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SUCCESS FACTORS OF STANDARDIZATION: AN EMPIRICAL STUDY

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Abstract: *The complexity in plant EPC (Engineering, Procurement, Construction) industry has increased significantly over the last decade. One common approach to manage this complexity is the implementation of standardization programs. Within this paper critical success factors (CSFs) of standardization programs in the German plant EPC industry are evaluated. Utilizing these success factors, EPC companies are able to implement more efficient standardization programs. The evaluation of the success factors was done based on a two-step multi-method approach. In a first step existing CSFs in the plant EPC business were collected using qualitative research methods. Afterwards they were tested for their suitability for standardization programs using expert interviews. Finally, nine CSFs could be determined which were evaluated in a quantitative online survey among experts with experience in the plant EPC industry. "Reusability","know-how" and "continuous improvement" turned out to be the most important CSFs. We further observed that the ranking of the CSFs is depending on the respective domain within the plant EPC industry. The CSFs "flexibility", "standardization in all stages of the lifecycle" and "continuous improvement" were considered rather domain-specific, while the CSF "reusability" has been proven to be both: domain-independent and important in all domains.*
Keywords: *standardization / plant EPC / critical success factors / CSF*

1. INTRODUCTION

The plant EPC (Engineering, Construction, Procurement) industry is characterized by its diversity. Companies provide engineering, construction and service of industrial - especially large-scaled - plants for e.g. petroleum refining, chemical processing, iron and steel processing or power generation. Orders are processed in form of projects. Contract volumes range up to and above several hundreds of millions of dollars [1].

Plant EPC companies work in a dynamic environment. They are challenged by competition, customer and investors to reduce costs and development time while meeting increasing expectations on quality [1][2][3].

A major challenge is the increasing complexity in plant EPC business. Motivated by the fact that bigger plants lead to significant cost reductions per production unit for the customer, the average size of projects grows. This causes increased complexity in projects not only on a technical level (e.g. by an increasing number of components and interfaces) but also by an increased organizational complexity caused by global coordination needs [1][2][3].

Standardization manages complexity by reducing the variety and number of components and processes. A common and proven approach to reduce this complexity is the implementation of so called standardization programs. Despite the proven benefits of standardization programs, many EPC companies have difficulties to successfully implement those programs [3][4].

To support plant EPC companies to face these challenges this contribution identifies critical success factors (CSFs). In this context CSFs are defined as influencing factors that explain a successful implementation of standardization programs [5]. The CSFs were collected from interviews with experts and prioritized in a subsequent online survey. If these factors are considered during the planning and implementation of standardization programs plant EPC companies will be able to better seize the opportunities that these programs provide.

2. DEFINITION OF STANDARD AND STANDARDIZATION

The term "standardization" is used in multiple ways in literature and industry. A short overview in the following will summarize common interpretations in the literature of the terms *standard* and *standardization*.

