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PhD Thesis Review
Applicant: Luca De Benedetto
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Title:

Integrated life cycle analysis approaches
to strategic decision making
in waste to energy

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Strategic decision making requites accurate and valuable information. Luca De Benedetto developed a Life Cycle Assessment based decision support methodology. He introduced the concept of Environmental Performance Strategic Map. As a component of his methodology this map visualizes the scaled values of environmental footprints and economic costs. The author suggested the application of fuzzy logic to handle uncertainty at the calculation of environmental footprints. Each elements of this methodology is tested in case studies.

The PhD thesis is written in English and has 112 pages.

Chapter 1. provides an excellent overview of Life Cycle Assessment. The LCA framework defined in the ISO 14040 standard is detailed. Limitations of existing methodologies are also discussed. Finally, the author focuses to LCA applications in the waste-to-energy field. Based on this logical introduction important research questions are defined. This part of the thesis is well written and published in 2008. The purpose of the research is well defined.

Chapter 2. proposes a novel tool for the graphical representation of environmental indicators (footprints) and financial factors to support strategic decision making. This chapter is based on a well-written paper published in Journal of Cleaner Production. 70 citations of this paper show the impact of this work.
The first part of the chapter presents the main footprints used to evaluate environmental impact. The second part presents a methodology how to build a map based on these indicators. A demonstrative example of a plant producing fertilizers and pesticides is presented.

A simple *radar chart* is used to plot scaled values of the indicators. Scaling from 0 to 100 is based on the deviation from target values.
Although the cost is also plotted in an extra dimension, I would not consider a simple radar chart as "strategy map".

Q1: Please overview the existing strategy maps handling environmental aspects (e.g. balanced scorecards). Please explain, what makes a radar chart to strategy map that can be used for strategy development and monitoring.

Chapter 3. presents an interesting idea. The author applied "bill of materials" (BOM) as information source for the calculation of environmental footprints. The contributions of the components and materials indicated in BOM are defined as Environmental Performance Points. The BOM extended by these values is referred as "Environmental Bill of Materials".
This idea has been published in *Clean Techn. Environ. Policy* journal.

Q2: Bottom-up footprint calculations are based on detailed information about raw materials and energy demands of the technology steps. Please, explain what is the added value of the proposed env-BOM methodology compared to the "classical" bottom-up calculation.

Q3: Please, present the features of advanced BOM management tools and show how these systems handle health and environmental aspects. Based on this analysis please conclude what are the similarities to the proposed env-BOM representation, and what are places of improvement of these tools and env-BOM.

Chapter 4. presents how fuzzy logic can handle uncertainty of the evaluation of the environmental impact. Instead of a detailed theoretical analysis, the idea is presented by a simple case study related to a fertiliser production plant.

The fuzzy logic toolbox of MATLAB is used in a standard way. Details about tuning, validation, and application of the fuzzy model are not presented. There are no results, so the applicability of the idea is not confirmed. The application example presented in Chapter 5 does also not utilize this fuzzy approach.

The figures are not informative. There are typos (like Mathlab). These bugs also show that the idea is not worked out properly. If this would be the draft version of the thesis, although the application of fuzzy modeling is a good idea, I would suggest removing this session or adding clearer introduction to fuzzy logic and detailed calculations showing how fuzzy model performs.

Q4: Please, show how the fuzzy model was designed and applied. Please give information about what were the uncertainties and how the parameters of the fuzzy model were tuned to represent these.

Chapter 5. integrates the previously presented elements in a new methodology. The applicability of the proposed E3 methodology is validated in a detailed case study comparing two technologies of transforming commonly available crops and waste into building materials.

The presentation of the methodology is clear. The developed tools support the applicability of this approach.

After reading the detailed and well-documented case study I realized none of the examples were focused to the problem of waste-to-energy. In earlier chapters a plant producing fertilizers and pesticides were studied, this example deals with plants producing building materials. It seems only one smaller session in Chapter 1. (entitled "*LCA Applications in the Waste-to-Energy Field*") focuses to the topic of W2E. From this aspect the title and the conclusion of the thesis is misleading, since the applicability of the proposed tools and methodologies in W2E is not demonstrated.

Q5: Please, discuss how the proposed techniques applicable to W2E technologies.

Chapter 6. gives an informative summary of accomplishments and concludes the original contributions.

Theses

Although the application of fuzzy logic to handle uncertainty is a good idea, due to the lack of sophisticated application example and the shallow presentation of the technique, this part of the thesis cannot be considered a novel scientific result.

Three theses (1,2,4) can be regarded as original and important scientific contribution.

Conclusion

As a summary of my opinion, the PhD thesis of Luca De Benedetto satisfies the conditions of the Doctoral School in Information Science and Technology, and can be the basis to achieve a PhD degree.