Life Cycle Sustainability Assessment and new technologies

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1. Introduction

Performing a sustainability assessment of new technologies is a complex task, as showed by the definition itself, which refers to two big issues: Technologies and Sustainability. Technologies can be classified in many ways, depending on the different typologies, development levels, effects and impacts on sectors, territories, markets, etc. The relation with sustainability is twofold, because technology can be considered both as the cause of many environmental problems and as the key to solve them. In fact, technologies are nowadays considered the main actor of the present industrial, economical and social evolution and the main cause of the high speed of current changes. Sustainability and sustainable development are very controversial and disputed at scientific and society level. Indeed, sustainable development cannot be considered simply a goal, but rather a social process where shared sustainability principles are taken as the starting point for assessing decisions through an interactive learning process.

Being sustainability a global concept, inevitably calls for a system-wide analysis, a perspective that is at the core of the life cycle approach. A framework for life cycle sustainability analysis has been proposed, namely LCSA [1], which requires the application of LCA, Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA) under specific consistency requirements. The framework has been applied to the assessment of an innovative technology, in order to test its applicability. In this paper, pros and cons of the LCSA approach are highlighted, and questions for further research are pointed out.

2. Materials and method

The LCSA framework has been applied to an innovative technology for tyres residues treatment and SiC production [2], at pilot scale. The analysis investigates the innovative system in comparison with a traditional end-of-life treatment of tyres. The reference option selected is burning in cement kilns, because it is very common and has some problems of social acceptability, and of capacity limits of the European cement industry in perspective. The technology under study is a multi-output system, that we analysed by defining two scenarios:

- Scrap tyres gasification, including production of electricity and SiC + thermal energy production from coal in cement kiln;
- Thermal energy production from scrap tyres in cement kiln + conventional production of SiC + electricity production.

The state-of-the-art of the three methodologies has been applied, represented for LCC and S-LCA by Swarr et al. [3] and Benoît and Mazijn [4], respectively.

3. Results and discussion

The analysis of the framework for this specific application highlighted two major problems:

- Applicability of the available methods of the framework. In fact, LCA, LCC and S-LCA have different degrees of maturity, and S-LCA still needs developments in particular for the impact assessment phase. Moreover, several methodological questions exist for each of the three methods in the specific application, due to the complexity of the technological system.
- Significance of the analysis performed with respect to sustainability. In fact, sustainability analysis clearly shows distinctive marks of complexity theory: non-linear relationships, feedback loops, emergent phenomena, and tangled connections among the parts. Adopting the LCSA framework, the modelling is linear and static, based on technological and environmental relations only[1]. Thus, it

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[1] For example, in LCC the monetary flows are modelled but without any modelling of economic mechanism.

is necessary to evaluate whether and to what extent the analysis performed with the LCSA framework is able to describe the most relevant aspects and thus, it can be considered a good proxy of a more comprehensive – but still not feasible – sustainability evaluation. Moreover, someone could argue that costs, as analyzed by LCC, are not the only economic element of sustainability [5].

As far as the applicability of the framework is concerned, the main aspect which emerged from the application was how to cope with the consistency requirements among them, i.e. ideally identical system boundaries. Moreover, theoretically, the most consistent solution would be to use one identical LCI for all three components [1]. However, we experimented the difficulties in guaranteeing such requirements, in particular in relation to the following aspects:

- *Functional unit*. The study at hand shows that the FU becomes tight in S-LCA. In fact, the analysis of social and socioeconomic aspects of technologies and their potential positive and negative impacts requires taking into account the following aspects: the way a technology is perceived and used in a social context; the way in which it affects or transform this context; the way it interacts with technological systems already in place and its physical context; the quantity of use [6]. Thus, the need exists to investigate whether a broader, non FU-based, perspective in the S-LCA would be more appropriate [7].
- *Data availability and their significance*. Data availability is a critical aspect since the technology is at pilot scale, while the effects we would like to measure (environmental, economic and social) are at full-implementation level. Thus, the analysis of the scaled-up system becomes necessary but critical, even more for the economic (in LCC detailed cost data can be estimated for the innovative technology while rought data are the only alternative for the compared system) and social aspects.
- *Scenarios vs produt analysis*. For comparative reasons, two scenarios are analysed, an aspect which makes the analysis more complex because of the high number of parameters involved, on which our control is loose.

4. Conclusions

The application of the LCSA framework to an innovative technology is a challenging task, mainly in relation to the following aspects: data availability and their significance; functional unit definition, especially in the case of S-LCA; and scenarios vs product analysis. On the other side, the framework showed also its strenghts in pointing out the most critical aspects of the assessment, on which further analysis will be necessary. Thus, the LCSA turned out to be an important knowledge instrument: it forces practitioners to think about the different options, and leads thus to detect important aspects that at first sight could be considered negligible. However, we suggest to support the application of the present LCSA with other methods and tools, able to take into account also aspects like the social acceptance, in which different ethical values (due to the different stakeholders affected and their own perspective) and risk elements are relevant. Thus, LCSA can learn from the field of Technology Assessment the way in which the problem is dealt with: the technology is at the core of the analysis, but the infrastructure and the organisation around it are equally important ingredients.

5. References

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