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LIFE CYCLE SUSTAINABILITY ASSESSMENT FOR LARGE SCALE PROJECTS IN MANUFACTURING AND PLANT INDUSTRIES

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ABSTRACT

Large-scale projects like a new line-production may not only change a company's profitability, but also its environmental and social compatibility. However, for a company-specific assessment of such projects, the product-related life cycle methods are suitable to a limited extent, as the project's scope may be broader and moreover, for the implementing company not the sustainability of the project itself, but the effects on the company are of utmost interest. Thus a concept for a sustainable and firm-specific project assessment is outlined, by designing a decision-oriented Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) followed by an overall Sustainability Assessment extended by a Stakeholder-Effect-Analysis.

INTRODUCTION AND GOAL SETTING

Large-scale investment projects like the implementation of a new line-production often lead to decisive changes of entire work processes. Measured against its effects on the natural environment, the employees and on the entire society as a whole, projects of this type may have a lasting effect not only on economic efficiency, but also on the environmental and social credentials of a company and its site. However, compared to a single physical product a Life Cycle Sustainability Assessment (LCSA) of such long-term projects may be far more complex. As with the definition of the functional unit, proving more complex the larger a project's focus is (Guinée, 2002, p. 7, in the context of LCA), the same especially holds true for the definition of the system boundaries, which in the course of a sustainable project life cycle assessment should take into account both, the plant - and the product life cycle (with the latter - e.g. a product manufactured by the new plant – intersecting in the plant's operating phase - see Labuschagne & Brent, 2005, pp. 162-165). For this reason, when regarding large-scale projects, accompanied by several changes in locational capacities (such as buildings, plants, …), going itself through different life cycles and involving perhaps the manufacturing of further products, thus the definition of appropriate system boundaries becomes more difficult. These challenges finally also lead to the core question from a practical, business perspective: How shall a LCSA of large-scale projects be designed and which (economic, ecological and social) effects therefore shall be assessed, in order to assist the facility operator in making sustainable investment decisions that are in line with the focus of the company? Clearly, no general answer can be given therefore, as this depends on the project and the company's motives. But yet it is evident, that at least from a business point of view a company-specific assessment approach is needed. Hence, the central goal is the development of a company-related sustainability assessment for large-scale projects, allowing the decision-maker a transparent separated assessment of the project's economic, ecological and social effects as well as its integrated evaluation with regard to chances and risks for the company.

METHODICAL FRAMEWORK

The indicated concept, containing itself different assessment methods for each sustainability dimension, has been developed in the course of a doctoral thesis (Huber, 2013). Starting from a thorough analysis of the underlying (investment-, decision making-, stakeholder- and system-) theories, followed by a general conception of sustainable project controlling and a critical literature review of possible assessment methods for its practical application, two rather new approaches have been focused on deeply:

- Design of a decision oriented LCC and LCA, by combing a periodic Cash Value Added Accounting with a project-based LCC on the economic side and analogical a corporate eco-balance with a project-based LCA on the ecological side.
- Integrated assessment of economic, ecological and social effects by means of a partially aggregated strengths-weaknesses/chances-risks profile, showing also potential implications for the operator due to the degree of economic, ecological and social performance.

RESULTS AND DISCUSSION

Life Cycle Costing and Life Cycle Assessment of large scale projects

The first approach follows the idea, that decisions on large scale strategic projects, should be based on its contribution to the company's overall performance, including financial and non-financial (e.g. organizational and ecological) implications (Hahn & Laßmann, 1993, pp. 26, 193). However, while a company's overall performance is measured periodically – as on the economic side in terms of a profit and loss account and on the ecological side by a corporate eco-balance – the project's impacts are ideally assessed along its entire life cycle. Clearly, for its possible linkage the use of similar operands and system boundaries is necessary. Regarding the former, at company and project level payments and annuities (as operands allowing also for a due consideration of compound interest and financial effects) are used to calculate the Flow to Equity (FTE), whereas indicators at midpoint level are used for the impact assessment on the ecological side. Concerning scope and time aspects, the focus is limited to decision-relevant payments/annuities (PA) and ecological impacts (EI) caused and avoided due to the project along its life cycle (e.g. additional PA/EI due to the construction of new capacities, avoided PA/EI due to decreased use or disposal of old capacities, …). Put into concrete terms, first these PA/EI are assessed by means of a project-LCC and LCA. Next they are period adjusted to one business year and in further consequence balanced with the accounted PA/EI at company level of the last business year before project planning. Finally compared to an equally modified FTE on the economic side and environmental profile on the ecological side in case of non-implementing the project (e.g. additional caused/avoided PA/EI due to an in- or decreased utilization of old, otherwise closed/continued operating activities) the project's overall effect on a company's profitability and environmental compatibility can be disclosed. Table 1 outlines the procedure and main features of this methodology.

