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Cleaner Production Program and Climate Change mitigation: organizational networks integrating competences for decreasing GHG emissions

Rogerio Ceravolo Calia - FGV Business School

Av. 9 de Julho, 2029 - Bela Vista - 01313-902 - São Paulo-SP, Brazil

calia@gvmail.br 55-19-9612 7332

Fabio Muller Guerrini - University of Sao Paulo – School of Engineering of Sao Carlos

Avenida Trabalhador Sãocarlense, 400 - São Carlos-SP - Brazil - 13566-590

fabmg@prod.eesc.sc.usp.br 55-16-3373-9382

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ABSTRACT

This paper presents the experience of a multinational company’s cleaner production program to mitigate greenhouse effect gases emissions. The research is empirically based on 205 projects that reduced emissions of greenhouse effect gases and were recognized by the corporate cleaner production program from July 2004 to December 2006. The paper compares the contributions of subsidiaries in different locations and analyses how the Six Sigma methodology for project management stimulates the creation of internal networks integrating different competences and different tactical knowledge to effectively implement the required changes for reducing emissions.

INTRODUCTION

The necessary conditions for the living cell creation and maintenance is the result of a long development process along billions of years. During this time, biological processes adapted to live in environments with very specific air, water and soil compositions. In less than 0.00001% of the living cell development time, however, the Industrial Revolution significantly changed the environment, by mining big quantities of heavy metals from the earth crust to the soil surface, by changing the concentrations of gases in the atmosphere and by generating considerable amounts of slowly degrading substances in landfills and oceans. Those drastic changes (proportionally, as fast as the last two minutes of changes in stable conditions of a forty years old person) frequently stress the life supporting biological cycles (ROBERT, 2002).

The insufficient understanding of the biological cycles basic requirements resulted in damages not only in the environment, but also in human health. As result, the United Nations estimates that more than five million humans die yearly due to environmental dangers like unsafe water, air pollution, poor waste disposal, unintentional poisoning and climate change (WHO and UNEP, 2006).

The average earth surface temperature increased around 0,6°C during the last century and numerous evidences indicate that this global warming is related to human activities (EUROPEAN COMUNITY, 2006).

In fact, human activities changed the chemical composition of the atmosphere, by increasing Greenhouse Effect Gases emissions (US-EPA, 2006). Moreover, projections by the Intergovernmental Panel on Climate Change (IPCC, 2001) estimate for the current century additional temperature increase between 1,4 and 5,8°C.

For the European Community, climate change is one of the biggest environmental, social and economic threats of the planet, since higher temperatures may trigger sea level increases between 9 and 88 cm by the end of the current century and cause more frequent extreme climate events (EUROPEAN COMUNITY, 2006).

CLEANER PRODUCTION

Cleaner Production methodologies aim to decrease the negative impact of manufactures in the natural environment.

The United Nations Environment Programme defines the term ‘Cleaner Production’.

> *"Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society" (*UNEP, 2001).

Thus, Cleaner Production is an environmental management preventive approach for producing goods and services with the minimum environmental impact within the current economic and technological limitations. In addition, the Cleaner Production concept explores win-win strategies, focusing projects that result both in pollution prevention and economic benefits. (UNEP, 2001).

ORGANIZATIONAL NETWORKS

Managers in companies with worldwide operations frequently try to solve strategic problems by changing the organizational structure. By doing so, managers redefine responsibilities and relationships so that immediate impacts occur communicating emphatic signals of change to all management levels (BARTLETT and GHOSHAL, 1991).

However, in recent years companies learned that changes in the formal structures are not sufficient for improved long-term performance, since these formal structures are in constant contact with highly dynamic business environments. Therefore, more flexible structures are needed to allow fast integration of multiple organizational competences, by creating more dynamic decision processes and systems, more effective communication channels and more freely connected interpersonal relationships (BARTLETT and GHOSHAL, 1991).

In order to compete in the global economy, the organizational structure should provide the balance between a global infrastructure of shared resources and management practices in one hand and adaptations to the specific characteristics of every location the company operates, in the other hand, related to local consumers preferences, work force profile and regulatory agencies policies (ECCLES and NOLAN, 1993).

For this purpose, the networked organizations are composed of two different levels. The first level is top management responsibility to make globally available to the company the infrastructure, the assets, the resources, the management practices, the performance metrics and a clear business vision. And in the second level occurs the self designed networks, in which individuals spontaneously take the initiative to utilize the global infrastructure, in order to build the relationships to access the competencies required for achieving their specific business goals (ECCLES and NOLAN, 1993).

