Review of PhD Thesis

by Zsófia Závodi-Fodor

title: *Integrated Energy Management Framework in Waste to Energy, Integration of Other Renewables*

1. Scope of the thesis

Zsófia Závodi-Fodor has prepared her PhD thesis at the Information Science and Technology PhD School of the University of Pannonia. She has done her research work at the Department of Computer Science and Systems Technology of the Faculty of Information Technology at the University of Pannonia under the supervision of Prof. Jiri Klemes and Dr. Petar Varbanov.

The subject of the thesis is the analysis, design and improvement of complex integrated energy management systems to achieve more efficient operation. It is well-known that one of the most important constraints for the sustainability and economic development of today's societies is the amount of accessible energy. Taking into consideration important environmental issues as well, we can clearly say that the possible most efficient use of energy is of primary interest in the maintenance and design of process plants. Thus, the topic of the thesis is undoubtedly extremely important in engineering practice and consequently, it is intensively studied in the international literature. The computational problems emerging during the design of complex process systems often make it unavoidable to develop new software tools. Therefore, the approach and results of the thesis fit nicely into the scope and traditions of the Information Science and Technology Doctoral School of the University of Pannonia.

It is important to state at this point that the reviewer can only evaluate the presented results from the point of view of his scientific background, which is process analysis/control and information technology.

2. Remarks about the structure and format of the thesis

The full extent of the thesis is 133 numbered pages, out of which an extended literature review is 43 pages, and sections 3-7 presenting original research results are 66 pages long. Sections 3-7 contain a short introductory part describing the studied problem, and they end with a short conclusion summarizing the results. The length of the thesis could have been reduced by merging the repeated (mostly introductory) parts in the different chapters. The thesis contains a useful list of nomenclature explaining the abbreviations and most frequent notations. The list of references covers a sufficiently broad area related to the thesis and (with the exception of classical books and papers) it contains up-to-date references mostly from the last 6-8 years. It would have been more practical to use numbered citation labels for the support of easier reading.

The thesis was written in English which is definitely advantageous from the aspect of international publication of the results. There are some grammar errors and typos throughout the text, but the overall quality of writing is good. Section 8 contains the summary of novel results corresponding

to chapters 2-6 in the form of numbered thesis points. In summary, the format of the thesis fulfills the requirements of the Information Science end Technology PhD School.

3. Publications related to the thesis

The author has published 2 referred international journal papers with high impact factors and 12 referred international conference papers. It is worth mentioning that two of these papers have got at least 10 independent citations that also indicates the significance of the results. Therefore, the publication activity of the author definitely exceeds the minimal requirements of the Information Science end Technology PhD School.

4. Detailed comments corresponding to the chapters

4.1. Chapter 1 (Introduction)

In the Introduction, the author presents the main motivations and statistical data behind the research work. Moreover, the key problem areas of the thesis are briefly introduced. Figure 1 is especially useful for the quick understanding of the basic notions and problems of the work.

4.2. Chapter 2

Chapter 2 is an extended literature review about the scientific background of the thesis. The author gives an overview on the classification of different types of waste, process integration and renewable energy sources.

In my opinion, this chapter (43 pages) is somewhat longer than necessary. With a more condensed literature review, the overall proportions of the thesis could have been more balanced allowing more space for the presentation of new engineering methods in chapters 3-6. From the point of view of later chapters, only sections 2.6 and 2.7 seem to be essentially important here. It is remarked however, that an important SCI journal publication of the author (Fodor Z, Klemes , J.J., 2011. Waste as alternative fuel – Minimising emissions and effluents by advanced design, *Process Safety and Environmental Protection*, 90(3), pp. 263–284) serves as a basis for this chapter. Section 2.8 about the focus and key areas of the thesis seems to be repetitive compared to section 1.1, and these should have been unified into one single section preferably in the Introduction. The contribution of this chapter is summarized in thesis point 1 in chapter 8.