Assessing dimension	Economy	Ecology
Method	**Differential Flow to Equity Account**	**Investment eco-balance**
Goal	Assessing a project's impact on the profitability of the company	Assessing a project's impact on the environm. compatibility of the company
Operands	• Payments / annuities	• Elementary flows (inventory analysis) • Midpoint indicators (impact assessment)
Period-adjustment	Period-adj. of inconstantly accruing payments/env.impacts through imputed items e.g. annuity depreciations + provisions	e.g. ecologic depreciations + provisions
Functional unit	1 Business Year (B.Y.)	
Scope	**Payments/Annuities (PA)** from operative + investment + financing activities ⇨ over the entire project (asset) life cycle $\sum_{t=0}^{n}$ ⇨ of the company (production site)	**Environmental Impacts (EI)** from operative + investment activities ⇨ over the entire project (asset) life cycle $\sum_{t=0}^{n}$ ⇨ of the company (production site)
Decision-oriented Life Cycle approach ⇨ Substantials:	Focus on additional caused and avoided payments/ecological impacts in the event of implementing the project compared to its non-implementation • Period-adjusted Cash Value Added Account • Project-Life Cycle Costing **Σ: Decision-oriented linkage by means of Differential Flow to Equity Account**	• Period-adjusted corporate eco-balance • Project-Life Cycle Assessment **Σ: Decision-oriented linkage by means of Investment eco-balance**
⇨ Decision-oriented linkage:	FTE $_{per-adj.}$ last B.Y. before project planning t_0 +/- Add. caused/avoided PA in case of project's implementation ⇨ $\sum_{t=0}^{n}$ period-adj. for 1 B.Y. = FTE $_{per-adj.}$ in case of project implementation FTE $_{per-adj.}$ last B.Y. before project planning t_0 +/- Add. caused/avoided PA in case of project's non-implem. ⇨ $\sum_{t=0}^{n}$ period-adj. for 1 B.Y. = FTE $_{per-adj.}$ in case of project's non-implem.	EI $_{per-adj.}$ last B.Y. before project planning t_0 +/- Add. caused/avoided EI in case of project's implementation ⇨ $\sum_{t=0}^{n}$ per.-adj. for 1 B.Y. = EI $_{per-adj.}$ in case of project implementation EI $_{per-adj.}$ last B.Y. before project planning t_0 +/- Add. caused/avoided EI in case of project's non-implem. ⇨ $\sum_{t=0}^{n}$ period-adj. for 1 B.Y. = EI $_{per-adj.}$ in case of project's non-implem.
Result	⇨ **Δ Flow to Equity** $_{period-adjusted}$ = FTE $_{per.adj.}$ in case of project's implemen. − FTE $_{per-adj.}$ in case of project's non-implem.	⇨ **Δ environmental profile** (Env. Impacts) = EI $_{per.adj.}$ in case of project's implemen. − EI $_{per-adj.}$ in case of project's non-implem.

Table 1: Differential Flow to Equity Account and Investment eco-balance

The Differential Flow to Equity Account builds up on related decision-oriented approaches of Riezler (1996, pp. 149-161), Holzwarth (1993, pp. 172-227) combined with the Cash Value Added concept of Lewis (1994), whereas its ecological equivalent - the Investment eco-balance – ties in with the "Eco-Rational-Path-Method" of Schaltegger and Sturm (1994, pp. 207-211) combined with period-adjustments of Steven, Schwarz and Letmathe (1997, pp. 19-21, 190-192), Prammer (1996, pp.214-215) and the impact assessment of Guinée (2002).

