CCE can improve, the trainings aspect is improving at the moment. The trainings center has developed a short training that will be given to every operator every year, this great. But we recommend to also give the temporally employees CCE this training, they must be able to do their MES tasks as well.

CCE can improve more on the education part, the two trainers will be able to educate all operators on all topics of MES. Because in different departments different education is needed for an operator be able to improve. In the ideal situation managers of a department deliver the input of the education that they would like to bring over on the operators to improve in their field. For the environmental department this means for example; operators who work on the lines must be taught what to do in case the water or energy KPI for their line is not met.

### 7.1.4 Responsibilities

In the framework responsibilities were defined two folded. Firstly the responsibility per IT system and secondly the responsibilities per MES module (or KPI).

In the current situation the MES champion is responsible for MES at the CCE industrial production plant in Dongen. There are a few complications, first of all the MES champion only get eight hours every week to spend on MES, which is way to less to solve all the issues that arise, even more since the system is still at the end of the implementation phase. Besides the MES champion is changes between employees for a few times, every time the champion changes a part of the knowledge this person has about the system partly disappears. Another complication is that the main responsible person of CCE works in Paris, this slows the communication down, resulting in problem that are solved less quickly than desirable and making decisions about changes harder to finalize.

Therefore we recommend CCE to place the main responsible person for the system in Dongen, close to his job, when this is not possible we advise that the MES champion will become a full time function, this way this person will be able to go all out solving all the issues with the system. This person will always available for employees who experience problems, while he is only able to this one day a week. This person will then also have time help the training center in setting up an improved MES training and education. This function will also be able to help build the KPI tree because he knows where all the KPI’s are in MES, but we will elaborate further on this when the factor KPI tree is discussed.

The second part responsibilities are those of the reports. Was we concluded earlier it is important for managers to know which reports and what KPI’s they are responsible for. In the current situation not all managers use MES to influence their KPI’s, this results in the fact that they do not use the system and therefore leave opportunities unused.

Therefore CCE should add MES to every function description, this will also result on rewarding an employee partly based on who MES is used to improve. This will contribute to the engagement there is with MES.

### 7.1.5 Data accuracy

The most mentioned concern regarding MES, especially mentioned by managers, is the data accuracy of the system. This in an interesting concern therefore we investigated if the concern was true and what might cause the fact that data inaccuracy occurs.

Because CCE works with multiple measuring systems we were able to compare the results and see if diversions between the measurements could be found. This was done using two approaches, first the values of the...
actual gauges where compared with data in the system. Besides some small diversions this data was accurate, or at least accurate enough that diversions could not cause the doubt in the data accuracy of the system.

The second test that was done compares the data that is constructed using other IT systems in the plant. The production volume that is shown in MES is constructed from counters at the end of the line that register the amount of units that pass by. However the system is not aware what passes the counter. This information is extracted from SAP the ERP system of CCE. The ERP system knows which product is made and what the metrics of this product are. This information is combined with the data from the counter, this way MES can calculate the produced volume. For example, MES counts 5000 bottles, in the ERP system MES finds that at that moment 1,5 liter bottles of sprite is produced. MES calculated and finds that 7500 liters are produced in that timeframe.

Issues with this mechanisms where found, this cause the volume that MES calculates to be wrong. This can have a big impact on the energy and water ratio that are most important KPI’s for the environmental department. Therefore this issue needs to be solved to improve the data accuracy of the system. We stared looking for the cause of the problem and we found that MES needs a production ID to be able to find the information in the ERP system. When this ID is not present MES assumes that volume of the product is one liter, this causes the diversion. When this was found we investigated why the ID was not present in MES. This can have two causes, first of all the operator needs to give in this ID, when the operators’ neglect to do this the problem occurs. Why this happens will be elaborated on later in this paragraph.

For this issue a solution was found, Het ID is now transferred automatically from SAP to MES when SAP receives the first units from the end of line. This is still not perfect because information gets lost on what happens on the line, therefore also the organization component needs to solved, the operators need to fill in the ID.

This is one of the steps that was taken during this research to improve the data accuracy of the system. CCE recently decided to make the system leading, this means that all revenant decisions are made based on the information from MES, instead of the old Excel files and measuring systems. This results in the fact more issue will be found that need to be solved, the MES team of CCE should keep on verifying and correcting the information of MES with other systems, but for the employees is positive they use since this will increase the engagement.

### 7.1.6 Relationship and Capability of the MES supplier

Confidential

### 7.1.7 Leadership

Leadership as success factor is also reviewed at CCE. From the interviews a few improvement points came forward regarding the way mangers approach the MES and how they communicate about it.

First of all, managers and operators agree that time should be made to execute MES tasks, this might be raised by the time that is not needed anymore for other systems, but who this works must be transparent, this way employees will see the benefits and will feel aspirated for the time they invest in MES.
Both operators and managers agree that a constructive attitude towards MES must be advertised by colleagues to engage each other more with the system.

The interviews also pointed out that when managers communicate about the system on a regular basis operators will feel more engaged to system.

Taking this into account we advise the managers of CCE to adapt a constructive attitude and to advertise this attitude towards other managers and operators. Concerns about the system can better be brought to MES champion or MES project leader in Paris. Managers will also have to show to operators who the time they invest in MES is gained somewhere else. In a set routine managers should communicate to other about what is done with the information from MES giving Operators a sense that there effort services a good cause, this can for example be done during the monthly team meetings. The MES champion can also play a role, the few managers that are not engaged with the system need to be convinced of the benefits in order for them to become constructive as well.

7.1.8 Functionality of the MES of CCE

The functionality of the MES present is Dongen can be described as extensive. Many modules that can be found in the ISA guideline are adapted by CCE, this is ratified by Bianca Scholten.

But there are a few key process from an environmental point of view that are not incorporated in the MES of CCE that could be a very valuable.

First of all the main gas meter of the industrial production plant is not linked to system while roughly one third of all energy used is coming from gas. This missing functionality makes it hard to deliver the KPI’s of Energy that are daily discussed by the management.

The functionality of MES regarding the entire gas use throughout the plant after the main gas meter can be questioned as a whole. Only a few meters are missing that would enable CCE to gain insight in their entire gas use, which is not possible at this moment. In the appendix iv we elaborate further on this. Although we advise to place all off the missing meters, one deserves extra attention. In the current situation there is a gas meter before the steam boilers, the boilers produce all the steam that is used in the plant to heat water and air. But is no steam meter placed after the boilers, causing that the efficiency of the boiler cannot be determined. The boiler transform gas to steam, in this process 31.1 percent of all Energy use in Dongen is transformed from gas to steam. When this process is inefficient this can result in a big loss of energy that cannot be determined at this moment. While we know from recent research by a third party hired by CCE that the efficiency of the boiler was not lower than expected, the efficiency of the boiler was reduced by broken steam traps. MES would be perfect in measuring the efficiency of the boiler. We would be able to build knowledge about the process when we know when and under which conditions steam traps break down, with this knowledge CCE might be able to prevent future break downs and design an adequate maintains schedule. More importantly CCE would be able to notice a broken steam trap right away and fix it improving the efficiency of the steam boilers and saving money.

An second functionality that is missing in our opinion is the possibility to review the high pressure air electricity use per production run and the blowing machine electricity per production run. If an operator would be able to view those KPI’s in real time he would be able to steer the process as he goes and try to reduce the energy usage of the bottle blowing process.

In short, high pressure air is created by three compressors. There are also three blowing machines that heat a pre-form; a plastic tub that can be blown into every shape, they thereafter use high pressure air to blow it up until it has the desired shape. A few parameters of this process influence the energy use per bottle, the pre
heating temperature; high pressure air leakage; air recovery program parameters; etc. An operator is at this moment only able to his total electricity use throughout his shift (Figure 21, left bottom side), which is the wrong information for improvement and therefore he will not be engaged, leading to missed energy reductions.

![Real Time gauges in MES](image)

**Figure 21** Real Time gauges in MES

### 7.1.9 KPI tree

The success factor KPI was later some other success factors added to the framework to fill a gap we encountered during the validation. But we were using the factor all along. For energy and water there are two main KPI's (Figure 23 at page 71):

- kWh per 1000 liters of product
- Liter of water per liter of product

Based on those KPI’s the daily, monthly and yearly performance of the plant in Dongen is evaluated. Before the MES was implemented CCE was unable to determine those KPI’s on a daily basis, now they are able to follow those KPI daily they are challenged by the question on how to transfer this to actual savings. The main problem with daily assenting the KPI is that they are very solid numbers seen over a year, but seen over a day they are influenced by many external factors. Take for example temperature, when the temperature is below zero the buildings need to be heated a lot, no matter the performance of the processes energy use, the target on the KPI will never be made, at least not when it is static and is not corrected for external factor like temperature. Therefore CCE will need to make this KPI flexible in order to compensate for all external factors, when they are able to do so they can really assess the performance of the energy use of the plant and develop knowledge on how to reduce the energy use. This research gave an approach on how this can be done, in chapter 7.3 this approach can be found.

The second problem found in the KPI tree is the way the dashboard operates. In the current situation every morning at 9.30 a.m. the previous 24 hour are discussed, the energy and water KPI are also discussed. Which is great, because of this dashboard meeting highly staffed personal gets useful information that might not have left the shop floor with the meeting. But there is one problem, the first meeting is Monday and last one is Friday.

Monday morning the KPI’s from start up until then are discussed, leaving the weekend out. For production related KPI’s such as scrape this not a problem since there is no production and no scrape in the weekend (normally CCE produces is in three shifts, from Sunday 23:00 until Friday 23:00). In this situation all the energy and water used in the weekend is not discussed, while this can be a lot. Think about all the filter cleanings that use a lot water and are all scheduled in the weekends. Therefore in current situation the dashboard might see very positive results for the water KPI all week, when they see the week overview they might be confronted with a KPI for water that does not meet the target, leaving them confused.
Therefore we also recommend to incorporate the weekend usages for energy and water in the KPI that is being discussed in the dashboard meetings in order for them to be able to control the weekends as well. CCE also needs to review it water and energy KPI for when their plant in production mode and a KPI for when they are in non-production mode.

Finally we can conclude that in the current situation the KPI tree ends right at the top, the KPI are not jet decomposed over the department and then over de processes. When more insight in the main KPI’s for water and Energy is desired this need to be done. This will also increase the responsibly people feel, when they are responsible for their processes KPI. Decomposing the energy and water KPI’s will take up quite some time but is very important to let MES succeed in the long hall.

7.1.10 IT systems integration at CCE

In the current situation the MES is integrated with SAP which an ERP system and a PLC from where data is extracted. This connect works adequately from a technical perceptive, on the organizational issues is already elaborated on in the paragraph about data accuracy.

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KPI, and how it can be decomposed throughout the plant. When the Champion does this, he takes into account that for the energy and water KPI's, the weekend should be made into a separate KPI or the weekly discussed KPI should be compensated for the weekend use and waste of energy and water.

Simultaneously we would like to advice the MES champion to make a business case for extra functionalities that are essential in reducing the energy usage of the plant. In case the extra functionality is more expensive than the potential cost reduction we still advice to consider other factors, such as system completeness and the Corporate Responsibility and Sustainability (CRS) goals of CCE.

The recommendations given above are especially useful for the management of CCE in Dongen. In our opinion the presented integrated approach will lead to a successful MES. This is a condition for the environmental department in using the CRS part of the MES to continuously improving the energy and water efficiency of the plant. In the next part is explained how this research helps the environmental department to use MES and how they can engage relevant employees in the area of energy and water efficiency improvement.

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Part III

Energy and water efficiency improvement

Based on the recommendations given in the previous part, the Management Execution System of Coca-Cola Enterprises in Dongen will become successful. This is a condition for the environmental department to start using the MES and engaging relevant employees in making Dongen even more energy and water efficient.

8. Energy and water efficiency improvement based on MES
8 Energy and water efficiency improvement based on MES

In the previous part recommendations were given on how the success of the recently implemented MES can be improved. The environmental department is one of the departments that needs to be engaged with the system, and that will have to stimulate other departments in using MES in order to improve the energy and water efficiency of the industrial production plant of CCE in Dongen. To see how the environmental department can do this, the following question will be answered in this chapter:

*How can the environmental department of Coca-Cola Enterprises in Dongen use the Management Execution System to reduce the energy and water consumption?*

During the research, most time was spend answering this question. The approach on how to answer this question changed often after discussions with the various department managers or the environmental manager. Therefore, the processes answering this question can be described as iterative.

The discussions with the different managers often revealed underlying problems, that were incorporated in the framework. Solutions for these problems to improve the overall performance of the organization with the MES are presented in the previous part. In this chapter will firstly be explained how the approach, that is used to engage the relevant employees with the MES to improve the energy and water efficiency of the plant, emerged from the iterative processes. Secondly, it will be explained which processes are relevant for improving the energy and water efficiency of the plant, as the MES of CCE has many functionalities, also in the area of energy and water. A selection is made on which processes will be focused during this research. Thirdly, this chapter will elaborate upon how the selected processes fit within the approach, and which steps were taken to engage the ‘owners’ of those processes.

8.1 Applying the framework to the CRS module of MES

At the start of this research, the framework for a successful MES contribution to OE did not yet exist. The first analysis was a review on how MES was used at that time, to reduce the energy and water consumption of the plant. In terms of the framework, the first step - a review of the factors engagement and data accuracy – was taken. (page 52).

At this moment, shortly after the implementation of the MES system, only the environmental manager was working with the CRS module of MES, and that the data it produced were not always accurate. An analysis on why the data were not accurate resulted in valuable information that helped to shape the framework.

Besides, the environmental department cannot influence all factors mentioned in the framework, which makes sense since the framework is made for MES as a whole, not only for energy and water. Therefore, the parts of the framework within the responsibility of the environmental department were used when the approach to engage the organization with MES in the area of energy and water efficiency started, but other parts were not. In Figure 22 the parts of the framework that are within the responsibility of the environmental department are shown.
Based on the remaining factors that are highlighted in Figure 22, we aimed to engage the employees with MES, in order to make them start improving the energy and water efficiency, based on the information from MES.

However, the reality is always less clear than the blocks of a framework. For example, education and training are not the responsibility of the environmental department. However the department can try to convince the training center to start education about MES and make it partly their responsibility, but it does not have the decision making power on this topic. On the other hand we found a few boundaries on the decision power of the environmental department regarding the highlighted blocks in Figure 22.

Firstly, as mentioned before, the MES of CCE has many functionalities, therefore a prioritization is made to determine where to start with engaging employees. This results in the fact that choices had to be made in on which functionalities and processes would be focused in the process of engaging the organization with MES.

The second boundary is a deliberated choice of the research. To explain it, an reflecting intermezzo will be made;

Imaging that the framework presented in chapter 6 would have been available at the beginning of the research. The application to CCE would have been very useful, but it would have led to a lot of changes with a large impacting the organization. Changing an organization with the size of CCE is extremely difficult, especially being an intern. Therefore, the aim of the research all along has been to find an answer to question of CCE that would be feasible and that would stick after the researcher’s participatory action research is finished.
Based on this intermezzo, the second boundary is defined as follows: find an approach that uses the current mechanisms in the organization and only try to change mechanisms when adaptation is not an option.

Within those two boundaries, while working at CCE, the approach on how to engage the relevant employees with MES in order to them to save energy and water got shape. Now is elaborated on the implications of both boundaries.

8.1.1 Boundary one: existing mechanisms at CCE

In the current situation, the main KPI’s are discussed on a daily basis by the management team of the plant. This meeting is called the dashboard meeting. The main KPI’s of the environmental department, shown in Figure 23, are also discussed in this meeting. Because the management team is present in this meeting, the decision power is high, which means that the organization can quickly respond if the targets of the KPI’s are not met. In terms of the framework this meeting would fit perfectly in the success factor ‘KPI tree’ (as the highest KPI’s in the KPI tree).

Energy KPI = kWh/1000l
I = liters of product that is produced over a certain timespan
kWh = That entered the factory over the same span

Water KPI = Lwater/Lproduct
Lwater = Total liters water that enters the factory over a certain timespan
Lproduct = Total liters product that is produced in the same timespan

Figure 23 Energy and water KPI’s at CCE

Some issues are encountered with the daily KPI review in the dashboard meeting. Originally, the two KPI’s are reviewed every year, which gave a good insight in the performance of the plant, since the fluctuations that influence the KPI’s, such as the weather and produced volume, level out over a whole year. In the current situation CCE discusses the KPI’s on a daily basis. The large fluctuations from day to day make it hard to make solid decisions based on the KPI’s.