About thesis point 1: With my above mentioned background, I'm not able to evaluate the scientific novelty of thesis point 1. However, I do not want to question the original contribution of chapter 2 by any means, since a high impact factor review paper was published on this topic.

Question about chapter 2: What are the most important new statements and findings of the overview in chapter 2 and in the corresponding journal paper?

4.3. Chapter 3

The topic of chapter 3 is Total Site Integration using renewable energy sources. The main engineering challenge here is to appropriately handle the time-varying energy needs and availability of renewables that is fluctuating on different time-scales, too. The main new contribution of this chapter is the handling of renewable sources to improve a previously developed integration methodology. The presented illustrative example clearly shows the effectiveness of the approach. Thesis point 2 summarizes the original results

About thesis point 2: I accept thesis point 2 as a novel contribution.

Question about chapter 3: In section 3.5, time slicing is shown using one specific renewable source (solar collector). How is the time slicing performed when there are multiple different renewable energy sources to integrate?

4.4. Chapter 4

Chapter 4 deals with the Total Site targeting problem, i.e. how to determine utility and heat recovery targets. The author gives a new procedure to solve this problem allowing different minimum temperature values for each process. This approach gives new degrees of freedom to the problem and it is not surprising that the quality of the solution is generally better than in the case of a uniform temperature difference.
About thesis point 3: Thesis point 3 is accepted as a new scientific contribution.
Question about chapter 4: Why are the power values corresponding to Process C equal (77.4 MW) both for the traditional and for the modified procedure in Table 17?

4.5. Chapter 5

Chapter 5 addresses the problem of Total Site targeting again, further improving the results of chapter 4 by assuming potentially different ΔT values for the individual process streams. The case study shows that the results of chapter 4 can still be substantially improved. Therefore, the targeting method presented in this chapter has important practical significance.
About thesis point 4: I accept thesis point 3 as a new scientific contribution.
Question about chapter 5: It is written on page 96 that the ΔT_{cont} values in Table 24 were defined empirically. How this empirical choice affects the quality/optimality of the final solution?

4.6. Chapter 6

Chapter 6 describes the software tool developed by the author, where the new methods for Total Site targeting are implemented. The tool clearly supports the practical application of the new targeting approach.
About thesis point 5: I do not consider thesis point 5 to be a separate scientific result (especially compared to the strong results of thesis points 2-4) but rather an application extension of thesis points 3 and 4.
Question about chapter 6: How computationally intensive are new procedures for Total Site targeting (i.e. approximately how many integrated processes and streams can be handled on a typical PC within a reasonable time)?

4.7. Chapter 7

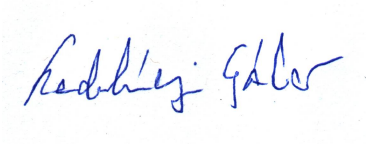
Chapter 7 contains two realistic industrial case studies to illustrate the possibilities for utility saving and more efficient operation through heat integration. In section 7.1, a plant for dyes intermediates synthesis located in India is analysed. It seems that some of the table and figure references (Table 1, 2 and Figure 3) are not correct in the second part of the subsection titled "Heat Integration analysis". Section 7.2 discusses the optimal setting of stream discharge temperatures for an industrial dryer model. No thesis points correspond to chapter 7.

5. Summary

Zsófia Závodi-Fodor studied important open problems in process engineering and she has developed new methods for Total Site integration and targeting. Through case studies and industrial appli-

cation examples, she has clearly demonstrated the practical applicability and usefulness of her new results. Moreover, she has sufficient quality publications related to the topic of the thesis. Therefore, I recommend granting the PhD degree to Zsófia Závodi-Fodor after the successful defense of her work.

Budapest, Aug. 10, 2013



Gábor Szederkényi, DSc
associate professor
Faculty of Information Technology
Pázmány Péter Catholic University,
senior researcher
Institute for Computer Science and Control
Hungarian Academy of Sciences