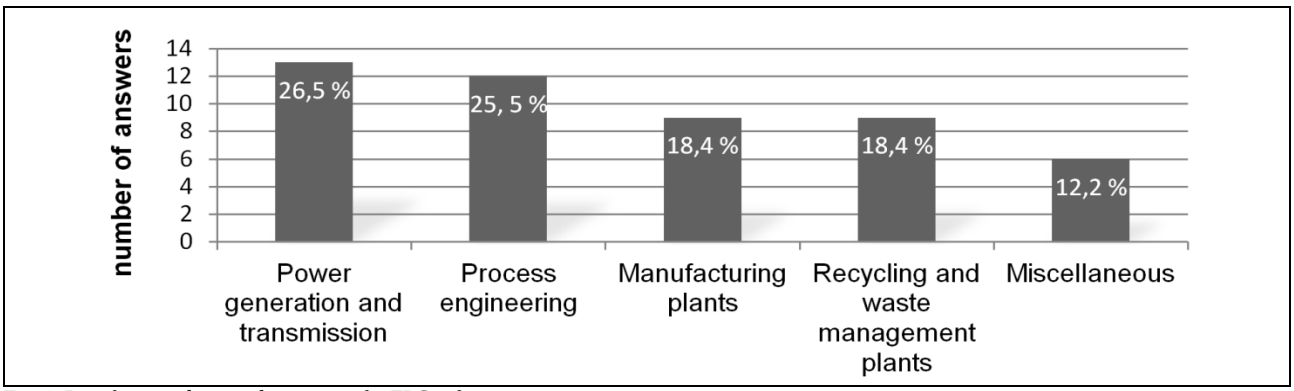


Fig. 1. Distribution of areas of activity in the EPC industry

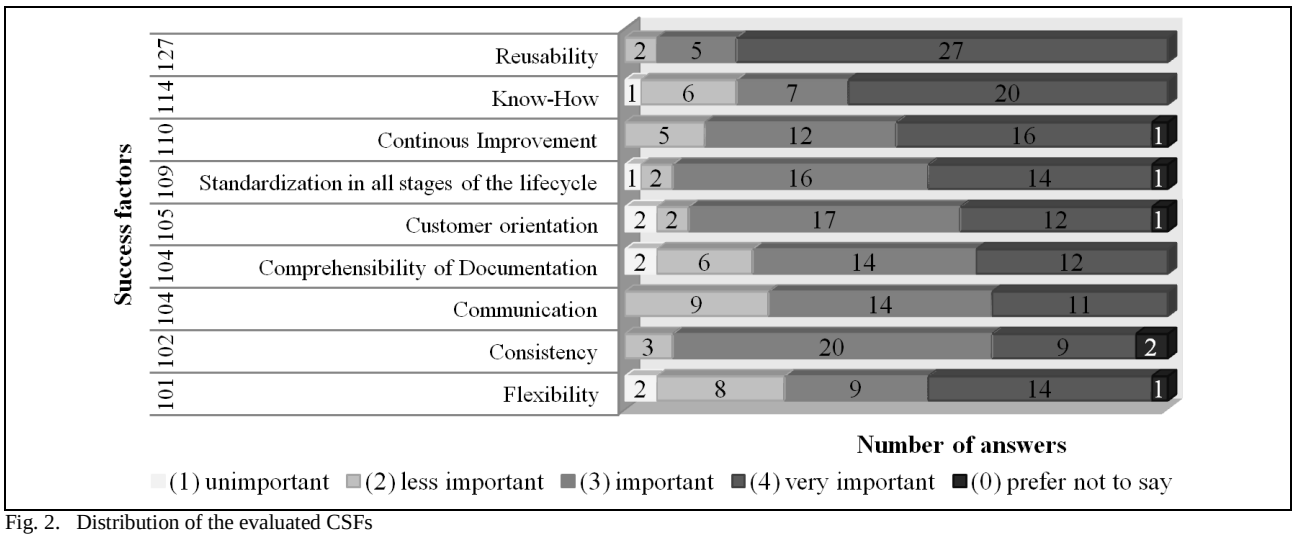


Fig. 2. Distribution of the evaluated CSFs

A *Standard* is a unified template which is used as a model for a specific application or its outcome. A standard is in general designed and established by an administrative authority [10].

Standardization is a process in which explicit standards are determined that constitute a groundwork for unified approaches. The division of the plant into modules and the repeated use of these modules enables to economies of scale. This has a positive impact e.g. on compatibility, quality, efficiency, or cost. Especially in manufacturing, standardization serves to counteract the growing complexity of for instance by the management of variants and the reduction of the continuous increasing number of modules [10].

3. RESEARCH METHODOLOGY AND DATA POOL

For the evaluation of the CSFs we used a two-step multi-method approach which combines qualitative and quantitative research methods in order to increase the robustness of research results [6]. In the first part we gathered existing CSFs using qualitative methods such as desk research, literature reviews [7] and structured interviewing of experts [8].