For example, on a very cold day the heating will use much more energy than on a warm day. In this example, the energy KPI target will not be met, but this does not mean that the performance of the plant, energy wise, was not satisfactory. Those fluctuations make it hard for the dashboard meeting to get a clear picture on the performance of the plant, based on the mentioned KPI’s, thereby making it difficult for them to make the right decisions. In terms of the framework: the information presented by MES is not accurate.

Nevertheless, we will take this meeting as a starting point of the energy and water reduction approach, as this meeting has such decision power and the environmental department is obliged to provide the water and energy KPI on a daily basis.

This leads to the question; how the KPI’s can be reshaped to make them show the performance of the plant, instead of the effects of daily fluctuations. Besides, we wanted to make the KPI’s as useful as possible in improving the energy and water efficiency of the plant.
8.1.2 Boundary two: limited time and resources

Making the KPI’s more relevant for the dashboard meeting will not result in engaging other employees with the MES system. While they are also able to improve the energy and water efficiency by using the real time functionality of the MES. Therefore, a second focus point of the energy and water efficiency improvement approach must be on engaging operators and departments with MES in order to stimulate them to start reducing as well.

Both boundaries resulted in an approach based on MES that should lead to an increased energy and water efficiency of the CCE plant in Dongen. Schematically this is represented in Figure 24.

![Figure 24 Energy and water efficiency improvement approach](image)

In the next paragraph the processes selection will be explained, and in the third paragraph is explained how the ‘owners’ and employees that work with the relevant processes are engaged.

8.2 Relevant processes for the efficiency improvement approach

Previously was described how the energy and water efficiency improvement approach emerged. In this chapter will be explained which processes will be incorporated in the approach. To realize this, the plant is analyzed to see which processes are relevant for energy and water efficiency improvement in the industrial production plant of CCE in Dongen.

This was a daunting challenge, due to three reasons. Firstly energy and water are used in an endless number of processes throughout the plant, from the conveyor belts to the lighting of offices.

Secondly, energy enters the plant in many shapes; electricity, gas, LPG, and diesel are used as energy source.

Thirdly, the energy flows incorporated in the MES do not reflect the energy consumption in the plant as a whole. The MES regards mainly the energy flows that are directly used in the production process, because manufacturing modeling systems, on which MES is based, are made using a technique called SADT (structured analysis and design technique). A SADT is based on a clear description of the plant by following a production entity through all the processes from beginning to end (Ang & Gay, 1996). However, there are several energy flows which
have a big impact on the energy system, but are used for so-called “indirect processes”. Examples of these indirect processes are the heating process and the conversion from gas to steam in the steam boilers. The latter uses a lot of energy, and room from improvement is feasible according to a study by the KWA (2010), but it is not incorporated into the MES as it is a “indirect process”. This results in an incomplete picture of the relevant energy flows, thereby risking the loss of valuable efficiency and performance improvements.

Due to these three challenges, it is not possible to take all processes into account in the energy and water reduction approach based on MES. Therefore, choices on which processes to focus have to be made.

Before this research was conducted, CCE focused on the big users of energy and water in the plant, which makes sense. Although these energy intensive processes waste only percentages of their total energy use, this waste might be more than the total of many small losses somewhere else in the process together. However, there is one disadvantage using this way of selecting processes: big users of energy and water might not be wasting anything. A process that does not waste can only be improved by changing the process entirely, for example by replacing the steam boilers for water boilers.

Therefore, an aspect need to be added to the current approach of selecting processes to focus on, is that the processes must have room for improvement besides that fact that they use a significant amount of energy or water.

In the next paragraphs, those processes will be identified, but because energy and water are used in very different ways, they will be analyzed separately.

8.2.1 Significant processes for energy efficiency

As is previously explained, this research is bounded by time and the resources of the environmental department. Therefore, an analysis is conducted, which maps out all processes that are relevant to incorporate in the efficiency improvement approach. Firstly, processes will be analyzed on amount of energy they use, thereafter is analyzed whether these process have room for improvement. When processes use a lot of energy and have room for improvement, they will be incorporated in the approach.

Based on existing knowledge of CCE, and an additional analysis, all significant users of energy are identified (appendix vii). They are presented in Figure 25. Below we will shortly explain them.
As can be seen in the figure above, the steam boiler is not presented. This is because it only transfers energy from gas to steam. However, as is explained before, the process of changing gas into steam does not have a efficiency of 100%. Besides, the waste of the process (gas that is not transferred to steam, but to heat, condensate, etcetera) is not constant. This variation can be reduced to improve the efficiency of the process. MES could provide useful information about this process, on which waste can be identified and removed. Unfortunately, the MES of CCE is not connected to the processes. Therefore, the advice to CCE is to incorporate this process in the MES, and thereafter in the efficiency improvement approach.

Other significant users of energy are the bottle washer, the PET (Polyethylene terephthalate) bottle production lines (meaning the machines together directly on the line), lighting, and Low Pressure (LP) air (used throughout the entire factory).

The production lines consume 19% of all energy used in the plant (without the back and box lines, which are not significant lines in terms of energy use). The energy use of the production lines is expressed in a KPI per line that has the same unit as the overall energy ratio (pd. 71). The question whether the efficiency of the lines can be improved by monitoring and acting on this KPI came forward. In the current situation operators explain that they are monitoring the KPI for energy on the line, but in case the target is not met, they do not know which actions they can take to improve the KPI. This can be explained by two success factors from the framework. Firstly, education, as operators need to be educated what actions they can take when a KPI is not satisfying. Secondly, the KPI itself, as it is, is influenced by external factors, just like the overall KPI. The main external factor in this case is the type of bottle that is produced, which is explained in Figure 26. But since this is such a significant user of energy, and the operators are already using the KPI, we will take it into account in the approach, as we might be able to improve this KPI.
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On a production line of CCE, many different machines are used; from the filler to the conveyor belts to the packaging machines. Those machines have a limited variation in their energy use, but the volume that is produced differs a lot. Both for a 0,5 liter bottle and a 2,0 liter bottle, all machines are needed. But for the production of the larger bottle of the two, the speed of line is slightly slower and the energy use is slightly higher. Therefore, the volume produced is a lot higher and the energy use nearly the same. This results in a much lower KPI for the two liter bottle than for the 0,5 liter bottle. Therefore the KPI has no useful information about the line performance in the area of energy. This could be solved by giving every bottle size its own KPI, but that is currently not the case. Because the KPI is not adequate in presenting information about the performance of the line the operator will not be able to improve the efficiency based on this KPI, or at least in the way it is presented in the current situation.

Figure 26 External factor volume on line energy KPI

The bottle washer is the second significant process that will be taken into account. According to the manager of line 3, who is responsible for the bottle washer processes, there is room for improvement. Extensive elaboration on how people were engaged in order to improve the energy efficiency of the bottle washer can be found in 8.3.2 on page 79.

The bottle blowing process is the third significant process. The KPI for this process is the same as the overall KPI for energy, which can be found in Figure 23 at page 71. During the research, this process was marked as important by CCE and therefore it is taken into account as well. The room for improvement is not completely confirmed, but sometimes during non-production the machines remain on, which is of course energy inefficient. How we tried to engage the employees in the bottle blowing hall with MES in order to let them blow the bottles using less energy can be found in 8.3.4 at page 82.

The production of the LP air used in the factory, is also a significant process. However, the LP air is used all over the factory making the production of LP air a secondary processes. This, again, is not presented in MES. But the LP air in the various places of the factory is measured, as monitoring this usage might lead to identification of leaks and other waste. This was not taken into account during this research, due to time pressure, but the environmental department will continue engaging employees in this area.

The usage of LPG (liquefied petroleum gas) is not incorporated in MES. This source will not be taken into account.

Concluding, for energy the following processes will be incorporated in the approach: Production lines, The bottle washer, and the bottle blowing process. Now we will investigate what relevant processes are from a focus on water use.

8.2.2 Significant process for water efficiency

Coca-Cola Enterprises has increased to efficiency of the water use of their plants a lot over the recent decades. A few decennia ago, twenty liters of water were used to produce one liter of product. This is now close to only 1,39 liter of water per liter of product (Appendix ii). This improvement was developed by improvement projects based on tactic knowledge of the employees, and research by third parties. One of the reasons of implementing the MES is to make a final step in reducing the amount of water needed to make Coca Cola and other beverages. Now we will explain where water is being wasted in plant, and which of those processes we will take into account in the approach.
The knowledge of CCE about the water use in their plant combined with an analysis done by this research. For this analysis, it is assumed that all water that does not end up in a bottle (product water) is waste. How the loss is divided over the processes can be seen in Figure 27.

![Water Analysis](image)

**Figure 27 Water Loss Analysis (appendix vi)**

As can be seen in Figure 27, a little less than half of all water loss is identified. A few other processes such as water for cleaning the shop floor is known as waste water but the amount of water used for this could not be found. CIP is short for Cleaning In Place. This process is used to sanitize the storage tanks and the tube system. In the water treatment the well water and city water is brought to the desired level of purity for the production of soft drinks. The rinser at line 8 cleans the freshly filled can with chlorinated water so that the can does not corrode. The bottle washer at line 3 washes the glass bottles with chlorinated and heated water.

In the efficiency approach, the biggest losses of water with room for improvement, will be incorporated in order to reduce the waste in those processes.

The bottle washer at line 3 with 7% of water loss is one of the biggest sources of water loss. This machine is special because it also uses a lot of energy, in the form of steam, to heat the water. When this machine was investigated, a big variance in the chlorinated water use was found. Based on that and same conclusion in the energy aspect of this machine, it was decided to take this process into account.

The second biggest is CIP of syrup room, this process also uses hot water and therefore it uses energy as well. When this process was investigated, a lot of uncertainty was found in the area of the actual use of energy regarding one CIP action. Besides, with the current MES, it is hard to get a clear picture of the use per CIP action. Therefore, this research advises to take look at this use, but it is not taken into account in the approach.
The biggest loss causing process is the water treatment. During the interviews, it was found that since a change in the organization, the loss of this processes has increased. During the change, the process lost designated employees that used to monitor the processes. Therefore, this process leaves a lot of room for improvement based on MES, so it will be incorporated in the approach.

### 8.2.3 Concluding: relevant processes for energy and water efficiency

In the previous two paragraphs, the relevant processes for energy and water were identified. These processes will be taken into account in the approach. Firstly, the KPI's that will be discussed in daily dashboard meetings will be changed in order to focus on the performance instead of external fluctuations. Secondly, the relevant processes selected on their significance in the area of energy use and water losses that have room for improvement will be incorporated during this research. Not all functionalities of MES can be taken into account, since the research is limited by time and the resources of the environmental department. The selected processes can be found in Figure 28.

But there are also a process that we would have liked to take into account but the MES did not have the functionality to accommodate this. This is the steam production processes, executed by the steam boilers. Since they transfer a lot of energy and there is room for improvement. Finally we advise CCE to extend the water loss analysis that can be found in Figure 27 at page 76, when this is done it might lead to the discovery of other relevant processes that can be added to the approach.

![Figure 28 Energy and water efficiency improvement approach with processes](image)

The next paragraph will explain how the actors that own the processes are identified, and how they are engaged with MES.
8.3 Engaging the relevant processes with MES

At this point, it is clear that we want to reshape the KPI's that are discussed in the daily dashboard meeting, and that employees of the departments that own processes with room for improvement in the area of energy and water have to be engaged.

Without consciously noticing, participatory action research approach is used when engaging the responsible employees of the processes selected in the previous paragraph. In the introduction is spoken about Lewin’s model of unfreezing, changing and refreezing (Figure 5). This is exactly what has to be done in order to let people start reducing the energy and water usage based on MES. We tried to show the actors what the benefits of MES are, and how their function can benefit from it. Besides, we tried to shape the organization based on the framework in order to allow people to get engaged. We also asked them what they wanted with MES, and how they perceive working with the system. Often this process unfreezes the way they were working, partially. We changed this part of their work by explaining to them how to use MES, and give them support while doing so. Thereafter, they were able to use MES to reduce the energy and water consumption of their machine or department. Then the final, and may be most important, step of Lewin was followed. We had to refreeze the way the employees were working with it. We mainly did this by corresponding often with them about their satisfaction with the new work methods. This was done orally, but also by emailing them, asking explanation why targets monitored with MES were not met. On the other side, we tried to make sure that the data remained accurate and the user friendliness of the system was improving. All this was done in order to refreeze the new behavior of the employees. This way we tried to get all relevant employees on in the area of energy and water engaged.

In the next paragraphs, we will explain how we engaged the employees that have to deal with the processes selected in the previous paragraph.

8.3.1 Daily KPI performance approach

The first step that was taken during this research, was to make an approach on how the daily KPI performance for the dashboard meeting could be handled best.

An approach was developed, that would allow the environmental department to have an overview every morning before dashboard meeting, that tells them if the KPI’s for energy and water are desirable, and, if not, which processes cause the disturbance, so that they can be fixed. In appendix vii the whole approach can be found, but in this paragraph the content of this approach is explained. We will start by explaining how the energy KPI is reviewed. Thereafter, we will explain the water KPI.

As we discussed earlier, the KPI for energy is largely influenced by a few external factors, the water KPI has this as well, but the effect is less extreme.

To cope this problem, an tool was made that allowed the environmental department to review the energy KPI, which was compensated for the external factors that influence the energy KPI. When the plant in Dongen was analyzed we found that the energy KPI (Figure 23 at page 71) can be split in a electricity KPI and gas KPI. Those sources of energy represent 95,9% of all energy used in the plant (appendix vi). The electricity use of the plant is not influenced by external factors because electricity is almost only used for direct processes (think about machines on the lines). For the gas use this is a completely different story. Two big external factors were found. Firstly, the temperature, as on a cold day the heating in plant is turned on, which uses a lot of energy. On a yearly basis, this represents 30,8% of all gas use in the plant in Dongen. The second factor is the volume of line three, which is taken as external factor because the environmental department cannot change the volume planed on line 3. Because the bottle washer is on this line, and uses a lot of energy, the volume has a big effect on the gas KPI of plant. When this
line has a relatively large production on a day, it is only party compensated by the output of line 3, meaning it is a lot less energy efficient than the other lines, which makes sense since bottles are recycled and need to be washed. Line 3 accounts for 38.4 % of the yearly gas use in Dongen.

Based on those two factors the gas usage prediction tool was made. We chose to make a regression analysis on the total gas use and these two factors. We found that 77.5% of the gas use can be explained by the two identified factors (appendix vii), meaning that the rest is used other processes, which can tell the environmental department about the actual performance of the plant.

The regression function that is found (appendix vii) is processed in a excel sheet, where all relevant processes that help making the main KPI’s insights to be fully represented. This allows the environmental department to have a quick overview of the daily performance. The gas prediction tool predicts the gas use based on the average temperature of the last 24 hours and the volume of line 3. Then it shows the difference between the actual use and the predicted use. When the diversion is little, this means that nothing particularly has happened in the previous 24 hours regarding the gas processes. When a big diversion is found, a stepwise approach, that was build, allows the environmental department to find the cause of the diversion. This approach can be found in appendix viii and reviews the most significant processes regarding gas.

In case of electricity and water use, no big external factors were found, and therefore the KPI for electricity and water can be reviewed right away. Similar to the gas approach, when the targets on the KPI’s are not met, a stepwise approach is offered to the environmental department, to detect which process cause the variation from the KPI target. In appendix vii this approach can be found.

To put it shortly, every morning, a few steps have to be taken to get all sub KPI’s clear. When this is done, the environmental department has an overview of the performance of the plant based on the most significant users of energy and water. This allows them to find diversions in those processes, and fix them, making the plant more efficient in the area of energy and water.

These diversions are only found after the problem occurred. Therefore we also need to engage the departments that own the significant processes for energy and water and engage the employees working in these areas, in order to work more efficient as well. This was done for the bottle washer, the water treatment, and the bottle blowing process.

8.3.2 Bottle washer approach

The bottle washer approach was shaped by the capabilities of MES, to present information real time and build knowledge on the long term.

One of the first parts of MES that was used, was the ‘Line Utilities Report’ of line 3. On this line, the glass bottles of product are filled. This line is special, because on this line all the glass bottles are washed before they are filled. The machine that washes the bottles uses steam to heat the chlorinated water that is used to clean the bottles. This machine is one of the largest users of energy, as is shown in Figure 45 (pd. 153), It uses 14.4 percent of all energy that is used in the industrial production plant, and it also can be accounted for 13.9 percent of all water loss in the plant Error! Reference source not found. (pd. 153).