SIX SIGMA METHODOLOGY

Pande, Neuman and Cavanagh described how the Six Sigma methodology for project management is implemented, in order to support significant change in the organizations.

The name of this methodology is derived from the Greek alphabet symbol utilized in statistics for standard deviation, a measurement to quantify variation and process inconsistency (PANDE, NEUMAN and CAVANAGH, 2000).

For Quality Management professionals, a product with 3 sigma quality represents that 93,3% of the products provide the expected quality, while the 6 sigma quality comprises of 99,9997% of the products meeting the quality specifications. Thus, a Six Sigma quality product has no more than 3.4 failures by million of opportunities for failures, given that ‘opportunities for failures’ are the failures categories that a product potentially may present.

The Six Sigma methodology defines an organizational structure for project management, project management structure phases and a sequence of analytical and organizational tools for conducting improvement projects.

The main role in Six Sigma is that of the expert project manager called ‘Black Belt’ in analogy to the oriental fights that define different belts to signalize level of proficiency.

This project manager is responsible to lead a project and to statistically validate the independent variables (project Xs) that most impact the project dependent variable behavior (project Y). Employees that keep in their functional organizational structure and are also trained to lead Six Sigma projects are denominated ‘Green Belts’.

In order to achieve the problem diagnosis and the improvements, the project team must structure the project in phases of: project definition, current performance measurement, analysis of the independent variables, independent variables improvements and independent variables control procedures:

- Define – A project begins with a statement about the problem to be solved.
- Measure – In this phase, the team measures the actual performance of the project dependent variables (Ys) in a time series.
- Analyze – In the analytical phase, the project team identifies the potential independent variables (project Xs), prioritizes them and quantifies their explaining power for the Y behavior.
- Improve – Once the independent variables (project Xs) are proved in the Analyze phase, the team manipulates the Xs, in order to experimentally optimize the process parameters in a prototypic solution.
- Control – Finally, the project team creates new work procedures and new roles and responsibilities, in order to ensure continuous maintenance of the improved performance.

The Six Sigma methodology was created by Motorola, which states that the implementation of this methodology generated economic gains of US$ 15 billions in 11 years (KWAK and

ANBARI, 2006). Then, General Electric utilized Six Sigma for conducting strategic organizational changes.

At the beginning, Motorola created the Six Sigma methodology, in order to improve operational performance, reduce failures and to produce faster, but currently, Six Sigma is also utilized for increasing market share, improve customer retention, develop new products, accelerate innovation and to manage responsiveness to new customer requirements. Thus, initially Six Sigma was utilized by quality engineers, but currently it is utilized by vice-presidents, software engineers and employees in areas like human resources, customer services and accounting (MOTOROLA, 2006).

General Electric implemented Six Sigma as integrated part of its organizational culture, because its leaders believed that the competitive environment is increasingly intolerant for products failures, which requires continuous search for new manners to satisfy customers' expectations (GE, 2006).

In addition, the Six Sigma methodology contributed to increase the replication of successful projects, multiplying best practices for the whole company. For this purpose, GE trains its Six Sigma experts in advanced statistical tools, quality control tools, change management techniques and tools for technology management.

In his memories as General Electric CEO (*Chief Executive Officer*), Jack Welch describes that he decided to allocate only high-level executives to lead the Six Sigma deployment, who first had to estimate the potential benefit of the Six Sigma implementation, which they estimated to be between US$ 7 and 10 billions or 10 to 15% of the annual revenue (WELCH, 2001).

Because of this significant opportunity dimension, Jack Welch decided to deploy Six Sigma not as a simple quality program, but as a corporate initiative.

For this purpose, GE's CEO defined that:

- Only the best employees should be chosen for the role of Six Sigma project leaders (Black Belts), for a two years full time assignment.
- All projects must be formally linked to business goals.
- Financial analysts should validate the project financial results.
- Black Belts should also utilize Six Sigma for solving problems in costumer's operations, in order to improve relationship.

For Welch:

> "Ultimately, (Six Sigma) drives leadership to be better by providing tools to think through tough issues"

DATA COLLECTION

The multinational company's Cleaner Production Program completes thirty years of continuous improvements for enhancing environmental performance.