In the second part we evaluated the gathered CSFs using a quantitative survey. For the survey 262 experts in the field of standardization were asked to answer a web-based questionnaire with – depending on the expert's field of activity – up to 16 questions. Of these 262 persons 99 responded to the survey between July 12th and July 30th 2012. 65 of them were excluded due to incomplete information. 34 questionnaires were completed, which equals a response rate of 13 %. The experts were approached via electronic mail. The addresses were gathered using XING (http://www.xing.com), a global social network of business contacts. Persons within XING were chosen if their profiles mentioned relevant key words, like standardization or plant EPC business. The experts were identified, by manually selecting persons who either had working experience in standardization or project business or were managers in companies in plant EPC business. The remaining persons were personal contacts of the authors. Geographically and language-wise the survey was limited to German speaking persons.

4. RESULTS

4.1 Results of qualitative approach

The collection of CSFs of standardization in plant EPC business was the goal of the first part of our study. After a desk-research four CSFs for standardization in plant EPC have been identified. These were "*Know-How*", "*standardization in all stages of the lifecycle*", "*reusability*" and "*customer orientation*".

CSFs	Description
Know-How	Knowledge, competence, etc.
Standardization in all stages of the lifecycle	Standardization is important in all stages of the value chain: development, production etc
Communication	National and international exchange of information, contact to standardization institutions
Continuous improvement	The technological progress ongoing improvement of the standards
Customer orientation	Important due to the unique and individualized construction of plants
Flexiblity	The possibility to deviate from common standards
Comprehensibility of documentation	Low barriers due to unified operating principles of standardization institutions
Reusability	The possibility to reuse standardized modules in different plants
Consistency	Reuse of artifacts in different manufacturing phases (e.g. engineering, commissioning) within a plant or project.

Tab. 1. CSFs identified in expert interviews

In expert interviews these CFSs were reviewed and five additional CSFs were added. For the expert interviews eight persons of a large German plant EPC company who had an average of eleven years of practical experience in standardization were chosen. After the literature review and the expert evaluation nine final CSFs have been identified (see Tab. 1). The determined CSFs from literature could be confirmed by answers of the experts.

4.2 Results of quantitative approach

In the second part we used a survey to give empirical evidence to the results of the first part. The survey opened with introductory questions concerning general business data. As can be seen in Fig. 1 the majority of the participants were employees in the domain "*power gen-*

eration and transmission" (27%) followed by "*process plants*" (26%). The category "*miscellaneous*" contained companies producing e.g. diesel engines, vacuum plants for the metal industry or packaging systems.

The distribution of the determined domains is very similar to that of other surveys conducted in the German capital goods industry [1]. This indicates that the given sample is representative.

Most of the interviewees have been working in plant EPC business for many years (2 more than 25 years, 11 for 15-24 years, 9 for 5-14 years) and thus had profound knowledge in the field of standardization (22 good up to very good knowledge).

4.3 Rating of CSFs

After this general business data, the experts had to assess the importance according to their background. The rating scale included the options "*very important*", "*important*", "*rather unimportant*", "*unimportant*" and "*prefer not to say*" (Fig. 2). Each of these options had an assigned value reaching from one for "*unimportant*" to four for "*very important*". "*prefer not to say*" was marked with a zero. The evaluation units were multiplied with the number of answers given and cumulated in order to receive a hierarchy. The maximum attainable score was 134.

Fig. 2 shows that the majority of the CSFs were rated "*important*" respectively "*very important*". This confirms the high relevance of the CSFs determined in the expert interviews.

The most important rated CSF is "*reusability*" with a total score of 127 points and is a main driver for developing standards [3].