We identified the ‘Line Utilities Report’ as the most valuable tool in MES to start saving energy and water use of the bottle washer, because we identified two important key performance indicators (KPI’s) that could be used to define the bottle washer during production. These KPI’s are kilogram steam per 1000 liters of product, and liters of
chlorinated water used per liter product. As can be seen in Figure 29, these indicators can both be found in the ‘Line Utilities Report’. Then we considered the KPI tree, and found that the bottle washer also uses energy and water in the weekend, which is not taken into account when only the previously mentioned KPI’s are used. Therefore, we determined a target for steam use and water use in weekend as well. This can also be seen in the Line Utilities Report. With those KPI’s we wanted to build knowledge about the bottle washer. MES presents information on when targets on KPI’s are not met, which needs to be combined with root causes, that can be linked to waste that leads to missing targets, thus creating knowledge that can be transferred to the actual project, to improve the bottle washer. Besides, we wanted to find waste as it happens in order to be able to remove it right away, and stop further waste form occurring.

![Figure 29 Line Utilities Report from MES](image)

Based on the organizational structure of CCE, it was decided to approach the production manager line 1,2,3, to start using this information from MES, The Asset Care Supervisor is responsible for line 3. Based on a few meetings, the environmental department and Asset Care Supervisor decided to follow up the previously named KPI’s every Monday, to incorporate the production of the previous week and weekend.

After a few weeks we noticed that we were indeed building knowledge. For example, the KG steam per 1000 liters of product was not met in very cold and snowy weeks, the ice within the bottles, which were stored outdoors, melted within the bottle washer, thereby cooling the water down. Therefore, more steam was needed to keep the chlorinated on the right temperature, causing the KPI to show waste. This knowledge can be used for possible improvements, like placing the bottle in the warehouse during cold and snowy weeks.

But we also found that all the information was gathered after the waste had taken place, and that the knowledge was based on only one person. Therefore we decided to try and engage the team leaders of line 3, who are responsible for the operations during a shift. This brought us closer to the machine and resulted in even more knowledge. But when the research was finished, we were not yet able to involve the right people to remove the causes of waste at the roots of the process,. Speaking in the terms of the framework, it was not possible to engage all the relevant people, because we did not get the responsibilities and KPI tree right.

Therefore, it is recommended to the environmental department to keep sprawling MES out on line 3, getting the operators to look at the KPI for the bottle washer at real time, also to educate them on how to remove the cause of the waste, in case it happens.

We also learned, that for other approaches of bringing MES to the relevant processes, we should focus on getting the real time aspect in the approach right away. The learning curve we had with this, is nicely described in the next paragraph.
8.3.3 Water treatment approach

Another process where we wanted to engage people with MES is the water treatment, because we identified that improvements in this area can be made. The water treatment process in the Dongen plant treats the water until it has the appropriate quality to be mixed with the syrup and CO2 to become an end product. We found that 11.7 percent of all waste water is cause by this process, see Error! Reference source not found. (pd. 153).

We identified the ‘Water Report’ as the most valuable tool in MES to reduce the loss in this process. Because two KPI’s can be found in this report, that were thought off. The loss of water in the water treatment is expressed in a loss percentage compared to all the water that enters the factory, see Figure 30.

| Current filters |
|-----------------|-----------------|-----------------|
| Site            | DONGEN          |                 |
| Start Date      | 8-4-2011 7:00   | End Date        | 12-4-2011 7:00 |
| Area            | Actual          | Perc            | Ratio          |
| Incoming Water  | 10,9740 Mi      | 100.00%         | 1.31           |
| Product Water   | 7,3310 Mi       | 66.80%          | 0.07           |
| Process Water   | 9,1843 Mi       | 83.69%          | 1.09           |
| W/Treat In      | 10,6109 Mi      | 96.68%          | 1.26           |
| W/Treat Out     | 9,7813 Mi       | 89.13%          | 1.17           |
| W/Treat Loss    | 0,8287 Mi       | 7.55%           | 0.10           |
| Soft Water      | 0,3670 Mi       | 3.34%           | 0.04           |
| Chlorinated Water| 0,5970 Mi    | 5.44%           | 0.07           |
| CIP             | 0,1080 Mi       | 0.98%           | 0.01           |

**Figure 30 Water Report from MES**

But, again, there are a few problems with this percentage, making it not completely reliable in interpreting the information the correct way. For example, in the weekend, all the filters have to be flushed to ‘reset’ them for the coming week. There are different types of filters that need to be flushed, depending the amount of water that is cleaned by them. Besides, the amount of flush water can differ between types of flushes. This makes it very hard to determine whether a certain loss percentage is good; meaning no waste indicated or bad; meaning the process is wasting right now.

Based on historic data, we determined a target that can be used when the factory is in production state. In this state, no flushes are executed unless it is really needed, and operators will be able to explain why the loss percentage was not met, thereby giving us a chance to build knowledge about the use of the different flushes.

For the weekend, we could not determine a target and therefore we chose to produce a graph every Monday with all the water losses in the water treatment. This way we can determine whether strange activities can be found, shown in Figure 31.
Based on the organizational structure of CCE we identified the actors we wanted to engage with our water treatment approach. The environmental department started with the Manager Upstream and Team Leaders Upstream, the managers is responsible for all upstream activities, see chapter 3 for more information. The team leaders are with three, all are responsible for the upstream during the shifts but they also have a specialism. Those are water treatment, central warehouse and syrup room.

After a few meetings we noticed that among the team leaders the engagement with MES differed based on their specialism and the possibilities they identified with our approach. Which is an interesting observation and it also makes sense, but we tried to get all three team leaders engaged.

Finally we came to a compromise which is very promising, during the discussion on how to use MES and more specifically our target for the water treatment we suggested to involve the operators as well, so they can stop the waste at the source. This is now being implemented, all upstream operators have a task to check the loss in the water treatment, based on MES, every four hour. When the target is not met they need to investigate if the process is wasting or if it is being caused by the flushing of one of the filters. They document all actions. How this looks schematically can be found in appendix ix.

This approach builds knowledge about the filters flushes, and about wastage in the process. But even more important is whether the operators remove the losses. If this occurs every four hours, it results in real time savings. This is an advantage over the bottle washer approach, and shows us that we learned during this research. However the application of the weekend graph to find strange losses in the weekend is not used in the desired way. At this moment, we are able to recognize big losses but, smaller losses are not significant enough for us to notice, while in non-production mode, the water treatment is still losing quite some water (party inevitable because the filters will have to be flushed). This indicates that we engaged the upstream personnel, but they are not educated enough to change all information into knowledge that leads to continuous improvement. Therefore, in future, MES can be used even better, to reduce the energy and water consumption of the plant in Dongen. In the next paragraph we will elaborate on future research that needs to be done at CCE, to further engage the organization with MES.

8.3.4 Bottle blowing process

The last process where this research wants to engage employees, is the bottle blowing process. During the research, the first conversation with the team leader, who is responsible for the bottle blowing process, was held.
Here, the environmental department proposed a similar approach as presented in the previous paragraphs, to increase the energy efficiency of this processes.

It was found that the biggest room for improvement in this process, is the shutdown after production (or non-production). In the current situation the machines that produce the high pressure air, needed to blow the bottles from tubes, are on standby in the weekends. There are three machines, of which only one needs to be working slowly to keep pressure on the network, which is needed for technical reasons. From historical data, gathered from MES, we found that the machines were not always been shut down in the weekend. Therefore, this will be monitored by the environmental department and the team leader responsible for the bottle blowing process. This way, the efficiency of the process can be improved. The work approach for this is described in appendix ix.

During the production, the standard energy KPI applies to the bottle blowing process (kWh per 1000 liters) liters in this case is number of bottle times their size. But at this moment, there were no targets for the bottle sizes and there was not enough time to determine all those KPI's. Therefore the environmental department will continue folding out the work approach, so it can also be used during production.

8.4 Conclusion: Improving energy and water efficiency based on MES

In this chapter is zoomed in on the request from the environmental department, which is defined as follows;

How can the environmental department of Coca-Cola Enterprises in Dongen use the Management Execution System to reduce the energy and water consumption?

To answer this question the framework to make MES successful is taken and applied to the environmental department of CCE in Dongen. We found that not all factors in the framework can be influenced by the environmental department because they are outside their responsibility. This led to an reduced number of factors that will be focused on in this chapter, those can be found in Figure 28 at page 77. The most important factors, engagement and data accuracy, are within their responsibility.

Therefore an approach is made that will engage all relevant actors in the field of energy and water efficiency improvement. Because CCE is existing organization with its own way of working, and the resources of the environmental department are limited (and so it the time of the research). Two deliberately chosen boundary are given to the approach;

- Use existing mechanisms for efficiency improvement. Which is the dashboard meeting where daily the most important KPIs are reviewed.
- Start engaging employees regarding, significant processes with room for improvement.

The boundaries led to a two pillar approach which will be executed to engage the relevant employees.

Firstly the energy and water KPI that are discussed daily in the dashboard are shaped in order for them to be about performance. This is done by analyzing which external factors influence the energy KPI without influencing the performance. We found that the temperature and the volume of line 3 (because there is the bottle washer) have a big influence. A tool is made that can account for those effects, this enables the environmental department to have actual information about the energy performance of the plant which is reported to the dashboard meeting. Besides the daily KPI reviews incorporates the most significant users of energy and water,
every morning there KPI’s are reviewed to see if the performance of the plant was desirable. This pillar mainly builds knowledge about the plant on which improvement projects can be based.

The Second pillar focusses on engaging employees who work directly with significant processes for energy and water efficiency. An analysis is done to identify processes that use a significant amount of energy or water and leave room for improvement. This resulted in three processes where we wanted to engage employees during this research; the bottle washer process, the water treatment process, and the bottle blowing process. The employees regarding those processes were educated on how to use MES, what they could do to improve when the KPI of there process is not met. Besides clear responsibilities were assigned to employees regarding the KPI’s and actions based on those KPI’s. We basically started with all the factors of the framework and while engaging the employees we found that some factors need more attention with certain processes than with others. This led to iterative processes where all the success factors need to be satisfied, some more often than others. How CCE works to improve the energy and water efficiency of the plant based on MES can be found in appendix ix and appendix x.

Fortunately at the end of the research the results of the two pillar approach could already be noticed. Firstly the satisfaction and ease of preparing the daily KPI performance increased a lot, giving both the environmental department and the dashboard meeting more insight the actual performance of the plant. Which will lead to improvement project in future. Secondly, more employees work with MES and are actually improving the efficiency of the of the plant based on the information the system presents them, a short example; In water treatment an unnecessarily opened valve was found and closed based on the information from MES. This valve would have been leaking for hours if the operator would not have been engaged with MES.

Throughout the research at CCE, some challenges were encountered that could not be solved during the research. This was sometimes caused by the simple fact that changes in the organization or on the MES take a while to become effective. Other times due to limited time or simply because we were not able to find a solution. This resulted in recommendations to environmental department which they can use to keep on improving the energy and water efficiency in the plant. Those recommendations can be found throughout this chapter and are summarized here.

Firstly, some elaboration on functionalities that are missing in our opinion regarding the CRS module of the MES;

- Enable MES to present trend analysis to increase user-friendliness
- Add central gas gauge to MES in order to improve the functionality
- Add central Low Pressure air meter
- Incorporate steam boiler in MES in order to improve the functionality (appendix iv)

Secondly, some actions that can be taken to further engage the relevant employees in order to improve the energy and water efficiency ever further are;

- Extent water loss analysis to identify more relevant processes
- Extent energy and water efficiency approach with;
  - CIP syrup room
  - Steam Boilers (once in MES)

Both process use a significant amount of energy. Beside the CIP syrup room also uses a lot of water. In this research the CIP was left out due to time pressure and the steam boilers due to the fact that MES does not have the functionality (yet).

- Further implement blowing processes approach
As mentioned, we only recently started on the implementation, the environmental department will finalize and further implement the approach.

- **Increase insight in the water treatment process regarding water loss**

  In the water treatment approach there is one main KPI for the whole water treatment approach. On this KPI all decisions are based. However it was experienced that it can be hard to explain what processes in the water treatment cause a overrun of the KPI to happen. Therefore more insight in this process will increase the number defects found based on the KPI improving the water efficiency even more. CCE is already investigating this.

- **Start reviewing the energy and water weekend KPI in the dashboard meeting to improve the KPI tree**

  In the current situation only on week days the KPI’s for energy and water are discussed, therefore everything that happens in the area of energy and water in the weekends is not discussed in the dashboard meeting. But many things happen in the weekends that are relevant for the overall energy and water efficiency. For example, all water filters are flushed which uses a lot of water and energy (heating of flush water). Therefore we advise to design energy and water KPI’s for the weekend that can also be reviewed by the dashboard.
Part IV
Discussion, reflection, conclusion and recommendations

In this part a discussion on the framework is held. Thereafter is reflected on the research. Then the research will be concluded by answering the research questions. This will lead to recommendation for CCE, both the management team and the environmental department will be discussed. Finally an elaboration on future research is given.

9. Discussion on the framework
10. Reflection on the research
11. Conclusion
12. Recommendations
13. Avenues for future research
Discussion on the framework

In the sixth chapter we assessed the framework with an expert in the MES field, which helped us to gain more insight in the application of the framework. Now, it would be interesting to know whether the framework can be applied to other organizations than CCE. Maybe it is even usable in other sectors than the sector of fast moving consumer goods. This will be done by answering the following sub question.

To what extent can the developed framework be applied to other enterprises?

This led to three discussion areas; the application of the framework; Possible weaknesses of the framework; Possible success factors. They will now be discussed.

9.1 On the application of the framework

First of all, in the second chapter is defined, that MES can only be successful in a manufacturing environment, since this is a condition for MES in itself. Therefore, we assumed that the framework would also only be applicable to a manufacturing environment, too. But Mauch (2009a) argues that the principle of continuous improvement can also be applied to service organizations. Since we concluded that MES can contribute to continuous improvement strategies combined with the fact that the framework can be applied to every MES, this would mean that service organization could benefit from the framework as well. This contradicts one of the starting conditions of this research.

Imagine a service organization, the first thing that comes to mind is that there are many types of services, complicating the question. Therefore we will look from the technical requirements side of a MES, which brings us to the fact that MES must be able to gather data from some kind of counter. Therefore the type of process must be measurable. IT services, for example, might be easy to measure. In banks also a lot of data gathering is done; think about the time it takes a consumer to do a certain act in a bank. Modern technology might enable service organizations to gather the data that is needed to feed a MES.

Besides the other success factors that are identified might very well be applied to service organization as well.

Concluding, common sense agrees with Mauch (2009a), when a service organization is able to gather the data, then why could a MES not be successful there? But the reozoning presented here is far from sufficient to make such a statement. Therefore this research will not deny the possibility and would be very interested in further research on the question if the framework, and MES in general, could be successful in service organizations.

A more evident application area would be; another type of production process. As mentioned before, the production process of CCE is can be illustrated as batch-wise according to ISA standards (ANSI/ISA, 2000). They identified two others; a continuous production process, and a discrete production process. An example of a continuous production process is a refinery, since the continuous production processes keeps on cracking the crude oil to; gasoline, kerosene, etc. A discrete production process does the same thing as the continuous one, but it produces entities instead of a continuous flow.

Sticking to the refinery example, the same values of continuous improvement are applicable to a continuous production process and there a MES can be beneficial, as we concluded from the CCE case. The same thing applies for a discreet production process. Since the principles are the same, we assume that the framework can be applied to other manufacturing organizations that have a MES as well, given that they strive for one of the continuous improvement strategies.
The final question regarding the applicability of the framework arises when the strategy it must contribute to is evaluated. The framework (page 50) is continuously trying to improve the core principles of operational excellence. When the other conventional management theories are reviewed; product leadership; and customer intimacy, different values are found. Such as customer relations; optimal service delivery; etc. (Nieuwenhuis, 2010). The question is if those principle can be improved continuously based on information from MES, or if those principles evolve around the relationships with customers. Because this relation might be too complex to measure and it is even more complex to improve based on information that might be constructed. Therefore we concluded that the framework might be applied to industrial production plant with a different strategy, as long as; they strive for continuous improvement of their processes, based on information that can be presented by MES.

9.2 On possible weaknesses of the framework

As we discussed earlier, the framework focuses on making MES a success after the designing and building phase. This leads to a complication. Some of the success factors that we identified, overflow those boundaries. The capability of- and relation with- the MES is one of those factors. When a MES is designed, this is often done in collaboration with the MES supplier. Design choices are made, based on potential savings and the cost to deliver the functionality required for the saving. Besides, it will difficult and expensive to change from MES supplier. Therefore, it can be hard to influence the capability of the MES supplier in the phase the presented framework is active. This inevitably results in an influence of decisions made in the past effecting the successfullness of the MES in the implementation and continuous improvement phase, while we decided to leave this part out of the research.