The Cleaner Production Program was created in 1975 and the aggregated results from the first year of each cleaner production project account 2.2 billion pounds of pollutants prevented and 1 billion dollars saved.

Since 2004, this multinational company's Cleaner Production Program also registers results in terms of Greenhouse Effect Gases reduction.

The basic idea of the program is the employees' volunteer engagement to improve products and production processes, in order to prevent pollution at the source.

In the sixty's, regulatory agencies were focused on the pollution control approach. In this sense, companies utilized additional equipments in the productive process for removing pollution, before it damaged the natural environment. However, in most of the pollution control cases, pollutants do not disappear, but just are transformed in another category of pollutants (LING, 1997).

In 1975, the multinational company's Cleaner Production Program pioneered with the concept of adopting pollution prevention in the whole corporation and registering the results.

After the first year of existence, the cleaner production program concluded 19 projects, which reported 1.5 million pounds of pollution prevented and 11 million dollars saved.

The Cleaner Production Program is conducted by a Coordinating Committee, composed by representatives of engineering, manufacturing and laboratory organizations together with the Environmental, Health and Safety department. This Coordinating Committee defines the program award criteria and recognizes the projects to be awarded. In order to be recognized as a Cleaner Production project it must at least reduce a pollutant (or reduce energy use) and save money, by eliminating or reducing the need to utilize pollution control equipment or by reducing operating and materials expenses or even by increasing sales.

In 2002, the program was reformulated, in order to obtain engagement of more functional areas. For this purpose, the program defined special recognition categories for logistics, packaging and also for the implementation of Life Cycle Management tools.

The research is empirically based on 205 projects that collectively reduced emissions in 266,295 metric tons of CO_2 equivalent. Those projects were conducted by 17 different subsidiaries and were recognized by the corporate Cleaner Production Program from July 2004 to December 2006.

METHODOLOGY

Firstly, this study conducts a descriptive statistics to understand the general distribution parameters of Cleaner Production projects emissions reduction in the sample.

Secondly, the analysis follows with the non-parametric Mann-Whitney test (CONOVER, 1998) to compare the emissions reduction performance of the Six Sigma Cleaner Production projects with non Six Sigma Cleaner Production projects. It was necessary to conduct the non-parametric Mann-Whitney test, instead of the 2-paired T test, because the variable ‘CO_2 equivalent’ reduced by project does not present normal distribution.

Finally, it was utilized the EKD - Enterprise Knowledge Development (BUBENKO, PERSSON e STIRNA, 2001) process model and actors and resource model to understand how the Six Sigma organizational structure stimulated the formation of self-organized networks to improve the process performance of the Cleaner Production Program.

DATA ANALYSIS

According to Figure 1, in average the Cleaner Production projects avoided 1,299 metric tons of CO_2 equivalent, while the median is 101 metric tons of CO_2 equivalent.