Closely related to "*reusability*, but less importantly rated is the factor "*consistency*". While "*reusability*" refers to the reuse of artifacts in different plants, "*consistency*" applies for the reuse of artifacts in different phases within a plant [2]. As can be seen in Fig. 2 a consistent use of standards is less important to the interviewees. This may result from that the concept of "*consistency*" is less known than "*reusability*" which would explain the two abstentions.

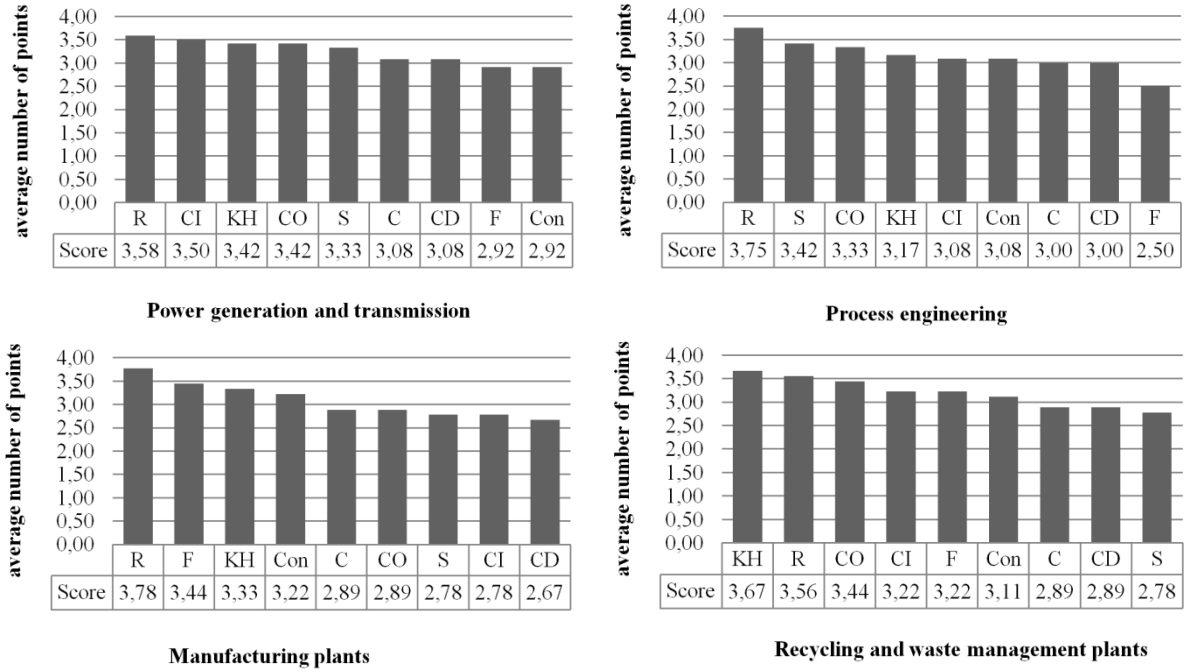
"*Know-How*", "*continuous improvement*" and "*standardization in all stages of the lifecycle*" are also rated rather important. This is not surprising, since the planning and implementation of standardization require a lot of knowledge. After the implementation is completed it is recommended to check if the developed standards still meet the market requirements s if necessary.

4.4 Distribution in industry domains

The focus of the following analysis lies on the differences in the rating of CSFs between the different domains. Instead of a total score which would be dependent on the number of interviewees of a domain, the average of the CSFs is used to ensure the comparability of the domains.

A major point of criticism of CSF research is that it is too abstract for a practical application of research findings [9]. To improve the practical reference of the CSFs the distribution of CSFs in each domain has been analyzed (Fig. 3, domain "*miscellaneous*" not listed here). As can be seen in the graphics, "reusability" plays a major role in most domains. In 4 of 5 domains this CSF came even out first in the ranking.

Having a closer look on the domain „*power generation and transmission*", besides "*reusability*" the CSF "*continuous improvement*" is rated relevant. This relatively high weighting may result from constantly increasing requirements for energy efficiency and stricter environmental laws in this domain forcing companies to continuously adapt their standards.