This is a weakness of the framework, because to be able to guarantee the success of the process it should take the entire life cycle into account. Because the goals of the system are defined before the MES is implemented, it could be measured if the goals are reached, and thereby the success of the system can be determined.

Another factor that has a big impact on the framework, it the fact that this research is conducted at CCE. Many of the success factors are found in literature, but are inspired by the challenges that were experienced with the MES of CCE, which might be different from other MES. The fact that participatory action research is used as research method, only strengthens the idea that the framework is useful for CCE, but might not be in general. In recent years, more MES are implemented. Some of those systems have the ability to influence the process without human interference. When the MES of CCE would have been able to do this, this might have changed the way we defined the research challenge, which is mainly based on the challenge on how people can make actual improvements based on the information presented by MES, with the condition that the information is accurate.

But even though some MES might be able to reduce some waste on their own, they will never be able to initiate improvement project themselves, nor will they be able to execute them. Therefore, the investigated gap will also be relevant for those MES, that have some acting skills. Furthermore, we concluded in the framework assessment of the sixth chapter, that the framework is also useful for other MES.

While applying the framework to CCE, an important question was raised. When CCE decides to implement the recommendations of this research, what will it (the increased functionally, a MES champion with a full time salary, and so on) cost us, and what will we it bear the organization? In this research we did not calculate the cost of the proposed improvements, which would have been a valuable addition, because ‘money is what make the world goes around’, especially among big multinationals. The same applies for the potential benefits in savings (energy and water reduction, decreased throughput time, increased quality, deceased use of raw materials, and so on).
Still, CCE wants to let MES succeed, also to reach their CRS goals. When the MES is successful in contributing to OE helping to best the competition, we are satisfied, nevertheless we acknowledge that it could have been a valuable addition to this research.

Finally the framework helps structuring the challenges, and will help to find solutions for those challenges per success factor. But in this research we also present an integrated approach. This approach is based on the challenges and solutions from the framework but the order in which they are solved is based on choices made by the researcher. The framework does not present an approach on how such an integrated approach can be reproduced. Therefore common sense and an out-of-the-box way of thinking will always influence the quality of the integrated approach that is necessary when an organization is advised based on the framework, this must be kept in mind.

In line with remark we want to note that the success factors imply a certain sense of importance in making the MES successful. In some factors possible actions are proposed but none of them give a structured technique or tool to actually bring the factor in practice. Fortunately Basu (2004) concludes that this happens in many researches regarding quality management theories, a special technique or tool per success factor is useful when bringing the framework to practice.

### 9.3 On potential success factors

During this research we had to make some choices on which success factors to incorporate in the framework, as there were some we did not found relevant enough to elaborate upon. This was mostly done because those factors did not contribute to continuous improvement. But some of those were definitely relevant for successfulness of the MES as IT system. They were identified during the assessment by the expert, and during discussions about the framework. A few success factors passed by that were left out of the framework, but that might be interesting.

The first is the ‘cost effectiveness’ of the system itself, as it became clear in this research that when a MES is implemented, it is not only the goal to recoup the investment cost of the system. The cost effectiveness of the system itself is also important. It basically assesses the question, ‘are we not spending too much money on the system?’ The first thought is often on the investment cost that needs to be made, but the maintains costs of a MES can also be substantial. Besides those direct costs, the employees of an organization also have to put a lot of time in building and using the system, all of which are costs that should be taken into account. If an employee needs to spend two hours a week on the MES of supplier A and only one hour on the MES supplier B for the same information, this difference can make a big difference in costs for an organization. Therefore, the cost effectiveness is often used as KPI for an IT system. In some cases the main responsible function (MES champion) will also be rewarded on this factor (Scholten, 2010). We chose to leave it out the framework, because, in our opinion, it does not contribute to the engagement an organization has with a MES and therefore we concluded that it does not fit within the scope of this framework, although it is important.

The second factor that was considered as success factor, is the security of the system. A Management Execution System is based on a server that often can be accessed from the internet. This online access is useful for employees who work from their homes, and for comparison of multiple sites from one central location. Basically, the system does not work on a closed system, which makes it vulnerable for unwanted access. Cyber-crime thus can be a threat for the safety of the system, as illegal access can result in stolen information about the production process, recipes, and financial information. Basically all information incorporated in the system can be stolen. Next to this,
some processes depend on MES, and when the system is not operational, this can have a negative influence on the output of the process.

The threat of cyber-crime is increasing (O'Rourke & Gollings, 2011), therefore the MES supplier and the IT department must guarantee the security of the system. We left this out of the framework for the same reason as the ‘cost effectiveness’, but it is definitely an important factor that should be taken into account, when a MES implemented, mainly by the IT department of the company and the MES supplier.

9.4 On how to use the framework

With the framework a stepwise approach on how to use it was given (page 52). The stepwise approach can be performed by the MES champion in order to improve the contribution of the MES continuously towards Operational Excellence.

The previous paragraph elaborated upon the completeness and validity of relations and factors in the framework. We found that all factors are important in letting MES succeed also they constantly need to be monitored. Mauch (2009a) explains that, due to a changing market, the organizational needs change with it. In the case of the CCE this means new products and packs, promotion actions, and changing quality demands. The MES needs to be kept up to date and needs to change with the organization, therefore the stepwise approach cannot be executed once; it has to be executed over and over again, like a continuous improvement process.

The first step defined in the stepwise approach - appointing a MES champion – always needs to be done first. The order in which the steps are placed thereafter may vary between organizations. As can be imagined, the challenges that are found when the engagement and data accuracy are checked upon might vary, and therefore the solutions might vary. Therefore, when applying the stepwise approach the MES champion should view the order of the steps as example and flexible.

Finally, a possible way of measuring the savings of MES to see whether the goals of the system are met, is introduced. As can be noticed, this topic is only slightly touched upon. For this research, the focus is on engaging people with MES, we concluded that it does make the system successful in contributing to OE as business strategy. How to measure the system’s performance is therefore outside the scope of this research, but it can be interesting to conduct more research in the matter; to get a better insight if the return on the investment of MES is positive.

9.5 Conclusion: framework generalization

In this chapter the framework was elaborated upon. This was done by first discussing the applicability of the framework. Thereafter the possible weaknesses are discussed and finally we elaborated on some success factors that are left out his research. This was done to answer the final sub question;

To what extent can the developed framework be applied to other enterprises?

We elaborated on the applicability of the framework on other enterprises and found a few conditions.

Firstly the possibility to apply the framework to a service organization was investigated. We argue that that when a service organization is able to gather the data required for MES (processes must be measurable in effective way) then the framework can also be applied to a service organization. However, we acknowledge that the rezoning presented in this chapter is far from sufficient to make such a statement. Therefore this research will not deny the possibility and would be very interested in further research on the question if the framework, and MES in general, could be successful in service organizations.

Secondly a more evident application area would be on another type of production process. As mentioned before, the production process of CCE can be illustrated as batch-wise production process. The ISA identifies two
others; a continuous production process, and a discrete production process. The same values of continuous improvement are applicable to the other production types and therefore we assume that the framework can be applied to other production processes as well.

Thirdly the question rises if the framework can also be applied to enterprise with another business strategy. The framework strives for continuous improvement, this is taken as reference point. When the other conventional management theories are reviewed; product leadership and customer intimacy different values are found, such as customer relations; optimal service delivery; etc. Those values might not benefit from continuous improvement as it meant in OE. Therefore we concluded that the framework might be applied to industrial production plants with a different strategy as long as they strive for continuous improvement of their processes based on information that be acquired from MES.

Concluding, to find out if the framework can be applied to service organizations as well more research is needed. The framework can be applied to an enterprise with another production process but that is striving for OE. In case an enterprise strives for a different conventional management theory, then must be determined if that strategy embraces continuous improvement. If this is the case the framework can also be applied to such an organization. If not the framework might not be useful.

The researchers acquired knowledge on Management Execution Systems, within the environment he participated in during the research, is the main input for the conclusions mentioned here. These findings are not validated by means of for example a cause study with another enterprise or a survey about the usability in other enterprises.; They are only elaborated upon based on the knowledge of the researcher with the help of a MES expert.

Furthermore a few weaknesses of the framework were identified;

Firstly, the framework is only applicable from the end of implementation phase of a MES until the end of life cycle. However in the phase before the implementation phase (investment decisions and design and build phase) many important decision are made that do influence the successfulness of the system. This is outside the scope of this research but it does influences this research. Also some of the success factor overlap the phases we identified.

Secondly the research is conducted at CCE. Many of the success factors are found in literature, but are inspired by the challenges that were experienced with the MES of CCE, which might be different from other MES. The fact that participatory action research is used as research method, only strengthens the idea that the framework is useful for CCE, but might not be in general.

Thirdly the current framework does not foresee in a cost benefit analysis, meaning that when an integrated approach is given to improvement the results of MES the cost and benefits might be interesting but will have to be calculated based on the integrated approach not on the framework.

This is partly touched upon by the last step in the stepwise approach of using the framework, here is explained that the benefits of the systems can be expressed in short term gains based on the real time module and longer term benefits based on improvement projects started by the knowledge build based on MES. However more research is needed to determine how the benefits can be quantified sufficient.

Furthermore some success factors that might been added but are left out of the framework because they do not contribute to continuous improvement, however they can influence the successfulness of the system;

The first one is the cost-effectiveness of the system itself. When MES is implemented in an industrial production plant the enterprise is not only trying to recoup their investment on the system, they are trying to let all
the benefits of MES add to their overall strategy. But the cost of the system can influence the success of the system, especially when the cost of the system start over shadowing the benefits of the system. Although this factor is important and could be taken into account, it does not directly contribute to engagement or continuous improvement of the process, therefore it is left out of the framework.

The second factor is the security of the system, nowadays the treat of cybercrime is increasing making the security of the system an important factor, even more for a company as Coca-Cola Enterprises. But again, since it does not contribute to continuous improvement it was left out of the framework.
10 Reflection on the research

In this chapter, a reflection on the research itself is conducted. Firstly is reflected on the structure of the research. Secondly is reflected on the energy and water efficiency improvement approach. In the next chapter an elaborate reflection on the framework for successful MES contribution to OE can be found.

10.1 On the structure of the research

During the research, the scope of the research changed a few times. Besides that, there was a struggle between the academic relevance and practical relevance of the research. When reading the report this can be noticed, especially in the second part, where the framework is introduced, and the third part, where is shown how MES can be used to improve the energy and water efficiency in Dongen, appear to be slightly different research projects within one research.

This was mainly caused by the practical fact that we were trying to use the MES in every possible way to improve the water and energy efficiency of the plant. How this was done, is explained in the third part. But the problem we encountered was that the MES was not yet functioning as desired at that moment. This meant that the data sometimes were not accurate, some employees were not working with the system, some functionalities were missing, etcetera.

Only using the CRS module of MES in the area of energy and water would not give Coca-Cola Enterprises a satisfying answer to their question. Therefore, it was decided to help CCE in giving the last push to the MES implementation, which is more interesting from a scientific point of view as well. Because here, existing knowledge about IT systems can be combined with finding a framework that can be used to solve the problems. Next to this, we will see how this works at CCE and learn from the application.

The difficulty with the four part structure of the report is that the advice, given in the second part of the research, should be executed by the MES champion or a senior manager, while the approach described in the third part is the responsibility of the environmental department. The fact that the two part advice different actors, creates tension. Next to this, some responsibilities and effects have an overlap which makes everything even more complex.

This can be illustrated by the following example: the operators on the lines have to insert the material IDs in MES to make the MES able to calculate the produced volume. When this is not done correctly, the main KPI’s for both energy and water are wrong, since they are based on the use of energy and water versus the production volume. The environmental manager sees the problems, because his KPI’s are wrong, but it is the production manager who must correct the operators. However, the production manager might have different goals, and therefore does not prioritize the MES tasks the same way the environmental manager would have done.

In this research was therefore chosen to give an advice to the MES champion with a stepwise holistic approach on how the challenges can be solved, and how to give the last push to the implementation of MES in making it successful in the contribution to the business strategy. The next chapter will reflect on the framework and this advice. Thereafter, assuming that the holistic approach will solve most challenges, we investigate how the MES could be used for the environmental department. On this will be elaborated in the next paragraph.
10.2 On the energy and water efficiency improvement approach

As is explained in the previous paragraph the framework is reflected upon in the next chapter. Now is reflected on the third part.

When the research started, the MES was only recently ‘live’ and therefore the engagement with the system was low. Besides that, the environmental department did not have a clear idea on how to use the MES to improve the energy and water efficiency, nor did the researcher at that time. Therefore, the starting point was to find significant users of energy and make an approach on how the efficiency of those processes can be mapped and improved. The MES was regarded as a new tool that could, not had, to be used to monitor those processes.

Later in the research, we discovered that most significant processes could be monitored using MES, but that the relevant actors were not using the MES to do so, leaving potential efficiency improvements unused. From this realization the idea of the factor engagement was born. Next to that, and in collaboration with the environmental department, we started to engage actors with the MES, by explaining the benefits and how the system works, on the one hand letting the actors be more efficient themselves based on MES, and on the other hand by letting them report to the environmental department. When the actors started to report the environmental department, it became more clear where efficiency gain could be made on long term.

This two pillar approach was used when engaging actors who were working with the significant processes. The first pillar: teach them to work more effective, based on the information from MES about the significant processes. Think about a steam KPI, when it is higher than x, check the machine because there is a problem. Secondly, the environmental department builds knowledge about the significant processes that can be used to improve the efficiency in future. Think about; that machines breaks down a lot, let buy a new one.

This approach was effective for CCE, but, maybe, for other organizations or other MES this does not work. Here lays the weakness of the third part. Although the approach is based on the factors of the framework, which are validated with the interviews at CCE, and by the expert, while they were also found in literature, not all factors of the framework were used engaging the relevant employees for energy and water.

Mainly because of the fact that engaging people is a human process, some people are more enthusiastic than others. Besides that, we used the existing mechanisms in the plant, when the framework would have been applied despite those mechanisms, the third part would have been different. For example; the daily KPI performance approach (8.3.1 at page 78) would have been shaped differently. It would not have been on a daily basis but on a weekly basis, because that way the weekend usage of water and energy could also have been taken into account, and, furthermore, the external factors would have a smaller effect. The knowledge of the system would still have been built, and for the real time efficiency improvement reviewing the KPI’s every 24 hours is useless. This can only be done by the operators on the line in real time.

Put shortly, the third part of this research is mainly shaped by an iterative processes during the time of research that gave a lot of input for the framework. But because real life is not perfect - we had to deal with existing mechanisms - and the framework was not available from the beginning, the approach chosen to engage the relevant actors for energy and water efficiency improvement would have been different when it would have been solely based on the framework. Nevertheless, the approach works for CCE and we were able to engage employees that work with the significant processes for energy and water. Besides that, the environmental department is building knowledge with the information it gets from MES and from the engaged actors.

Now the employees are engaged, more waste in the significant processes is found, which already has let to efficiency improvements. An example of this is an operator, who monitored the KPI for the water treatment, found
that the KPI was not met and investigated the processes. He found an open valve in the night shift, which he closed. Normally the first time this problem could have been found would have been the following morning.

During this research, not all processes where the energy and water efficiency could be improved were taken into account. Therefore, the environmental department will continue to engage people using the approach used in part three, hopefully improving the approach and thereby efficiency as a whole.

### 10.3 On personal experiences

Finally we will shortly reflect on the personal experiences encountered during this research and how those experiences effected the research.

Firstly, during the research a struggle between the scientific aspect on the one hand and the practical aspect on the other hand complicated the research. Especially in the beginning the relation between the two aspects was hard to find for the researcher, which led to a split in the research. The experiences that we had at CCE every day could not be linked to the papers and books red about the topic, therefore the scientific research went in a slightly different direction than practical one at CCE. The gap was a its fullest during the midterm meeting (when this research was half way), there we realized that the experiences should feed the literature research and that this give a better understanding of the challenges seen in practice. When we got this clear the research approach was formed into participatory action research, which is a very fitting methodology in hindsight.

However the gap between the scientific and practical side of the research was by then quite big and the struggle to align the research began. Interestingly the alignment here was as important and interesting as the alignment of the organization of CCE with their MES and the other way around.