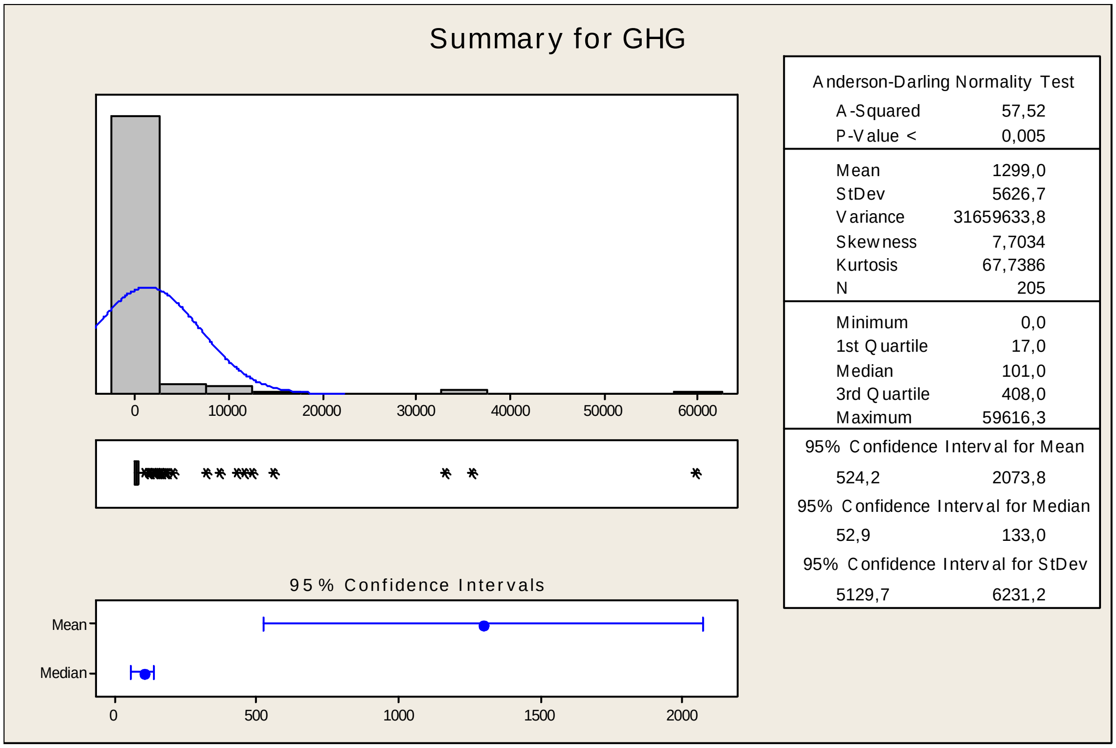

Figure 1. Descriptive statistics for the Cleaner Production projects GHG emissions reduction in metric tons CO2 equivalent (From the author)

As shown in Figure 2, the facilities in USA avoided 50,5% of the total Greenhouse Effect Gases. In addition, 28% of the emissions were reduced by plants in United Kingdom, 13% by German operations and 2,5% by Japanese manufactures.

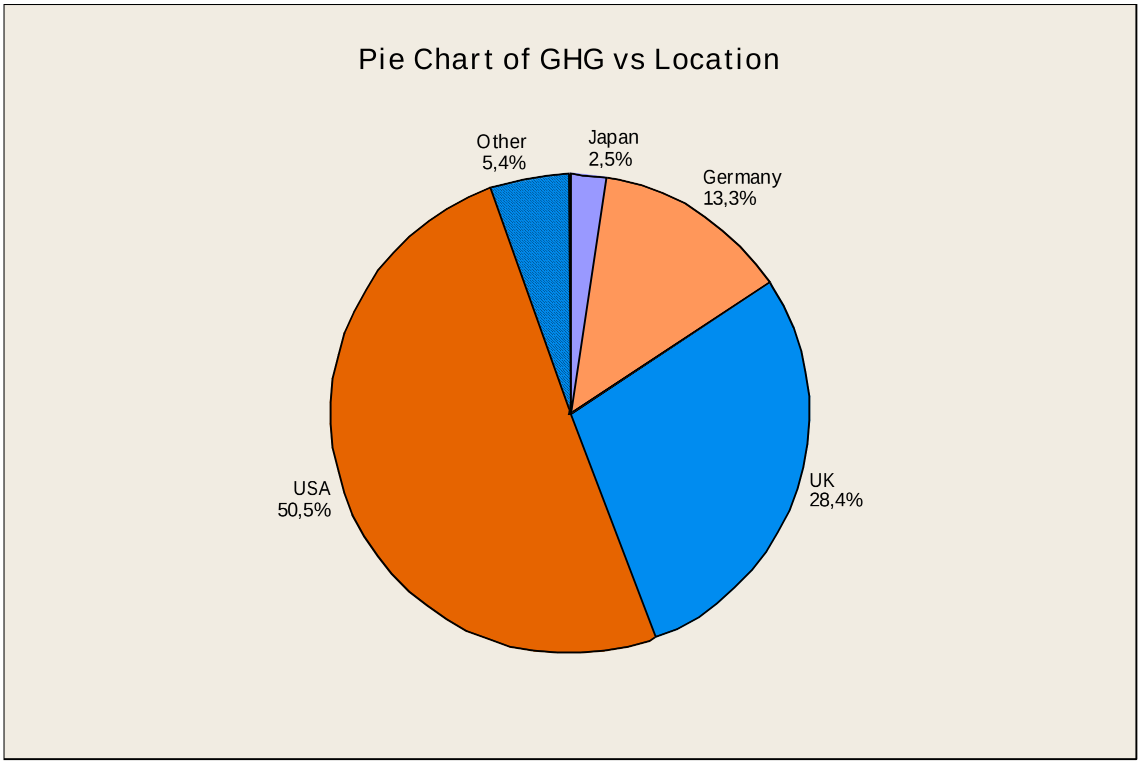

Figure 2. GHG emissions reduction by the operations country (From the author)

Analyzing only the projects conducted by plants located in USA, as represented in Figure 3, projects managed by the Six Sigma methodology and by the Six Sigma organizational structure were more numerous and individually reduced more than three times Greenhouse Effect Gases compared to projects conducted without the Six Sigma methodology.