Figure 1 gives two examples for visualising the results of the Investment eco-balance, with the left chart showing a T-diagram at midpoint-level, as once proposed by Schmitz and Paulini for a comparative product LCA (1999, p. 24) and the right chart revealing a stronger aggregated strength-weakness profile using the linear scaling of Hoffmeister (2000, p. 289).

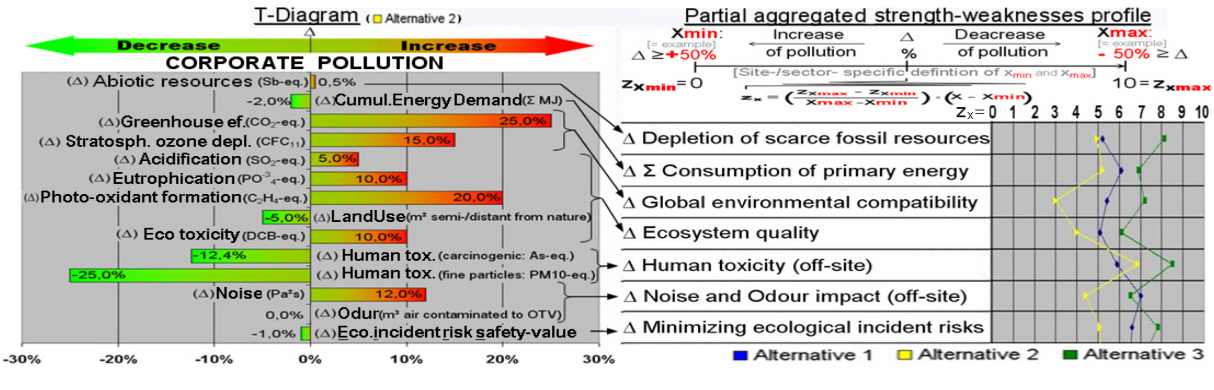

Figure 1: Options for visualizing the results of an Investment eco-balance

Certainly the latter is less objective as it demands a sector and site-specific definition of the minimum and maximum values ($z_{0/10}$), but enables therefore the integration of the Investment eco-balance in an overall sustainability assessment as described below.

Integrated assessment of a project's economic, ecological and social impacts
Once economic, ecological and social effects have been assessed separately, its results are transferred into linear-scaled targetvalues, aggregated to midpoint categories within each sustainability dimension (by arithmetic weighting) and visualised by means of a strength-weakness profile as illustrated before in figure 1 (right side) or below in figure 2 (left side).

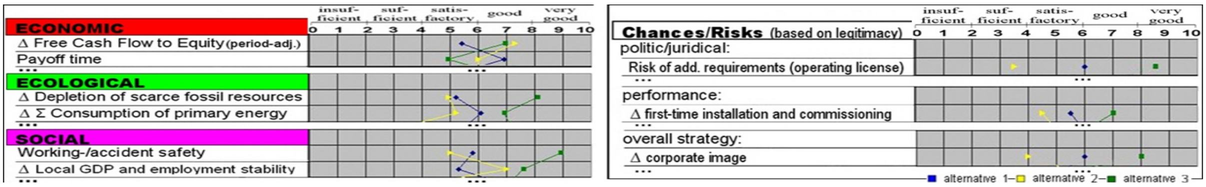

Figure 2: Strength-Weakness/Chances-Risks profile

Finally the left profile is completd by an additional profile (figure 2, right side), disclosing chances/risks associated with different project-alternatives. Based on stimulus-contributing theoretical considerations, therefore a Stakeholder-Effect-Analysis has been developed forcing the decision-maker to identify potential consequences for the company in general and the project in particular. Roughly outlined the analysis begins with a project assessment from the viewpoint of various stakeholders, linking its results to chances/risks caused by a potential change of stakeholders' contributions to the company. Designed as a strategic probability-impact analysis this approach is not necessarily sustainable in a pure altruistic manner, but gives at least incentive to avoid an isolated focus on solely monetary criteria in the first place.

CONCLUSIONS

The outlined concept is obviously only decision-oriented in a wider sense, as finally no single score is calculated. However, the advantage of the concept is its transparency, aggregating the single results only to company-specific midpoint categories and thereby supporting the company to come to sustainable and strategically conforming investment-decisions.

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