Although the research has become a quite homogeneous the gap can still be noticed by the second and third part that follow up and never became as homogeneous as we would have liked.

Secondly, a struggle between the work for CCE and the scientific relevance requested by the Delft University of Technology requested a lot of energy. But it was also the most learning full experiences of writing this thesis. Because working for CCE gave countless experiences that could feed the research and the tutoring form Delft gave insights that we might not have had on our own. Also figuring out the weight of scientific relevance and practical relevance was an interesting process, that definitely shaped the way this research is presented. There are many stories more to tell about the time we spend at CCE, but scoping choices needed to be made.

Concluding, due to the gap between the scientific and practical relevance, which was created by the researcher, this research might not feel completely homogeneous, especially between the second and third part. In hindsight we should have embraced the scientific input right from the start. Secondly, the work done for CCE took a lot of energy but also gave endless experiences that could be used in the research. The balancing was perhaps the most learning full experience during this research and we would not have done that any other way.

### 10.4 Conclusion: difficulties of the research approach

The difficulty in the structure of the report lays in the fact that the second part advices the MES champion while the third part advices the environmental department. Because the framework advises the MES champion, who has different goals and responsibilities, it is difficult for the champion to fully use the framework to engage employees in the field of energy and water. Besides that, at CCE some mechanisms for energy and water efficiency are already in place and we took those into consideration, because changing an organization can be tough.
However, during the research, we were able to engage relevant employees with MES, which made the plant more energy and water efficient, and thus made the MES more successful in contributing to Operational Excellence.
11 Conclusions

In the introduction the research challenge was defined as finding a holistic Operational Excellence approach for the implementation of Management Executions Systems in an industrial production plant. This led to the research question;

*How can the implementation of a Management Execution System contribute to the strategy of the Operational Excellence in the industrial production plant of Coca-Cola Enterprises in Dongen?*

The main research question is wider question than the initial request of CCE that can be described by the following problem statement:

*How can the MES of CCE adequately contribute to the improvement of the energy and water efficiency in the CCE plant in Dongen, without new investments?*

However first the MES must be successful in contributing to OE, the second part of this research was spend explained how this was done. Thereafter the energy and water efficiency of the plant in Dongen can be improved based on MES. This was described in the third part of this research.

In this conclusion the sub questions that enable the answering of the main question are discussed. This also led to recommendation to the management team of CCE and the environmental department of CCE that can be found in the next chapter. During this chapter we will work towards solving the problem of the environmental department.

Based on the experiences gained at CCE the interest in the interface between the; the technical aspect of MES, and the organization that has to adapt it, was aroused. Therefore the focus is on which factors are needed from both a technical and organizational perspective. This led to the first and second sub question.

1. **What technical factors are essential for a Management Execution System to be successful in contributing to an Operational Excellence strategy?**

Firstly, a good representation of an industrial production plant is required to let a MES succeed. The ISA-95 guideline gives an excellent grip to investigate if the desired functionality of a MES is met and how that functionally can be reached. Besides discussion and interviews with the employees that will work with the system regarding specific processes can be held. This way you can find out if and how a certain processes should be incorporated in MES.

Secondly, to make MES successful it needs to be integrated in a plants IT environment. This increases the functionalities, because data can be assessed that otherwise might not have been available. On the other hand, employees only have to insert data in only one IT system. While making the data available to all IT systems, thus reducing IT redundancy. The challenge lays within the technical integration of the IT systems, which can be complex. Therefore the MES supplier has to be competent. This resulted in next success factor.

Thirdly, the capabilities and relationship with the MES supplier are essential to let a MES succeed. That the capabilities of MES supplier must be outstanding might be an obvious finding, but the cost of the system might cloud the judgment of the acquiring enterprise regarding the quality the supplier can deliver. Therefore the
acquiring enterprise needs an experienced project team or the expertise of a third party to select the supplier. The actual selection of a MES supplier is outside the scope of this report. Therefore the focuses will be more on the relationship with the chosen supplier.

Throughout the whole MES life cycle the relationship with the supplier essential. During the implementation this relation is needed to smoothly implement the system, but also on the longer term to keep the system updated to future desires the supplier is needed. A solid relation needs to be built from day one, information sharing and combining employees of the supplier and buyer in the project team both improve this relationship.

2. How can an industrial production plant and its Management Execution System be organized in order to successfully add to an Operational Excellence strategy?
During the research is established that the most important factor is engagement, this is defined in this research as follows;

An organization is engaged when; all relevant employees use a system, and all relevant employees have the knowhow to use the system in order to continuously improve.

Engagement can be accomplished when six factors are satisfied, the first one is clear responsibilities. They need to be defined and communicated within an organization. This needs to be done in two areas;

First, it needs to be clear which party is responsible for MES as a system, especially when MES integrated with other IT systems in the industrial production plant.

Secondly it needs to be clear which party is responsible per functionality of MES. In the investment decision cost reductions are identified in various parts of the plant, they are translated to functionalities that can be found in the MES. In order to realize those improvements a party must feel responsible to actually achieve the improvement.

The second factor is the KPI tree; an adequate KPI tree is needed for the information to flow from the shop floor to the management and in opposite direction for the decisions made by the management to be communicated downward. Every important KPI is discussed in a dashboard meeting; every department has its own decomposed KPI’s from the main ones discussed. This way control over the factory is guaranteed. The KPI’s need to be aligned with the goals and organizational structure.

The third factor is education and training; employees need to know where to find the information in the system, they need training to learn how to be able to retrieve this information themselves. More importantly they need be educated how they can use the information to actually improve based on the information from MES.

To secure the right implementation of these factors a form of supervision or leadership that guarantees the right execution of these factors should be exercised. Transformational leadership is suggested as a way to inspire employees to align their goals with the goals of the organization. This way, a clear and especially broadly accepted KPI tree is more likely to be successfully constructed and education and training is more likely to be set up in such a way it contributes to the empowerment of employees.

The fifth factor is user-friendliness. In this research user-friendliness is assessed by two criteria, the ease of use and the ease of learning. Basically this means that a person is able to quickly use the system and once the person understands the system it will be easy to operate it in the future. Both criteria are taken into account when the user-friendliness of a MES is reviewed.

The last factor is data accuracy, In this research we found that there is a feedback between engagement and data accuracy. Basically managers start using MES less when they perceive the information from the system as
inaccurate, operators also start entering less data into the system because they notice that the data is not used, this has a negative impact on the accuracy and completeness of the system, starting the cycle again. Therefore it is essential that system is accurate and all relevant employees, use the system and stimulate others to work with the system as well.

3. How can the identified success factors be framed in such a way that a well-defined method is developed to support an industrial production plant in successfully implementing a Management Execution System?

In the sixth chapter, supported by interviews held at CCE, the relevance of the success factors was established. Thereafter the relation between the success factors is established. This resulted in the framework for successful MES contribution to operational excellence, that is shown in Figure 32 at the next page. The arrows represented the effect one factors has on another. For example, user friendliness influences engagement directly; when an employee cannot find the desired information in the system, or has to spend a lot of time on the system, an employee will resort to other ways to gain the information. Leading directly to a decrease in engagement.

In the second figure at the next page presents; a stepwise approach on how the framework can used. In this research is concluded that the order of the steps presented in Figure 33 might be changed based on the findings in second step (map out situation based on; the engagement; data accuracy; and IT integration). The type of challenges found might request for a different order, than presented, in solving them.

In the sixth chapter the results of a the interviews with a MES expert are presented as well. The MES expert assessed the framework and concluded that is extensive and useful in contributing to a successful MES, besides the expert reasoned that the framework would be useful in other organizations as well.
Figure 32 The Framework for a successful contribution of MES to OE | Relations between factors

Figure 33 The Framework for a successful contribution of MES to OE | stepwise approach
4. **Based on the framework, what changes can Coca-Cola Enterprises make to improve the success of their Management Execution System?**

Firstly, all success factors are applied individually to CCE, this resulted in many challenges and possible solutions on the various topics of the success factors. Based on the stepwise approach of the framework, and some creativity, an integrated solution to solve the challenges at CCE is presented. This approach can be found in chapter 12 and aims to advice the management team of the CCE in Dongen.

5. **How can the environmental department of Coca-Cola Enterprises in Dongen use the Management Execution System to reduce the energy and water consumption?**

First the situation for CRS module was mapped out. Since the MES is recently implemented, the engagement was low and some variation in the data accuracy was found. In cooperation with the environmental department a way was found to engage the relevant employees in the area of energy and water. Yet first we had to find out who were relevant in the first place. This depended on the relevant processes: all processes significantly contributing to energy and water usage were identified, and subsequently the processes with room for improvement on these subjects were selected. This resulted in the following three processes:

1. Bottle washer
2. Water treatment process
3. Bottle blowing process

To engage the employees that work with those processes we ‘stepped’ so to say into the factor (relational) leadership and basically took the role of ‘MES vice champion’ in the CRS module. From this position we:

1. ... experienced a low engagement overall (see interviews in appendices) and tried to identify (framework) success factors that held potential for improvement;
2. ... reviewed data accuracy as much as possible, indeed finding some errors which were communicated and corrected, and by this restoring potential engagement;
3. ... used the ISA 95 guidelines were relevant for the CRS module to asses IT integration and functionalities (see appendix iii);
4. ... improved user-friendliness of processing MES information by making more efficient, more clear and more easy to use spreadsheets in excel;
5. ... assessed the current KPI mechanism and assigned new or more clear responsibilities based on this;
6. ... aimed at educated employees ourselves by exercising relational leadership; this means in this specific case talking to employees, asking them questions and explaining them the goals and relevancies of them using of MES. On top of that the training center of CCE is looking into ways of providing the (relevant) employees with actual trainings.

To give you a short example of one of the experiences leading to above said: When applying the KPI tree success factor it was found that there is already a KPI mechanism in place at CCE. This is called the ‘dashboard meeting’ In this meeting the most important KPI’s are discussed by the management team. Since it is hard to change any part of an hierarchically structured organization on the short term, it was decided to use those KPI’s in the most valuable way as possible. On top of that those meeting hold a lot of decision power, which makes that the KPI’s discussed in those meetings are thought of as very relevant making it even more suitable for our research. The environmental department has the responsibility to produce key figures for the KPI’s for energy and water. We found that the energy KPI [kWh/1000l product] is influenced by some external factors. These external factors can
significantly influence the KPI while the plant performance does not change at all. Therefore an excel tool was made that can correct for the energy KPI given the change in those external factors. Two examples are correcting for temperature and correcting for the water usage of line 3. When it is cold during winter a lot of energy is used to heat the plant, which means the energy KPI should be higher during winter. Volume line 3 is the line were the glass bottles are washed and the bottle washer used for this uses a lot of energy. The original KPI did not take this into account. Because the new excel tool accounts for those factors the dashboard meeting is able to make decision based on the actual performance of the plant.

This resulted in two pillars where we engaged people with MES that has already led to efficiency improvements in the area of energy and water. First we engaged employees that work with significant processes in the area of energy and water. They are mainly using the real time functionality of MES to continuously improvement the efficiency of their process. An example of a result of this in the water treatment: an unnecessarily opened valve was found and closed based on the information from MES. This valve would have been leaking for hours if the operator would not have been engaged with MES and checked the KPI for the water treatment. By removing the cause of the waste the efficiency was improved. In case this valve has problems often the operational excellence team will structurally improve the situation and thus the efficiency.

Secondly we further engaged the management team with MES and improved the information they receive from MES. Based on this information the management team will initiate improvement projects that can structurally improve the energy and water efficiency of their plant. An example of such a project could be the replacing the of bottle washer by a more efficient process.

6. To what extent can the developed framework be applied to other enterprises?
Firstly the possibility to apply the framework to a service organization was investigated. We argue that that when a service organization is able to gather the data required for MES (processes must be measurable in effective way) then the framework can also be applied to a service organization. However, we acknowledge that the rezoning presented in this chapter is far from sufficient to make such a statement. Therefore this research will not deny the possibility and would be very interested in further research on the question if the framework, and MES in general, could be successful in service organizations.

Secondly a more evident application area would be on another type of production process. As mentioned before, the production process of CCE can be illustrated as batch-wise production process. The ISA identifies two others; a continuous production process, and a discrete production process. The same values of continuous improvement are applicable to the other production types and therefore we assume that the framework can be applied to other production processes as well.

Thirdly the question rises if the framework can also be applied to enterprise with another business strategy. The framework is built for a successful MES contribution to Operational Excellence, this is taken as reference point. When the other conventional management theories are reviewed; product leadership and customer intimacy different values are found, such as customer relations; optimal service delivery; etc. Those values might not benefit from continuous improvement as it is meant in OE. Therefore we concluded that the framework might be applied to industrial production plants with a different strategy as long as they strive for continuous improvement of their processes based on information that be presented by MES.

How can the implementation of a Management Execution System contribute to the strategy of the Operational Excellence in an industrial production plant?
MES contributes to three main aspects of OE; customer satisfaction, employee involvement, and process improvement. The main contribution of MES to those factors is the information it can present to the employees of an industrial production plant on which they can continuously improve the industrial productions plant efficiency. This research found that the main pitfall lays in the interface between MES and employee. Therefore we defined the term engagement in this research as follows;

*An organization is engaged when; all relevant employees use a system, and all relevant employees have the knowhow to use the system in order to continuously improve.*

Without engagement an MES cannot be successful because there will always be benefits that the MES offers, which are not exploited. Therefore the framework was made, in the framework the success factors all, directly or indirectly, increase the engagement when they are satisfied. Besides the framework also satisfies the technical aspects that is needed to let the system produce accurate information, because when an industrial production plant is fully engaged but the information from MES is inaccurate it will lead to wrong conclusions. This is also why data accuracy is such an important success factor.

Concluding MES can contribute the three main principles of operational excellence; customer satisfaction, employee involvement, and process improvement. This can be done by making an industrial production plant engaged with MES and by letting MES produce the desired accurate information. This both can be achieved by following the framework presented in this research.
12 Recommendations

In the previous chapter the research questions are answered, it is also explained how this research contributes to the request of the environmental department. This also resulted in some recommendation that will be presented in the second paragraph. In the first paragraph the recommendation that followed from the fourth sub question is presented.

12.1 For the management team

For the management team

12.1.1 The framework can be used to engage an industrial production plant with MES and to ensure that MES presents accurate information. In chapter seven the framework is applied to CCE. This resulted in structured challenges and solutions per success factor, they can found in paragraph 7.2. From those challenges and solutions an integrated approach was constructed, when this approach is followed CCE will increase the successfulness of their MES.

First and foremost, the MES champion must be fully dedicated to MES. This needs to be done by increasing the number of hours the MES champion is allowed to spend on MES, from 8 to 40 hours. This function can make or break the MES. The first task of work the MES champion, is to establish intensive contact with the CCE MES project leader in Paris. This is important to be able to get things done quickly, since he calls the shots.

Secondly, the MES champion has to push the 'training center' to give a MES training to all relevant people, also the temporary operators. Simultaneously the champion should deduct from the managers of the department, which parts of MES they are using and what operators, team leaders and lower managers need to know in order to improve based on MES. When the champion notices that the managers of the departments do not have a constructive attitude towards MES, he must convince them of the benefits of MES. In case this does not work, other ways must be found, like finding a suitable person that can spread the right attitude towards the system.

When the Champion knows what education is needed in the departments, he has to negotiate with the 'training center' about how to build the required knowledge in the departments.

While the trainings are being given, the Champion has to keep verifying the data accuracy of the system. He might need other people to help with this.

Thirdly, the hardware in the production hall needs to be updated, to improve the user-friendliness for the operators. This combined with training and education will improve the data accuracy. For managers, the user-friendliness should be improved as well. The MES project leader should make this happen. When he is not able to do so, the MES champion should consult a third party to get more pressure on the MES supplier to make the system more flexible at lower cost. A third party might be able to do this for less money, and it will increase competition.

Fourthly the Champion will have to review the KPI tree of the industrial production plant and align this with the functionality in MES. This needs to be done in collaboration with the management of the plant, and the managers of the departments. It must be clear who is responsible for which KPI, what targets are linked to each KPI, and how it can be decomposed throughout the plant. When the Champion does this, he takes into account that for the energy and water KPI’s, the weekend should be made into a separate KPI or the weekly discussed KPI should be compensated for the weekend use and waste of energy and water.