In fact, the Mann-Whitney test concluded that the median of projects with the Six Sigma methodology was a reduction of 131 metric tons of CO2 equivalent, while the median of projects without Six Sigma was a reduction of 36 metric tons of CO2 equivalent emissions (Table 1).

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Mann-Whitney Test and CI: GHG Non Six Sigma; GHG Six
Sigma

                       N  Median
GHG Non Six Sigma  37    36,0
GHG Six Sigma      94   131,0


Point estimate for ETA1-ETA2 is -33,7
95,0 Percent CI for ETA1-ETA2 is (-122,0;-0,1)
W = 2051,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0231
The test is significant at 0,0231 (adjusted for ties)
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Table 1. Statistical test to compare in USA Six Sigma versus non Six Sigma Cleaner Production projects GHG emissions reduction in metric tons CO2 equivalent (From the author)

Although less statistically significant, this relationship is also to observe for all projects worldwide (Table 2). Projects managed by the Six Sigma methodology were almost twice as numerous and reduced more than twice the greenhouse effect gases compared to projects conducted without the Six Sigma methodology. Thus, the Mann-Whitney test concluded that the median emissions reduction of projects with the Six Sigma methodology was 129 metric tons of CO2 equivalent, while the median emissions reduction of projects without Six Sigma was 49,5 metric tons of CO2 equivalent.

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Mann-Whitney Test and CI: GHG Non Six Sigma; GHG Six Sigma

                       N  Median
GHG Non Six Sigma   74    49,5
GHG Six Sigma      131   129,0


Point estimate for ETA1-ETA2 is -17,0
95,0 Percent CI for ETA1-ETA2 is (-64,6;5,0)
W = 7028,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0730
The test is significant at 0,0730 (adjusted for ties)
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Table 2. Statistical test to compare worldwide Six Sigma versus non Six Sigma Cleaner Production projects GHG emissions reduction in metric tons CO2 equivalent (From the author)

It is possible to understand the Cleaner Production corporate program as a process that transforms project ideas into demonstrated pollution prevented and cost reduction, by motivating employees to conduct Cleaner Production projects and demonstrating the environmental results and by recognizing and celebrating those results (Figure 3).

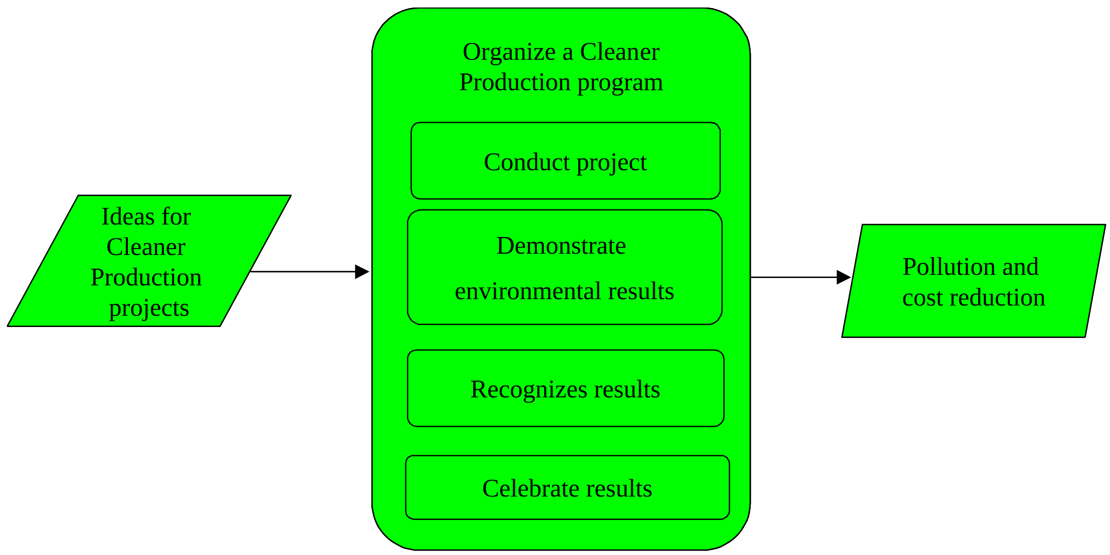

Figure 3. Process diagram of the Cleaner Production Program (From the author)

However, the performance of this Cleaner Production program increased with the contribution of a very different initiative to institute a project management culture to decrease costs, improve inventory turns and increase sales (Figure 4).