R – Reusability, **CI** - Continues Improvement, **KH** - Know-How, **CO** - Customer Orientation, **S** – Standardization in all stages of the lifecycle, **C** – Communication, **CD** - Comprehensibility of Documentation, **F** – Flexibility, **Con** – Consistency.

Fig. 3. Distribution of CSFs in the industry domains

In the domain "*manufacturing plants*" in contrast to the other domains "*flexibility*" is rated high. This may be explained by the high importance of customer-specific plants. In the domain "*process plants*" individual customer requirements often relate to the output volume of the plant, which can be relatively easy met by using scale-up techniques. Customer requirements address the functionality which requires flexible engineering and development processes. Furthermore products manufactured on these plants usually change during the operation phase, which requires retrofits. Flexible standards make those retrofits easier.

Finally, in the domain "*process plant*", the CSF "*standardization in all stages of lifecycle important*" is seen on the second rank, as a result of the long life-time of industrial plants in this domain.

Surprisingly in all domains the CSF "*customer orientation*" - which is seen as one of the key success factors in literature - can be found only in the medium range. A possible explanation for this unexpected low ranking could be that build-to-order is the common production approach in plant EPC business. So customer orientation is already an inherent feature in this business model.

Not listed in the Fig. 3 is the fifth category "miscellaneous". Here the most important CSF is, by a large margin, "*reusability*" (4.00) followed by "*continuous improvement*" (3.43), whereas "*flexibility*" is least important (3.00).

Finally the dependency of the CSFs ranking on the respective domain was analyzed. To estimate if the ranking position of CSFs (see Fig. 3) is dependent on a domain the average ranking position in the domains (1 = 1st rank, 9 = last rank) and standard deviation was evaluated (Tab. 2). If a CSF has a high standard deviation it is rather domain-specific i.e. it is ranked differently in the respective domains. If a CSF has a low standard deviation, it has a similar ranking in all domains.

Abbr.	CSFs	Average rank	Std. dev.
KH	Know-How	3,40	1,62
S	Standardization in all stages of the lifecycle	6,20	2,48
C	Communication	6,40	0,80
CI	Continuous improvement	4,20	2,23
CO	Customer orientation	3,80	1,17
F	Flexiblity	6,60	2,73
CD	Comprehensibility of documentation	7,20	1,72
R	Reusability	1,20	0,40
Con	Consistency	6,20	1,60

Tab. 2. Average ranking and standard deviation of the CSFs

The factors "*flexibility*", "*standardization in all stages of the lifecycle*" and "*continuous improvement*" turned out to be highly domain-specific. While "*flexibility*" is rated on second rank in manufacturing plant, it is one of the last ranks in other domains.

The CSF "*reusability*" proved to be both domain-independent and important. "*communication*" is also relatively independent, but not as important.

5. LIMITATIONS

Basic limitations of the quantitative research approach are the lack of control over the participants and the truthfulness of their answers as well as the need for simple questions due to the lack of a common terminology. In order to overcome these limitations we followed a mixed methodology approach combining quantitative and qualitative techniques to use the strengths of both approaches [6].

The sample size of the quantitative survey was relatively small. However, through a preceding qualitative study and a representative sample structure the quality of the results could be increased. Additionally we focused on experts and interviewees with many years of professional experience to profit from their profound judgement of CSFs.

6. CONCLUSION

This contribution describes CSFs for standardization in plant EPC business. The conducted survey suggests that all evaluated factors are considered to be relevant/significant due to their score (ranked important or very important). The most important ranked success factor is "*reusability*". Our findings further indicate that the CSFs "*flexibility*" and "*standardization in all stages of the lifecycle*" are particularly dependent on the respective domain of plant EPC.

For future research we suggest to set an international focus for the survey to further validate the results.

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