Holistic framework for land settlement development project sustainability assessment: Comparison of El Hierro Island hydro wind project and Sivens dam project

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A B S T R A C T

Project developer in the domain of land settlement project are involved with many stakeholders and are usually overthrown by data relative to technical, economic and social issues. This paper contributes to the necessary multi-scale approach challenge and we propose a holistic framework that enables to describe the development process of land settlement project and assess its sustainability. It would help developers to take decisions compliant with the project complexity. In the model driven engineering perspective, the metamodel framework is described with the ISO 19440 four views to represent complex systems: architectural, structural, functional and behavourial. We confront it to describe two case studies: the successful project of hydro-wind power plant in El Hierro in the Canaries, and the Sivens Dam project in France sadly famous for its deadly outcome. Their comparison enables us to draw hypothesis on what are the ingredients of success and validate the framework.

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1. Introduction

Among the three pillars of sustainable growth, economics, society and environment, the involvement of people is the least easy, especially in engineering-based projects. In the academic context where interdisciplinarity is strongly encouraged, interdisciplinary teams are complicated to set up and make running. In the industry context, if customers’ concerns are scrutinized with care when making engineered products, the implication of all stakeholders is not a settled issue. Even if, one identifies needs and contexts for consumer involvement in sustainable technology development, “Transmitting the consumer’s voice into product development is another challenge that is not automatically solved by consumer participation” (Heiskanen et al., 2005). Besides, other stakeholders are not systematically consulted although they might be impacted, like inhabitants in land settlement projects and may oppose firmly the project, leading to delay at best and cancellation at worst. The people concerned by any engineered project are numerous: customers, company’s manager, marketer, engineers, operators, and, near the production factory site, local stakeholders: elected representatives, inhabitants, environmental associations. … Those people are intrinsically different in terms of backgrounds, qualifications, roles and power, which complicates interdisciplinarity interaction and taking decisions.

Buchholz et al. (2009a) stated that sustainable bioenergy systems“…are, by definition, embedded in social, economic, and environmental contexts and depend on support of many stakeholders with different perspectives”. The resulting complexity holds for any land settlement project and especially the ones involving systems based on renewable resources. Besides any such development project is a sequence of activities that does qualify as being a process. From the Process System Engineering (PSE) perspective, that complexity can be translated as a multi-objective optimization problem embedded into a decision support framework. The PSE solutions should transcend the simple selection of the best techno-economic solution, but unfortunately, it may remain anchored in technico-economics with some arbitrary description of social and environmental issues as mathematical constraints. Indeed, we postulate that any engineering design process that primarily concerns technology should also always be run in good intelligence with other issues relative to people, ecosystems and macroscale economics to be successful. That is why we use a model driven engineering (MDE) perspective. In MDE, the complexity of any problem is handled by considering modelling layers of abstraction that distinguish metamodel and model layers and confront them to the real system through a case-specific implementation layer. We set our proposal at the metamodel level of abstraction with the intention to develop a metamodel level framework.
the future, a possible software implementation will belong to an abstract implementation layer and a possible use of that software for a case-study would belong to a case-specific implementation layer. Nevertheless, we can still use the metamodel framework on past case studies for describing them and evaluate the framework capability to do it with acceptable accuracy.

The article is structured as follow: after a state-of-the-art section (i), section (ii) gives prerequisites notions used to develop the framework, section (ii) presents the framework based upon the four enterprise views, section (iv) apply the framework to two case studies: El Hierro energy project in The Canaries and Sivens dam project in France. The comparison between the two case studies allows us in the discussion (section (vi)) to draw hypothesis about the human factor importance in increasing the success rate of development process in renewable resources exploitation projects.

2. State-of-the-art

Buchholz et al. (2007) recalled that modelling social, economic, and ecological components of bioenergy systems requires defining suitable criteria to assess sustainability and embedding them in a multi-criteria analysis approach. Azapagic et al. (2016) widen that perspective and propose to use "life-cycle thinking" within a system approach supported by a decision-support framework to effectively sustainable engineering addressing all three pillars of sustainable growth: economics, society and environment.

The sustainability criteria issue is very well documented. But it is rarely agreed as most sustainability problems are "wicked" in the sense of being difficult to define univocally and solutions proposed are difficult to describe fully, assess and test (Azapagic and Perdan, 2014). As an illustration of that, Buchholz et al. (2009a) asked experts to rank 35 criteria to assess sustainability. The top 12 criteria in terms of importance concerned environment (7), social issues (4) and economics (1) but 7/12 ranked low in practicality and reliability. For solving the practicability of criteria, Dale et al. (2013) gave a short list of 16 indicators claimed as practical since they could be assessed unambiguously. They were classified among 6 categories, including 8 social indicators that were split between Social well-being (employment, income, work safety and food security indication) and Social acceptability (public opinion, transparency, effective stakeholder participation, risk of catastrophe).