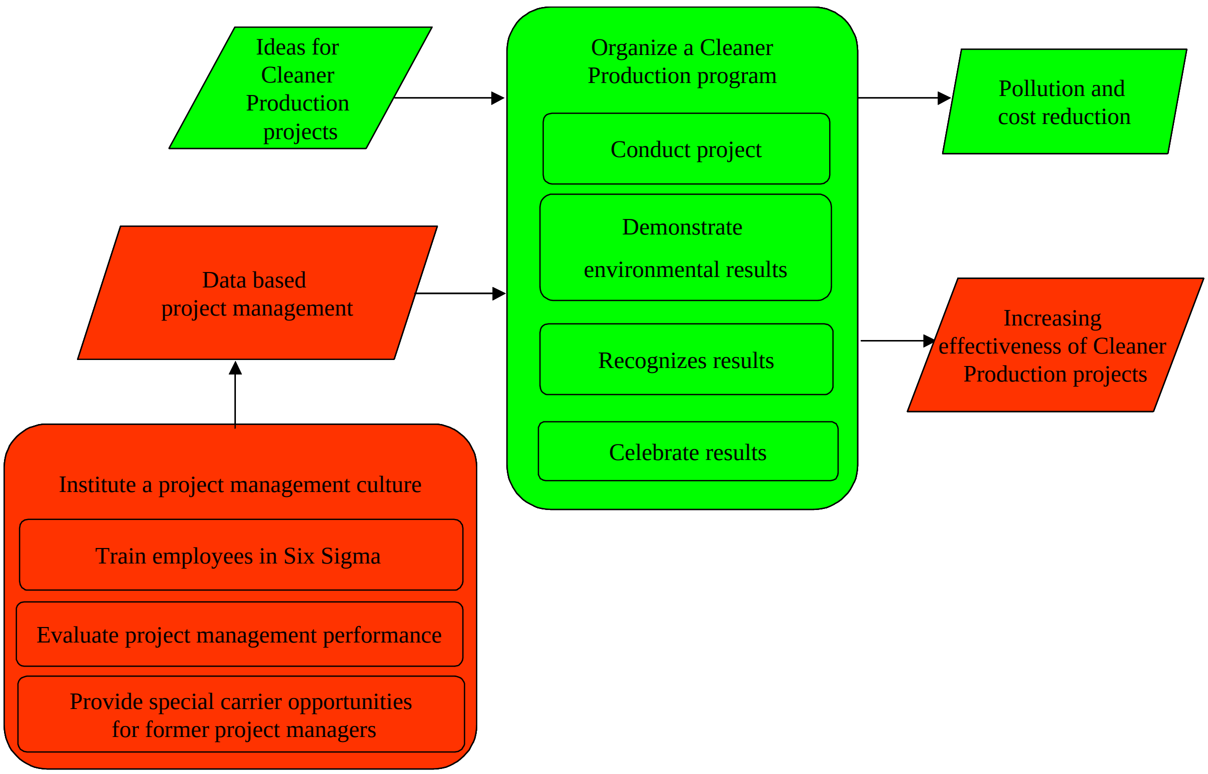

Figure 4. Process diagram of the Cleaner Production Program in synergy with Six Sigma project management (From the author)

Thus, the Cleaner Production program combined with the Six Sigma initiative can also be understood as a process transforming data based project management into increased effectiveness of Cleaner Production projects. This data based project management is created as a result of an initiative to institute a project management culture, by training employees in the Six Sigma methodology, by evaluating employees performance as project leaders and by offering special carrier opportunities for high performance project managers. The process to increase the effectiveness of the Cleaner Production program is performed by an organizational network combining different actors and resources. The project management matrix organizational structure (CLARK and WHEELWRIGHT, 1993) for Six Sigma explains the authority relationship between project managers (Black Belts) and team members. However, the matrix organizational structure does not explain how the different competences in the company are really integrated, in order to achieve increased environmental performance in the Cleaner Production program. For this purpose, the organizational network is described in Figure 5.