Simultaneously we would like to advice the MES champion to make a business case for extra functionalities that are essential in reducing the energy usage of the plant. In case the extra functionality is more...
12.2 For the environmental department

Throughout the research at CCE, some challenges were encountered that could not be solved during the research. This was sometimes caused by the simple fact that changes in the organization or on the MES take a while to become effective. Other times due to limited time or simply because we were not able to find a solution. This resulted in recommendations to environmental department which they can use to keep on improving the energy and water efficiency in the plant. Those recommendations can be found throughout this chapter and are summarized here.

Firstly, some elaboration on functionalities that are missing in our opinion regarding the CRS module of the MES;
- Enable MES to present trend analysis to increase user-friendliness
- Add central gas gauge to MES in order to improve the functionality
- Add central Low Pressure air meter
- Incorporate steam boiler in MES in order to improve the functionality (appendix iv)

Secondly, some actions that can be taken to further engage the relevant employees in order to improve the energy and water efficiency ever further are;
- Extent water loss analysis to identify more relevant processes
- Extent energy and water efficiency approach with;
  - CIP syrup room
  - Steam Boilers (once in MES)
Both process use a significant amount of energy. Beside the CIP syrup room also uses a lot of water. In this research the CIP was left out due to time pressure and the steam boilers due to the fact that MES does not have the functionality (yet).
- Further implement blowing processes approach
As mentioned, we only recently started on the implementation, the environmental department will finalize and further implement the approach.
- Increase insight in the water treatment process regarding water loss
In the water treatment approach there is one main KPI for the whole water treatment approach. On this KPI all decisions are based. However it was experienced that it can be hard to explain what processes in the water treatment cause a overrun of the KPI to happen. Therefore more insight in this process will increase the number defects found based on the KPI improving the water efficiency even more. CCE is already investigating this.
- Start reviewing the energy and water weekend KPI in the dashboard meeting to improve the KPI tree
In the current situation only on week days the KPI’s for energy and water are discussed, therefore everything that happens in the area of energy and water in the weekends is not discussed in the dashboard meeting. But many things happen in the weekends that are relevant for the overall energy and water efficiency. For example, all water filters are flushed which uses a lot of water and energy (heating of flush water). Therefore we advise to design energy and water KPI’s for the weekend that can also be reviewed by the dashboard.
13 Avenues for future research

During the discussing on the framework (chapter nine), a few questions are raised regarding; the context of the framework; weaknesses of the framework; and the possibility of other success factors. In this chapter will be disused how future research can help improving the contribution of MES to OE in an industrial production plant, this resulted in three avenues for future research. In the following paragraphs they will be shortly elaborated upon.

13.1 Avenue one: extent the framework to the entire MES life cycle

First of all, future research could contribute tremendously to this research by extending the reach of the framework to whole life cycle. Currently the framework can only applied at the end of the implementation phase and on, Figure 34.

This would solve the challenge regarding the choices from the past that influence the successfulness of the MES in the researched phases. Beside it will reduce the current challenge that some success factors should have been taken into account from the start, making it harder to influence them in the current phase, think about the relationship with the MES supplier that can be built from the start.

Preferable this research is done in a comparable environment in order for the researches to come together nicely. Besides it would be interesting to do this research with an organization that is starting to consider a MES, allowing the possibility to learn from day one. Project managerial knowledge will also be useful for this research, the challenge will lay in the fact of connecting the possible benefits of the system to the investment cost, also how the design choices will determine the functionality later on, are issues that are valuable to research.

![Figure 34 Life cycle for MES](image)

13.2 Avenue two: acquire tools and techniques for the framework

The second avenue for future research inspired on the discussion on the framework for successful MES contribution to operational excellence, and on a book written by Basu (2004). In this book he explains that often in the case of research in the area of quality management the importance of aspects is explained and defined, but that the researches not give a specific technique or tool to really bring the aspect in practice. Think for example about the value a costumer has from quality, obviously it is important for Coca Cola to know what this cost is, but it is rather difficult to determine the actual value. In terms of this research the same thing happens in with the success factors. The sense of importance is given, but not all factors are presented, in this research, with a tool or technique on how they can be improved or handled in when applying the framework. For example which actions can be taken to show relational leadership?
Future research can contribute to this research and improve the framework by researching the success factors further, by presenting hard tools and techniques that can be executed by a party that wants to use the framework.

During this research the idea of developing a serious game to give more context to the success factor education and training passed by. This can be an example on how a success factors can be further developed in order for it to present a technique or tool with it.

13.3 Avenue three: possibility of application to services organizations

The final avenue for future research is not aimed to improve the framework presented in this research but rather on the exploration of the framework to other type of organizations. This idea was first gained from Mauch (2009a) who discusses if the concept of quality management theories can be applied to service organizations also. In his research he concludes that this should be possible.

But in this research quality management as very broad concept is narrowed down to a MES contribution to operational excellence. However service product can still be measured and the processes they pass by can also be continuously improved so it might be possible to export the framework to service organizations that use quality management type of IT systems to improve their business.

Therefore it might be interesting to explore the option of taking the framework to another environment than an industrial production plant.
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Appendices

i. Interview preparation
ii. Interview results
iii. Functionalities of the CCE MES based on ISA-95
iv. Gas as energy source at CCE
v. Global operating framework
vi. Energy and water usage analysis Dongen
vii. Gas usage prediction tool
viii. Daily KPI performance energy and water for dashboard
ix. Individual processes in the approach
Appendix i – Interview preparation

In this appendix the interviews that were held will be explained. The outcomes of the interviews will contribute to two chapters in this research. Firstly they will contribute to the chapter 4.2: The MES experience of CCE. The data for this part of the research will be gathered in the first part of the interviews. In the second part data will be gathered for chapter 5.1: Validation of the success factors. The validation of the framework will be done by interviewing expert in the IT systems field. In the next chapter the method will be described to gather the desired data. Then the interviewees will be identified. Finally the questions will be presented per part.

i.1 Interview approach

The interviews will start with an introduction about the research and how the interviews will contribute to that. The interviews will be confidential to ensure that the respondents feel safe to tell everything and be honest. There will only be a distinction between operators and managers. This is done to investigate the way these groups experience MES, they work with the system is a different way and therefore it is interesting to see if they experience the system differently. Thereafter the interview will take place in two parts.

The first part will be an oral conversation guided by questions to gain insight in the experience CCE employees have with MES. This is done to identify challenges CCE has with MES, this will also be a test to see if the employees experience the same challenges as the researcher. This might also give insight in extra success factors or conditions that might have been missed in the literature research. In this part will be investigated if the goals of MES, to enable continuous improvement, are met at the moment at CCE. There is also attention on how continuous improvement works, so if MES information actuality leads to the removal of defects and if the information indeed leads to improvement projects. In this part there will be a difference between operators and managers, most questions are the same but managers get a few extra question.

In the second part of the interview the discussion on the success factors will take place. The respondents will be asked how important they find a certain success factor. This will be done indirectly by making a few questions per success factor that together will construct a success factor. The respondents will be asked to answer the question on a 5 point scale Likert scale (Hayes & Stratton, 2003). This way we can discover if the respondents find a success factor important or not important. All success factors will be submitted to the managers, only relevant success factors will be submitted to the operators.

When is finished the success factors will be presented to the respondents and they will be asked to rate them on an Ipsative scale. This means that they will arrange the success factors in order of importance (Hayes & Stratton, 2003). When this is done and the data is significant we will be able to conclude which success factors are more important than others in this case, this will help prioritizing which challenges must be solved first to make the current MES more successful.

i.2 Interviewees

For the previous explained analysis a representative dataset will be constructed out of the employees of CCE. Firstly a roughly vertical diversion can be made between the employees of CCE, the operators and the managers. Obviously there are more layers in the hierarchy of the company, but for this research it is interesting to investigate the experience of the group that mostly enters data into the system versus the group that mainly extracts data from the system, this roughly the operators respectively the managers.
Besides a vertical split a horizontal split will be made to get a good sample of the employees of CCE. As is discussed in chapter four, CCE has four big departments within their production plant in Dongen that use MES, Production, Utilities, Upstream and QESH. From all departments a few operators and managers will be interviewed. In all seven operators and seven managers were interviewed. The response forms can be requested be requested and the interviews were taped as well.

i.3 First interview

In the first interview questions will be asked that will support the experience employees have with MES. The questions will asked orally by the researcher.

Operators

1. Successfulness:
   a. Zijn er defecten die u opspoort met behulp van MES?
   b. Vindt u meer defecten nu u MES gebruikt?
   c. Ziet u dat er verbeterprojecten worden opgestart aan de hand van de gegevens uit MES? Bijvoorbeeld aan de hand van veel voorkomende defecten die nu geregisseerd worden?

2. Educatie
   a. Heeft u genoeg training gehad om MES goed te kunnen gebruiken?

3. Leadership
   a. Vindt u dat uw leiding gevende genoeg aandacht en prioriteit geeft aan MES?

4. Responsibilities
   a. Is het duidelijk wat er van u verwacht wordt mtb tot de MES taken?

Managers

5. Successfulness:
   a. Zijn er defecten die u opspoort met behulp van MES?
   b. Vindt u meer defecten nu u MES gebruikt?
   c. Ziet u dat er verbeterprojecten worden opgestart aan de hand van de gegevens uit MES? Bijvoorbeeld aan de hand van veel voorkomende defecten die nu geregisseerd worden?

6. Functionalities
   a. Mist u processen of machines in MES?

The main conclusion that are drawn from the intervies can be found in chapter 4.

i.4 Second interview

The second interview consists out of two parts, firstly a couple of questions per success factor will be made; those questions will be rated on a Lihert scale to find out how important CCE employees find the success factors. This will be done by making constructs for every success factor that the employees rate on a Lihert scale. Secondly the employees will rate the success factors on an Ipsative scale to find out which success factors they find more important than others. Not all success factors will be presented to the operators because some are not applicable to their tasks and they will therefore have irrelevant responses. The topics that are applicable to both groups will be constructed by the same questions. In this way a comparison between the groups can be made. Now the results will be presented. At the end of this appendix the question list that is used can be found, this list in Dutch because not all respondents are able to understand English, upon request the lists can be translated.
1. MES functionaliteiten
   i. Alle machines en processen die gemonitord kunnen worden, moeten in het MES systeem gemonitord worden
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</table>

   ii. Alleen machines en processen waar voor de implementatie verbeteringsmogelijkheden geïdentificeerd zijn moeten in MES gemonitord worden

<table>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</table>

2. Verantwoordelijkheden
   a. Het moet 100% duidelijk zijn welke MES modules u moet gebruiken voor uw functie
   
<table>
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<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
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</table>

   ii. Elke module in MES moet direct een doel de organisatie ondersteunen (bijvoorbeeld voor het doel waterbesparing: water besparingsmodule in MES)

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<th>1</th>
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<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

b. Verantwoordelijkheden per IT system
   i. Het moet duidelijk zijn welke persoon verantwoordelijk is voor een IT system in een bedrijf (SCADA, SAP, MES, HARDWARE)

<table>
<thead>
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<th>1</th>
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</table>

   ii. Er moet een vast persoon of nummer zijn waar altijd contact opgenomen kan worden als u iets wilt weten of melden over een IT systeem

<table>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</table>

3. Leadership
   i. Er moet een vaste routine zijn waarmee er over MES gecommuniceerd wordt

<table>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>
ii. Het is belangrijk dat een leidinggevende een positieve en constructieve houdingen heeft tegenover MES

1  2  3  4  5

iii. Er moet tijd vrij gemaakt worden om MES taken goed te kunnen uitvoeren

1  2  3  4  5

4. Engagement
   a. Betrouwbaarheid
      i. Als ik de informatie uit MES niet betrouwbaar/geloofwaardig vind gebruik ik MES niet

1  2  3  4  5

   ii. Elke persoon die gebruik van MES kan maken moet dit doen

1  2  3  4  5

   b. Education
      i. Ik zou MES meer gebruiken als ik meer over de technische achtergrond van het MES system zou weten.

1  2  3  4  5

   ii. Als ik meer trainingen zou krijgen over welke informatie beschikbaar is in MES zou ik een grotere meerwaarde uit het systeem kunnen halen

1  2  3  4  5

   iii. Met meer trainingen over hoe ik informatie uit het systeem kan halen, zou ik een grotere meerwaarde uit het systeem kunnen halen

1  2  3  4  5

   c. User friendly
      i. Als de respons tijd (hoelang het duurt voordat de data geladen is) van MES lang is ga ik MES minder gebruiken

1  2  3  4  5

n.v.t.
ii. Als de pagina’s er onduidelijk en lelijk uit zien ga ik het systeem minder gebruiken (grafische representatie van de data is belangrijk om MES tot een succes te maken)

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>n.v.t.</th>
</tr>
</thead>
</table>

Managers

<table>
<thead>
<tr>
<th></th>
<th>Helemaal mee</th>
<th>Neutraal</th>
<th>Helemaal mee</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONeens</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

1. IT systems integration
   i. MES moet data uit kunnen wisselen met SAP zodat alle relevante informatie in beide systemen beschikbaar is.

   |   | 2 | 3 | 4 | 5 | n.v.t. |

   ii. Meer afdeling specifieke informatie over, bijvoorbeeld de waterbehandeling of het stoomnetwerk, zou MES een beter systeem maken.

   |   | 2 | 3 | 4 | 5 | n.v.t. |

   iii. Het MES systeem zou betrouwbaarder zijn als het los van andere IT Systemen als SAP en SCADA zou functioneren

   |   | 2 | 3 | 4 | 5 | n.v.t. |

2. MES functionality
   i. Alle machines en processen die gemonitord kunnen worden, moeten in het MES systeem gemonitord worden

   |   | 2 | 3 | 4 | 5 | n.v.t. |

   ii. Alleen machines en processen waar voor de implementatie verbeteringsmogelijkheden geïdentificeerd zijn moeten in MES gemonitord worden

   |   | 2 | 3 | 4 | 5 | n.v.t. |

3. Sustainable relationship with capable MES supplier
   a. Relatie met de MES leverancier
      i. Een goede relatie met een MES leverancier is cruciaal om MES succesvol te implementeren

      |   | 2 | 3 | 4 | 5 | n.v.t. |

      ii. Een MES leverancier moet werknemers van de opdrachtgever opnemen in het project team.
b. MES leverancier
   i. Een MES leverancier moet alles kunnen m.b.t. de MES implementatie (van ontwerpt tot trainingen, van hardware tot werkwijzen met MES)

4. Responsibilities
   a. Responsibilities per MES functionality
      i. Het moet 100% duidelijk zijn welke MES modules u moet gebruiken voor uw functie
      ii. Elke module in MES moet direct een doel de organisatie ondersteunen (bijvoorbeeld voor het doel waterbesparing: waterbesparingsmodule in MES)

   b. Responsibility per IT system
      i. Het moet duidelijk zijn welke persoon verantwoordelijk is voor een IT system in een bedrijf (SCADA, SAP, MES, HARDWARE)
      ii. Er moet een vast persoon of nummer zijn waar contact mee opgenomen kan worden als u iets wilt weten of melden over een IT systeem

5. Leadership
   i. Als leidinggevende/manager moet ik een vaste routine hebben waarin ik communiceer over MES
   ii. Het is belangrijk dat een leidinggevende een positieve en constructieve houdingen heeft tegenover MES
iii. Er moet tijd vrij gemaakt worden om MES taken goed te kunnen uitvoeren

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

6. Engagement
   a. Reliability
      i. Als ik de informatie uit MES niet betrouwbaar/geloofwaardig vind gebruik ik MES niet

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

   ii. Elke persoon die gebruik van MES kan maken moet dit doen

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

b. Education
   i. Ik zou MES meer gebruiken als ik meer over de technische achtergrond van het systeem zou weten.

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

   ii. Met meer trainingen over welke informatie beschikbaar is in MES zou ik een grote meerwaarde uit het systeem kunnen halen

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

   iii. Met meer trainingen over hoe ik informatie uit het systeem kan halen, zou ik een grotere meerwaarde uit het systeem kunnen halen

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

c. User friendly
   i. Als de respons tijd (hoelang het duurt voordat de data geladen is) van MES lang is ga ik MES minder gebruiken

| 1 | 2 | 3 | 4 | 5 | n.v.t. |

   ii. Als de pagina’s er onduidelijk en lelijk uit zien ga ik het systeem minder gebruiken (grafische representatie van de data is belangrijk om MES tot een succes te maken)

| 1 | 2 | 3 | 4 | 5 | n.v.t. |
i.5 Part 2.2 Ipsative scale

Now the questions are answered the success factors will be presented to the respondents and they will be explained to them. Then the respondents will be asked to arrange the success factors in order of importance. Most important success factor on top and the least important success factor below.