The multi-criteria analysis (MCA) issue is also thoroughly studied and we are here interested in those with stakeholder involvement. Buchholz et al. (2007) advocated using MCA to implement a model assessing the sustainability with a participatory approach. Later in 2009, they noticed that “in a decision assisted by MCA, stakeholders can contribute to various steps in the process: (i) model building and criteria selection, (ii) selection/description of scenario, (iii) criteria weighting and/or, (iv) scenario ranking” and compared how it was done in four popular MCA tools (Buchholz et al., 2009b). In the same vein, Cherni et al. (2007) proposed the model SURE that includes stakeholders in the third and fourth step aforementioned. Mendoza and Prabhu (2005) suggested combining MCA tools and participatory modelling to include stakeholders in the first step. Scott et al. (2012) broader review of multi-criteria decision-making (MCDM) methods in 57 papers studying bioenergy systems gave useful results: nearly 72% dealt with optimizing the system, 13% concerned qualitative/stakeholder interview “to focus on identifying success criteria and collect detailed opinions of key stakeholders”, and 10% predicted future patterns of renewable implementation or energy use. Regarding the application areas, nearly 40% of the papers dealt with technology selection, 25% with policy decisions (to measure impacts or makes recommendations), and 21% (12/57) concerned sustainability criteria covering environment, social and economic issues. In the 12 papers dealing with sustainability, 9 used it to select or compare technology alternatives. Sustainability assessment method was usually carried out in two ways, either in evaluating a global set of indicators or in trusting local actors to evaluate sustainability in the local context.

The trend observed by Scott et al. (2012) about the major focus of the bioenergy system literature on technological optimization is confirmed as it occurs for many other diverse sustainability problems, whether it be for designing and sizing models of wind farm with water storage system (Bueno and Carta, 2004), for the smart power management of photovoltaic/wind/electrical and water storage (Zaibi et al., 2014), for the design of bio refineries (Geraldi et al., 2014).

What seems to be missing in our opinion is a holistic approach that would gather expert knowledge in social, environment, economy, and engineering areas and that would be generic enough to apply to any development process, incl. chemical engineering plant installation, although we illustrate it with land settlement project here because of more information about the social issue. Part of the difficulty lies in the difference in approach, concepts and methods between social, economic, environmental and engineering sciences.

On one hand, in social sciences, most works related to engineering projects deal with the measurement of the acceptability of technical devices after they are designed. For instance, Phillips-Bertin et al. (2015) measured the acceptability of electric vehicles whereas Baud and Couturier (2015) deal with the acceptability of new regulation policies in intelligent office buildings. But the true challenge lies in studying acceptability in line with the development process. For that goal, methods to facilitate participatory process have been proposed, like the ESTEEM method aiming at managing societal acceptance in new energy projects (Raven et al., 2009). Another one is the Companion Modelling method ARDI (Actor, resources, dynamics, interactions) (Etienne et al., 2008). We remark incidentally that the four ARDI steps are indubitably close to the ISO 19440 standard recommendations for representing the enterprise by using four views (ISO 19440, 2005): organizational (enterprise structure), resource (resource, capability), functional (event-process-activity) and informational (object-data) (IEEE, 2000) that we use in this paper to build our framework. In the context of wind energy projects, an International Energy Agency expert group stated that there exists no holistic approach to deal with social acceptance of any project (Huber and Horbay, 2010) but they could ultimately finalize a set of recommended practices for improving social acceptance by addressing five issues: (1) policy and strategy framework; (2) well-being and quality of life; (3) individual evaluation of the project cost-benefits; (4) consultation and involvement of local stakeholders in the decision-making process; (5) implementations strategy to overcome pre-set ideas (Huber and Horbay, 2013). Those issues can be categorized differently according to a spatial hierarchy: macro scale wind turbine sector; meso scale where the developer operates, local scale where the project will be implemented.

On the other hand, in engineering science to which belongs the PSE system approach, sustainability problems are handled in a mathematical and quantified way: for example, Sharma et al. (2013) considered stakeholder value across the multiple product bio refinery supply chain through quantifiable variables. They related customer satisfaction to production achieved; investor’s appreciation to minimum interest and dividend payments; and farmer’s concern for a reliable income source to land utilisation. In a review by Boix et al. (2015) on the development of eco-industrial parks, different alternatives to consider the degree of satisfaction of participants have been proposed by several authors incorporated social benefit of bio refineries as quality of life to direct job creations (You et al., 2012; Santibáñez-Aguilar et al., 2014) or to direct, indirect and induced jobs creation (Miret et al., 2016).
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