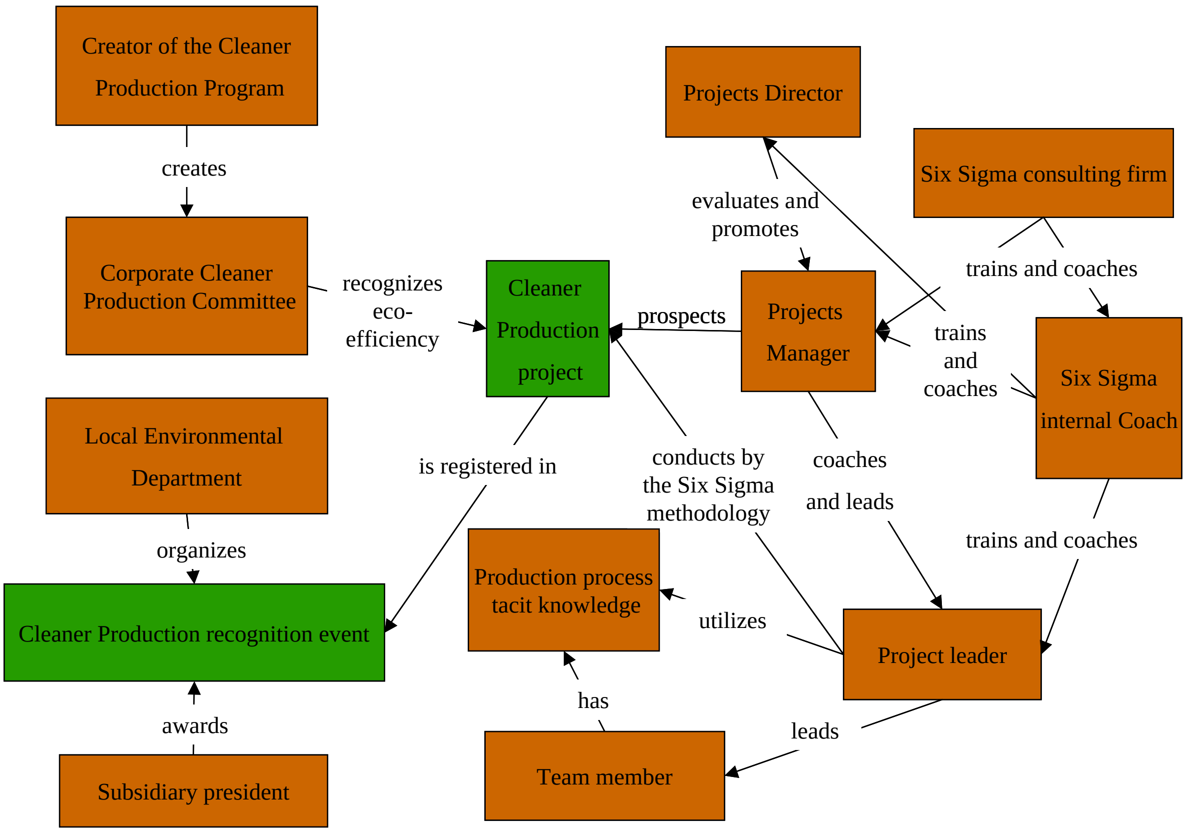

Figure 5. Organizational Network for decreasing GHG emissions (From the author)

The creator of the Cleaner Production program instituted a corporate committee to decide on the acceptance of individual Cleaner Production projects. The projects recognized as Cleaner Production projects are registered in the Cleaner Production recognition event organized by the local subsidiary Environmental Department, in which the subsidiary president awards the recognized projects team members.

The team members of Cleaner Production projects have the option to utilize the Six Sigma methodology for project management and the Six Sigma internal professionals as support.

The opportunity for a Six Sigma Cleaner Production project usually is identified by a project manager (Black Belt), who is a professional especially trained by Six Sigma experts (external Six Sigma consulting firm or internal Six Sigma Coaches). The Six Sigma director awards high performance professionals in the assignment as Six Sigma project managers with attractive promotions. Thus, Six Sigma project managers are highly motivated employees supporting and leading specific project leaders in the Six Sigma methodology usage. In addition, to achieve practical results, project managers and project leaders utilize their informal professional relationships, in order to utilize specific tacit knowledge in the production process for diagnosing the pollution causes and for proposing feasible solutions to decrease pollution and emissions.

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