**Operators**

1. Functionalities
2. Clear responsibilities
   a. Responsibilities per MES functionality
   b. Responsibility per IT system
3. Leadership
4. Engagement
   a. Reliability
   b. Education
   c. User Friendliness

**Managers**

1. IT Systems integration
2. Functionalities
3. Sustainable relationship with capable MES supplier
   a. Capability MES supplier
   b. Relationship MES Supplier
4. Clear responsibilities
   a. Responsibilities per MES functionality
   b. Responsibility per IT system
5. Leadership
6. Engagement
   a. Reliability
   b. Education
   c. User Friendliness

### i.6 Ipsative scale: success factor cards

<table>
<thead>
<tr>
<th>Functionaliteiten</th>
<th>IT systemen moeten geïntegreerd zijn om over meer informatie te kunnen beschikken</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Alle gewenste processen en machines moeten worden meegenomen in het MES systeem om MES tot een succes te maken</td>
<td>- Er moet een goede communicatie zijn tussen IT systemen als SAP, MES en SCADA om MES tot een succes te maken</td>
</tr>
</tbody>
</table>
### Capabele MES leverancier
- De MES leverancier moet precies weten wat ze doet op technisch en organisatorisch vlak om MES tot een succes te maken.

### Goede relatie met MES leverancier
- Zodat er op langere termijn nog veranderingen door gevoerd kunnen worden, zodat het systeem flexibel blijft en aan de wensen van CCE kan blijven voldoen. Zo wordt MES een succes.

### Verantwoordelijkheden 1: MES modules
- Voor elke MES module moet minimaal 1 persoon verantwoordelijk zijn en deze moet weten wat van hem verwacht wordt met deze module. Op deze manier wordt MES een succes.

### Verantwoordelijkheden 2: IT systemen
- Het moet voor iedereen binnen het bedrijf duidelijk zijn welke persoon of afdeling verantwoordelijk per IT systeem zodat bij problemen gelijk de goede persoon aangesproken kan worden.

### Leiderschap
- Leidinggevende moeten een positieve en constructieve houding aannemen en MES promoten bij de rest van het bedrijf om het tot een succes te maken.

### Engagement 1: Betrouwbaarheid
- De informatie uit het systeem moet betrouwbaar zijn en het systeem moet 99% beschikbaar zijn om MES een succes te maken.

### Engagement 2: Trainingen en Opleiding
- Trainingen en opleidingen zorgen ervoor dat de meerwaarde van MES zichtbaar wordt en het duidelijk wordt hoe deze meerwaarde eruit gehaald kan worden. Dit is nodig om het systeem tot een succes te maken.
Appendix ii – Interview results

In this appendix the results of the interviews that were held at Coca-Cola Enterprises will be discussed. In the first part questions are asked that are related to the success factors identified by this research in order to find out how important the employees of CCE find those questions. They can answer totally agree until totally disagree. Explanation on the method and the question can be found in appendix X. In this part the answers will be analyzed and the difference between operators and managers will be investigated. In the second part the success factors will be ordered from most important to least important.

The results of the first interview where the experience with MES was discussed have been processed in the mean text, mainly in paragraph 6.1. We were allowed to tape the full interviews, the respondents privacy is guaranteed, but with a good reason and in collaboration with the respondents the tapes can be requested from the researcher.

ii.1 Part 1

1. MES functionalities has two questions:

   i. Alle machines en processen die gemonitord kunnen worden, moeten in het MES systeem gemonitord worden

   ii. Alleen machines en processen waar voor de implementatie verbeteringsmogelijkheden geidentificeerd zijn moeten in MES gemonitord worden

As can be seen the graphs, operators are more consistent in their answer to the first question. Before the questionnaire was made we expected that only the machines and processes where actual savings could be realized would be agreed with by both groups, since in the end installing meters is quite expensive. However in the interviews operators often used the argument that machines or processes that work perfect now can function less efficient in the future and that MES can help with that. This is a perfectly good argument since the maintenance functionality can support in making plans based on information like this. From this question is learned that not only
machines and processes that can be improved need to be adopted in MES but also machines with a big impact that need monitoring to keep them on target need to be adopted in MES.

2. Responsibilities

i. Het moet 100% duidelijk zijn welke MES modules u moet gebruiken voor uw functie
ii. Elke module in MES moet direct een doel de organisatie ondersteunen (bijvoorbeeld voor het doel waterbesparing: water besparingsmodule in MES)
iii. Het moet duidelijk zijn welke persoon verantwoordelijk is voor een IT system in een bedrijf (SCADA, SAP, MES, HARDWARE)
iv. Er moet een vast persoon of nummer zijn waar altijd contact opgenomen kan worden als u iets wilt weten of melden over een IT systeem

Responsibilities are looked at in two ways in this questionnaire. First of all it focuses on the responsibilities per MES module. As expected both groups think that it must be clear who uses what. Most respondents agree that organizational goals need to be aligned with MES. The few people who did not agree with the question explained that for them insight in a certain process can be valuable but that it will not directly contribute to a goal of the organization. They did explain that in the end the insight will lead to saving costs. From this question we concluded that the goals of organization need to be supported by MES, when it is clear which goal is supported this has a positive effect on if people think it will make MES more successful, however not all employees are influenced by this.

Secondly everybody agrees that it needs to be clear who is responsible for an IT system, and they also would like a set phone number which they can call when problems arise; this is in line with the expectation we have from the literature research.

3. Leadership

i. Een leidinggevende moet een vaste routine hebben waarin hij of zij communiceert over MES
ii. Het is belangrijk dat een leidinggevende een positieve en constructieve houdingen heeft tegenover MES
iii. Er moet tijd vrij gemaakt worden om MES taken goed te kunnen uitvoeren
Both managers and operators agree on the fact that extra time needs to be allocated to operators and managers to fulfill the tasks they have with MES. Good routines regarding MES are valued positive but not overly convincing. Finally a positive attitude towards MES is valued less important by operators than managers. This is different than we expected, operators argue that the tasks need to be done or they will be notified, this control is the force behind execution tasks with MES. Managers are more convinced that this will improve the successfulness of MES, but not all managers are questioned and form experience can be said that not all managers are enthusiastic about MES, besides some people agreed about the constructive part but not enthusiastic part of the question, therefore no conclusion will be attached to his question. Concluding, operators at CCE react to control on their tasks, both operators and managers think that time needs to be allocated to execute MES tasks.

4. Data Accuracy
   i. Als ik de informatie uit MES niet betrouwbaar/geloofwaardig vind gebruik ik MES niet
   ii. Elke persoon die gebruik van MES kan maken moet dit doen

This question shows a interesting difference which can be linked to the previous question. Operators care less about the accuracy of the data, since they are triggered by the fact that they are controled. Managers are freer in their
decision to use MES, therefore data accuracy is more important for them, an argument they presented is that they will the information elsewhere if they are not convicne of the accuracy of the data form MES. In both groups people agreed that MES needs to be used, two operators answered this question with one because they found the question to strick. Concluding, the respondents think that as many people that can have positive effects should use it. Managers tend to use MES less when they precive the data as not acurate, operators are not influenced by this.

5. Education & Training

i. Ik zou MES meer gebruiken als ik meer over de technische achtergrond van het MES system zou weten.
ii. Als ik meer trainingen zou krijgen over welke informatie beschikbaar is in MES zou ik een grotere meerwaarde uit het systeem kunnen halen
iii. Met meer trainingen over hoe ik informatie uit het systeem kan halen, zou ik een grotere meerwaarde uit het systeem kunnen halen

Operators are neutral and managers are divided about the importance of understanding the technical background of the system. Operators are clear on the fact that education/training with MES will give them greater benefits, not all manager are convinced about that. Therefore from this question is concluded that operators find education/training important and are requesting more in this specific case.

6. User-friendliness

i. Als de respons tijd (hoelang het duurt voordat de data geladen is) van MES lang is ga ik MES minder gebruiken
ii. Als de pagina’s er onduidelijk en lelijk uit zien ga ik het systeem minder gebruiken (grafische representatie van de data is belangrijk om MES tot een succes te maken)
The visual representation of the data appears to not influence engagement people have with the system. However, an argument often heard with this questions is that the data and information needs to clear not fancy. Again managers are more influenced by the response time for using the system where operators are triggered by the fact that they have to do the tasks.

7 MES supplier (only managers)
Not all employees are aware of the role of the MES supplier has, therefore only the managers where asked this question.

i. Een goede relatie met een MES leverancier is cruciaal om MES succesvol te implementeren

ii. Een MES leverancier moet werknemers van de opdrachtgever opnemen in het project team.

iii. Een MES leverancier moet alles kunnen m.b.t. de MES implementatie (van ontwerpen tot training, van hardware tot werkwijzen met MES)

As can be seen all managers agree on the fact that a MES supplier has to competent but also that the relation with the supplier has to be good in order for MES to be a success. Most also agree on the fact that the supplier should guide the buying company throughout the whole process.
8. It integration (only managers)

Not all employees are aware of the role of IT integration, therefore only the managers where asked this question.

i. MES moet data uit kunnen wisselen met SAP zodat alle relevante informatie in beide systemen beschikbaar is.

ii. Meer afdeling specifieke informatie over, bijvoorbeeld de waterbehandeling of het stoomnetwerk, zou MES een beter systeem maken.

iii. Het MES systeem zou betrouwbaarder zijn als het los van andere IT Systemen als SAP en SCADA zou functioneren.

The question about the integration between MES, SAP (ERP) and SCADA, was answered very unconsitantly. In our opin in this case the question was not posed correctly, anyway the data is not very usefull. What we can conclude is that most mangers agree with the question that more processes would make MES more succesfull, this is accoring to our expectation we got form question 1 about the MES functionalies.

Now the results of the second part will be presented.
ii.2 Part 2

In this part will be shown how the respondents rate the success factors on an Ipsative scale. On the next page the graphs are named and explained.

Operators
In the graphs shown above, VAR stands for variable, the number behind that refers to one of the success factors shown below.

VAR2: Adequate functionalities
VAR4a: Responsibilities MES modules
VAR4b: Responsibilities IT systems
VAR5: Leadership
VAR6a: Data accuracy
VAR6b: Training and Education
VAR6c: User friendliness

From the data shown above we can conclude that operator’s value, **data accuracy** as the most important success factor. The managers agree therefore this research will focus on this topic.

*Leadership* is often rated highly by operators; this means that they find a constructive attitude towards the system from their managers important

*Responsibilities per IT systems* are not put highly in the rating, operators indicate that they find it important in the first questionnaire; literature also indicates that this important, therefore it is interesting to find out why operators rate it lower. More elaboration on this can be found in chapter 6.1.

*Training and education* are rated medium but the data has big deviations, therefore we cannot conclude that they find this more important than any other factor.

The ratings for **user friendliness and responsibilities MES modules**, are spread out over the entire rating, therefore we cannot attach clear findings on whether they rate it high or low.

*Adequate Functionalities* also does not present clear data on whether it is more important than other success factors.

More extensive elaboration on the causes of a higher rating or the cause of a spread rating is given in chapter 6.1. On the next page the results of the manger will be shown.
Continuous Improvement based on Management Execution systems

Managers
In the graphs shown above, VAR stands for variable, the number behind that refers to one of the success factors shown below.

VAR1: IT systems integration
VAR2: Adequate functionalities
VAR3a: Good relationship with MES supplier
VAR3b: Capable MES supplier
VAR4a: Responsibilities MES modules
VAR4b: Responsibilities IT systems
VAR5: Leadership
VAR6a: Data accuracy
VAR6b: Training and Education
VAR6c: User friendliness

Data accuracy and the capabilities of the MES supplier are clearly the most important factors for managers at CCE. User-friendliness is consistently above average, manager find this important and they find it more important than operators.

Leadership is consistently put in the middle, indicating that it not the most important factor but that is constantly is found relevant. For operators it is important.

IT systems integration is ranked below consistently below average, for managers this success factor does not have a high priority.

The functionality of the system is clearly not the most import thing for managers.

Responsibilities per IT system and Responsibilities per MES module are put low in the ranking by managers which is surprising because in the literature research this factor was found to be very important.

On the relationship with the MES supplier, Training and education managers are divided, the deviation is too big to draw conclusions.

In chapter 6.1 the reasons that might cause the result will be discussed.

ii.3 Reflection on the interview results

The questions were made to find out if the employees of CCE would agree with the success factors that we found in the literature and during this research. In this paragraph we will reflect on the questions and the results to see if this worked.

A first shortcoming came forward during the validation, the employees of CCE are not authorities on the topic MES, they all work with the system but they have limited knowledge about the technical and organizational impact of the system, also the managers whom were asked about the relationship with the MES supplier do not all have knowledge about his part of the system. Therefore the goal of the interview changed, the results of the interview will be used to discuss the success factors. When CCE employees find the factors not important we will reason if this is because it is really not an important factor in making MES successful.

A second shortcoming is way the questions in the first part are asked, some of the questions point to engagement where others point to successfulness, therefore different kind of conclusions can be drawn between the questions and it remains hard to compare the outcomes of the first part. In the second part the respondents had to rank the success factors in order of essentialness in making MES a success, therefore in this part this
problem did not occur. However in the second part the managers have more success factors than the operators causing the results to be difficult to compare, therefore in this part we mainly focused on if the respondent putted the success factor in the; top; middle or bottom part of the ranking.

A third difficulty is the way the questions are decomposed over a success factor. We never posted the statement, do you think leadership is important. We chose not do this because some of the success factors are vague themselves, leaving a lot of room for interpretation. Therefore we decomposed the factors in questions we found relevant for the success factor, both to better discuss the factor and give a better recommendation to CCE on how to improve concrete point per success factor.

Finally we noticed that in the second part the approach per employee in ranking the factors differed. Some really argued, this is for me the most important thing to let MES succeed, in order as it was explained earlier in this interview. But others argued that one success factors should be satisfied before the other becomes relevant, we took notes of those reasoning and they will be taken into account when recommending CCE, but they might cause deviation in the results of the second part.
Appendix iii – Functionalities of the CCE MES based on ISA-95

The ISA has developed a functional enterprise-control model shown in Figure 35. In this model the main functionalities that a ‘management execution systems’ can have. They are explained in the chapter: MES from a technical perceptive. Every functionally has a few functions, who are mentioned in the ISA guideline (ISA, 2000). Below all relevant functionalities for environment are mentioned will be compared with what CCE actually has, in order to investigate the functionality level of the MES of CCE.

![Functional Enterprise Control Model](image)

**Figure 35: Functional Enterprise Control Model (ISA, 2000)**

### iii.1 Material and Energy Control (4.0)

<table>
<thead>
<tr>
<th>ISA defined function</th>
<th>MES of CCE</th>
<th>comparable/fit?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Confidential
### iii. 2 Quality Assurance (6.0)

<table>
<thead>
<tr>
<th>ISA defined function</th>
<th>MES of CCE (supplied by Simatic-IT)</th>
<th>comparable/fit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing and classification of materials</td>
<td>Not applicable to environmental department</td>
<td></td>
</tr>
<tr>
<td>Setting standards for material quality</td>
<td>Not applicable to environmental department</td>
<td></td>
</tr>
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<td>Issuing standards to manufacturing and testing laboratories in accordance with requirements form technology, marketing and customer services</td>
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<tr>
<td>Collecting and maintaining material quality data</td>
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<tr>
<td>Checking of product details versus customer's requirements and statistical quality control routines to assure adequate quality before shipment</td>
<td>Not applicable to environmental department</td>
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<tr>
<td>Relaying material deviations to process engineering for re-</td>
<td>Not applicable to environmental department</td>
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Confidential
Modifies the following information:

a) Quality assurance test results
b) Approval to release materials, or waivers on compliance
c) Applicable standards and customer requirements for material quality

### iii. 3 Maintenance management (10.0)

<table>
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<tr>
<th>ISA defined function</th>
<th>MES of CCE (supplied by Simatic-IT)</th>
<th>comparable/fit?</th>
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Information generated or modified:

a) Maintenance schedules that specify the plan for future work orders
b) Maintenance work orders that specify specific equipment to be taken out of service and available for maintains functions
c) Diagnostic and self-test requests to be performed on the equipment

They might partly overflow the boundaries of the enterprise-control system boundary.

As is noticed when this appendix was written is that these functionalities referred to by the ISA, are more applicable to the central warehouse. Here all equipment used in the plant and other material enter the factory. This appendix also gave us insight the CRS module of CCE is quite unique because it has so much detailed information about energy and water use that is not incorporated in the ISA standards. This is also custom made by the MES supplier for CCE because they have a strong focus on CRS.
Appendix iv – Gas as energy source at CCE

This appendix is added because when the functionalities of the system were invested we experienced some weaknesses with MES regarding the energy, specifically gas usage of the industrial production plant. Those weaknesses where experienced mostly by the environmental department that was not able use MES for all the KPI’s that are their responsibility. Besides some interesting processes in the field of energy efficiency and Corporate Responsibility and Sustainability are not incorporated in the system. We will show how gas is used in the industrial production plant in Dongen and which processes are incorporated in MES and which are not. We will end this appendix with a recommendation on which meter to add to increase the functionality of the system.

In the CCE plant gas provides a big share of the energy that is needed to keep factory running, on average approximately one-third of all energy used in plant is produced by gas (Coca-Cola Enterprises, 2012a). Gas is only used in two primary processes. Multiple central heating units are powered with gas and the steam boilers also use gas. In Figure 36 is shown how the gas is used, also the steam that is being produced by the boilers is pictured. The department that is responsible for the processes are also shown in the figure.

In the CCE plant gas provides a big share of the energy that is needed to keep factory running, on average approximately one-third of all energy used in plant is produced by gas (Coca-Cola Enterprises, 2012a). Gas is only used in two primary processes. Multiple central heating units are powered with gas and the steam boilers also use gas. In Figure 36 is shown how the gas is used, also the steam that is being produced by the boilers is pictured. The department that is responsible for the processes are also shown in the figure.

![Primary gas and steam figure (A0)](image-url)
In this picture is also shown which meters are installed at the moment. Obliviously the meters placed after the steam boilers are steam meters, the other is a gas meter.

In this picture is also shown in what kind of processes the steam that is produced by the steam boiler is used. In the picture five categories are defined. In the next paragraphs those categories will be explained and this research will show how the steam is used within the categories. The categories have a different kind of complexity, when analyzing the categories this research tried to use the same aggregation level. In the conclusion we will elaborate on which meters we would incorporate in the system as improvement.

iv.1 Line 3

Line 3 is the only glass line in the CCE plant in Dongen. Besides that line 3 is the only line that cleans the bottles that are recycled itself. This is done by a machine called the bottle washer; this machine uses hot water and cleaning materials. The water is heated by steam. Because line 3 is only line with a bottle washer it is also the only line that uses steam directly for the production of glass bottles of soft drinks. All line indirectly use steam, this will be explained in the next paragraph CIP. Because the bottle washer is the only machine on line 3 that uses steam the figure is straight forward, this can be seen in Figure 37.

![Figure 37 Bottle washer line 3 (A1)](image)

iv.2 CIP

CIP is an abbreviation for Cleaning In place (Melrose Chemicals, 2010). This is a process that needs to be performed when a production line changes from one product to another. Basically water is heated with steam, cleaning chemicals are added. This cleaning water is then flushed through all the tubes of the line, until all previously product is replaced with the warm cleaning water. Thereafter the pipes are flushed with normal water and the production of the new product can commence. At the CCE factory in Dongen there are four types of cleaning methods between productions, called CIP’s on the shop floor. Which kind of CIP needs to be performed depends on the change of product. CCE constructed a matrix that shows which CIP needs to performed for every possible product change, e.g. Coca Cola light caffeine free to Fanta zero. There are four different kinds of CIP’s below they are explained in order of energy and water they use.

Blow and go, the product is pushed out of the pipes. Normal water CIP, the pipes are flushed out by normal water without cleaning product. Water with normal cleaning production, in this case light cleaning product is added to the water to clean the pipes. Finally, a CIP with Alkali, for this CIP hot water is used that is heated up with steam.
Two cycles of cleaning are needed to completely clean the pipes. First the pipes are pre-cleaned with the residue of the previous cleaning. Then the pipes are cleaned and the residue is stored to use it as pre-cleaner in the next Alkali CIP.

In the CCE factory heat exchangers that use steam facilitate the CIP’s of all the lines. Those machines will not be explained in detail, but they use steam to heat the water. Two installations are used for line 1,2,4,5,6,8 and line 3 has his own CIP installation. In Figure 38 is shown how this looks schematically.

![Figure 38 CIP installations (A2)](image)

In the next paragraph the processes that use steam in the syrup room will be discussed.

### iv.3 Syrup room

The syrup room of the CCE plant in Dongen is the place where the syrup is prepared before it is transported to the filler where it is put together with water and CO2. In the syrup room four heat exchangers use steam to heat water for different purposes. Firstly a machine called ‘contisolve’ uses the hot water to dissolve sugar in water. Thereafter the water with the sugar in it is pasteurized; this process requires heat, which is extracted from the heat exchanger that uses steam. The third and fourth machines are CIP installations that are used to clean the tanks that hold the syrup and to clean Preparation Street, a part of the CIP installations uses steam as well. Schematically this is shown in Figure 39.
iv.4 Air treatment

A part of the plant is heated by central heating boilers. They run directly on gas and can be seen in Figure 36 Primary gas and steam figure (A0). Air treatment is the other heating method in the plant. This heating technique is based on a heat exchanger that warms the air using steam. In the plant seven heat exchangers that use steam are placed. In Figure 40 Air treatment (A4), can be seen what is being heated by the seven heat exchangers.
The last category that uses steam is the water treatment; this will be discussed in the next chapter.

iv.5 Water treatment
The last area where steam is used is in the water treatment. In the water treatment area, one heat exchanger is placed. The heat exchanger produces warm water that is used to disinfect the active choral filters. Those filters are used in the water treatment to get the well and tap water to a sufficient level so it can be used to produce the soft drinks. In Figure 41, this is shown schematically.
iv.6 Conclusion
First of all the main gas meter of the industrial production plant is not linked to system while roughly one third of all energy used is coming from gas. This missing functionality makes it hard to deliver the KPI’s off Energy that are daily discussed by the management.

The functionality of MES regarding the entire gas use throughout the plant after the main gas meter can be questioned as a whole. Only a few meters are missing that would enable CCE to gain insight in their entire gas use, which is not possible at this moment. In the appendix iv we elaborate further on this. Although we advise to place all off the missing meters, one deserves extra attention. In the current situation there is a gas meter before the steam boilers, the boilers produce all the steam that is used in the plant to heat water and air. But is no steam meter placed after the boilers, causing that the efficiency of the boiler cannot be determined. The boiler transform gas to steam, in this process 31.1 percent of all Energy use in Dongen is transformed from gas to steam. When this process is inefficient this can result in a big loss of energy that cannot be determined at this moment. While we know from recent research by a third party hired by CCE that the efficiency of the boiler was not lower than expected, the efficiency of the boiler was reduced by broken steam traps. MES would be perfect in measuring the efficiency of the boiler. We would be able to build knowledge about the process when we know when and under which conditions steam traps break down, with this knowledge CCE might be able to prevent future break downs and design an adequate maintains schedule. More importantly CCE would be able to notice a broken steam trap right away and fix it improving the efficiency of the steam boilers and saving money.
Appendix v – Global operating framework

- Being # 1 or strong # 2 in every category in which we compete
  Strategic Priority: Grow value of existing brands and expand our product portfolio
- Being our customers’ most valued supplier
  Strategic Priority: Transform our go-to-market model to improve efficiency and effectiveness
- Establishing a winning and inclusive culture
  Strategic priority: Attract, develop and retain a highly talented and diverse workforce
Appendix vi – Energy and water usage analysis Dongen

In this appendix the energy and water use of the plant in Dongen is explained. This information is used in the third part to find which processes are interesting to engage the employees of CCE with. It also gave more insight in the way the plant in Dongen works. The energy and water use will stepwise be decomposed for the main energy and water sources to the processes that use the energy and water.

This analysis is based on existing knowledge of CCE; firstly a study of KWA on the gas network was used to get a better understand of where and how gas is used. Secondly the energy and water usage report of the environmental department (2011) was very useful this gave an idea where to start and most significant processes were already identified by this study. Thirdly the CIP (cleaning in place) analysis executed by the engineering department of CCE is used, in cooperation with the engineering department MES is used to analyze how much water and energy the different types of CIPs use and how often they are executed. Fourthly the analysis of ‘WB Nvotek’ to the water losses in the plant is used. Finally a lot of data is extracted from the MES itself, ether to verify the data presented by the previously mentioned researches or to find new signification processes.

The first step in analyzing the energy use of the plant in Dongen was to look at the various sources of energy that enter the plant. They are Electricity, Gas, Diesel and LPG the amount of energy they contribute to all kWh’s used in plant on a yearly basis can be seen in Figure 42.

![Energy sources [% of Total energy use]](image)

**Figure 42** Energy sources in the CCE plant Dongen

Since gas and electricity represent by far the biggest share of energy and because diesel and LPG cannot be measured with MES, we will continue with gas and electricity. Firstly the gas is used by two processes, 1 two steam boilers, 2 various central heating boilers located throughout the entire plant. The diversion between those two processes can be seen in Figure 43.
The central heating boilers just produce heat. But the steam boilers produce steam, which is then used in other parts of plant to power and heat all kind of processes. We refer to this as secondary gas use and what happens with the steam can be seen in Figure 44.

This figure is completely explained in chapter 8 and therefore we will not elaborate more on it in this appendix.

There are numerous electricity users of the plant and many of them are incorporated in MES. Therefore some groups are formed (for example all the machines that are directly on a production line are taken together). When this is combined with the gas users the Figure 45 shows all the significant users of energy. As can be seen a big share of all energy use (calculated to kWh to be able to compare them) is consumed by a few processes (which makes me think about pareto).
This nicely shows what are significant processes for energy in the industrial production plant of CCE in Dongen. In chapter 8 is discussed which of those processes will be taken into account first when starting to engage employees. This is done based on the use of energy and room for improvement the process has.

Water is less complex because all water is directly used. In Dongen water enters the plant from ether the city, which is the same water as is given to the citizens of Dongen. Or well water is pumped up from an underground river. Side note: many industries that use a lot of water are located on the same industrial site as the CCE plant because a lot of natural water is available, which is closely monitored by CCE. Because CCE attaches great importance to the state of the natural water the environmental manager has a seat in a governmental task force that monitors the natural water in all Brabant.

The distribution between will water and city water can be seen in Figure 46.
For this research we found how much of the water that enters the factory end up in a product, this resulted in Figure 47. In the main text is explained how this data is used.

**Figure 46** Incoming water distribution of total

**Figure 47** Water analysis
Appendix vii – Gas usage prediction tool

In this appendix will be discussed how this tool to predict the gas usage of the plant in Dongen is developed. The data on which it is based is presented below in red marked shape. The regression analysis, the method of use, and results that are accomplished so far by the tool. In the main text it is used in chapter 8. The gas prediction tool helps the environmental department to account for the factors ‘Temperature’ and ‘Volume line 3’. Because those factors represent a big external influence in daily gas KPI of the industrial production plant of CCE in Dongen. As can be seen under ‘predictor’ the constant and temp are significant with a 95% interval the production line 3 is just outside. But still it will be taken into account.

The regression equation is incorporated in an excel sheet that used on a daily basis by the environmental department. When the temperature and volume of line over the previous 24 hours is inserted the Excel sheet compares the real use of gas with the predicted use of gas. When this lays in a range of 5% we assume that gas fluctuation is based on temp and volume of line 3. When the prediction and real gas use are outside the 5% range the stepwise plan explained in appendix viii will come to play.

Below the regression equation with all statistical details can be found.

![Regression equation table]

The regression equation is

\[
\text{Gas gebruik weekly [kWh/week]} = 64616 - 2975 \text{ Gemiddeld temp [graden celcius]} + 93,1 \text{ productie L3 [m3]}
\]

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S = 42229,6  R-Sq = 78,4%  R-Sq(adj) = 77,5%

Analysis of Variance

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R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
Normal Probability Plot
(response is Gas gebruik weekly [kWh/week])

Figure 48 Normal probability plot, for gas usage prediction tool
Appendix viii – Daily KPI performance energy and water for dashboard

In the current situation the main KPI's are discussed on a daily basis by the management team of the plant, this meeting is called the dashboard meeting. The main KPI’s of the environmental department are also discussed in this meeting, those are shown in Figure 23 at page 71. Because the management team is present in this meeting the decision power is high, this means that when the targets of the KPI’s are not met the organization can quickly respond. In terms of the framework this using this meeting would fit ideally in the success factor KPI tree (as the highest KPI’s in the tree).

Earlier in paragraph 7.1.9 at page 63 is explained that these KPI’s are not presented every day, causing weekend diversions of the KPI to pass by unnoticed. In this seventh chapter further elaboration and a solution for this can be found.

As is explained in the eighth chapter the KPI for energy and water depend on so many variables that it is hard to determine the performance of the plant based on it. But the dashboard requires a performance update of the plant for energy and water based on the KPI for energy and water that are expressed in:

\[
\text{Energy KPI} = \frac{\text{kWh}}{1000l} \\
\text{l} = \text{liters of product that is produced over a certain timespan} \\
\text{kWh} = \text{That entered the factory over the same span} \\
\text{Water KPI} = \frac{\text{Lwater}}{\text{Lproduct}} \\
\text{Lwater} = \text{Total liters water that enters the factory over a certain timespan} \\
\text{Lproduct} = \text{Total liters product that is produced in the same timespan}
\]

Therefore a stepwise approach was made that can be executed on a daily basis giving an accurate overview of the performance of the plant. The approach must reveal which processes cause a problems that can explain why a KPI is not met. This was done based on MES, the significant users of energy and the employees engaged with the significant users and we tried to compensate for the external factors. During this research this approach got its shape, it started with one step looking at one processes along the way it got bigger and bigger. This resulted in the fact that more particularities could be identified and could be fixed increasing the efficiency. Also it gave a better overview to the dashboard meeting that gained knowledge about the processes which can result in improvement project over the longer term.

In Figure 49 is schematically shown how the daily KPI can be found, the numbers in figure refer to the numbers in Figure 50. Below the figures the approach is explained.
Figure 49 Stepwise approach on presenting the main KPI's
As can be seen in Figure 49 as stepwise approach is presented to the environmental department that is used on a daily basis. The first steps are taken to actually extract the KPI's for energy and water from the system. Thereafter steps are presented that are used to find the causes in case the KPI targets are not met.

As can be seen on the short term the approach tries to remove the waste thus improving the energy and water efficiency of the plant. In causes are being documented, when causes often occur this is communicate to the operational excellence team that can start improvements project based on the information form MES.

All analysis are put tighter in one Excel sheet, where a few reports from MES are imported to. This enable the environmental department to see the results of the analysis in one centralized place. This Excel is not added due to confidentiality reasons.
Appendix ix – Individual processes in the approach

In this appendix the individual processes will be discussed, this is where we engaged employees with MES in order to improve the process efficiency. Firstly the bottle washer approach will be discussed, secondly the water treatment approach is explained, lastly the bottle blowing approach is explained.

Bottle washer approach (line 3)

![Bottle washer approach](image)

Weekly review KPI’s

- Request Technical Services or solve intern [line 3]
- Save defects and actions [Line 3 + Qesh]
- Returning defects

Daily review

- Dashboard
- Potential Improvements projects

Longer term (operational Excellence team)

Basically all three approaches are agreements made with the departments that own the processes. We divided the responsibilities over the environmental department and the departments with whom we made the agreement.

Besides all three approach are made based on the same principle used when making the daily KPI performance approach. This way of thinking about MES is explained in the second chapter; in real time increasing efficiency by instantly removing the cause of the inefficiency. And on the longer term initiate improvement projects to take away the causes of often reoccurring defects, this improves the efficiency of the energy and water structurally.
As can be seen in the figure we found which things might be happening when an KPI is not met, this is a part of education of the employees of CCE that work with the bottle washer. When having the meetings we also explained to them where they can find certain things in MES in order for them to be trained. This combined with the clear responsibilities engaged the employees working with the bottle washer.

Water treatment approach

Approximately the same steps are taken in this approach as in the bottle washer approach. Only the actors are different and it is slightly differently displayed. The special thing with the water treatment approach is that we gained a big momentum with the managers of the plant and upstream, which is responsible for the water treatment. This led to fact that special MES tasks are created for the operators. This will increase sense of responsibility they feel for their KPI since they are also rewarded based on the KPI and way the handle the documentation of the KPI that will also work based in MES.
Approximately the same steps are taken in this approach as in the bottle washer approach. Only the actors are different and it is slightly differently displayed. Furthermore this approach was not yet operational at the moment the research finished. But the first conversations about the approach were held and the approach was received with a positive attitude by the team leader of the blowing hall who is responsible for this process during the case of the shift he or she works.

Figure 53 Bottle blowing approach, stepwise representation