



# Integrated Energy Management Framework in Waste to Energy, Integration of Other Renewables

**Zsófia Fodor**

**Supervisors: Dr Jiří Klemeš, Pólya Professor , Dr Petar Varbanov**

EC MC Chair (EXC) INEMAGLOW

Research Institute of Chemical and Process Engineering Faculty of  
Information Technology  
University of Pannonia, HU

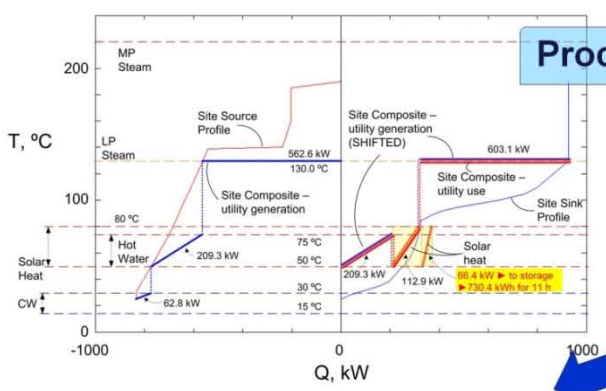




### ***Main research activities:***

- E-business
- Medical information technologies
- Formal systems
- Information retrieval
- Intelligent control system
- Image processing
- Visual ergonomics
- Mobile telecommunication networks
- Multimedia and virtual reality
- Highly dependable system
- Optimization
- Content and knowledge management
- Portal solutions

# Research directions



Process Integration

Water and energy management in food processing

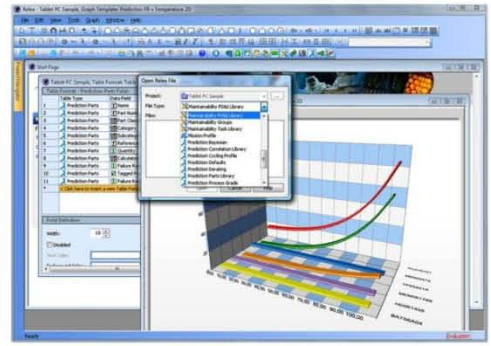
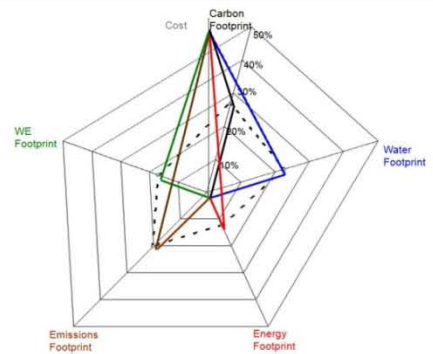
CO<sub>2</sub> emissions reduction and mitigation exploiting IT tools

Integrated Energy Management Framework in Waste to Energy

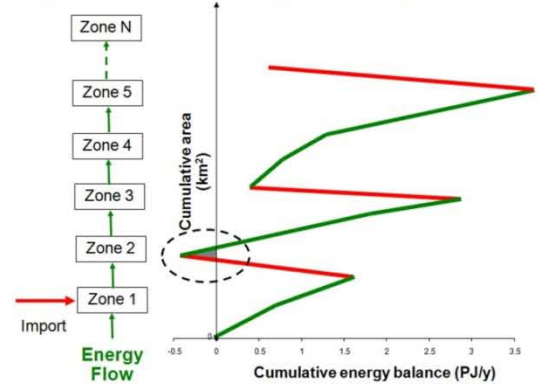
Integration of Renewable sources of Energy Into Energy Supply Chain

Optimum maintenance and availability

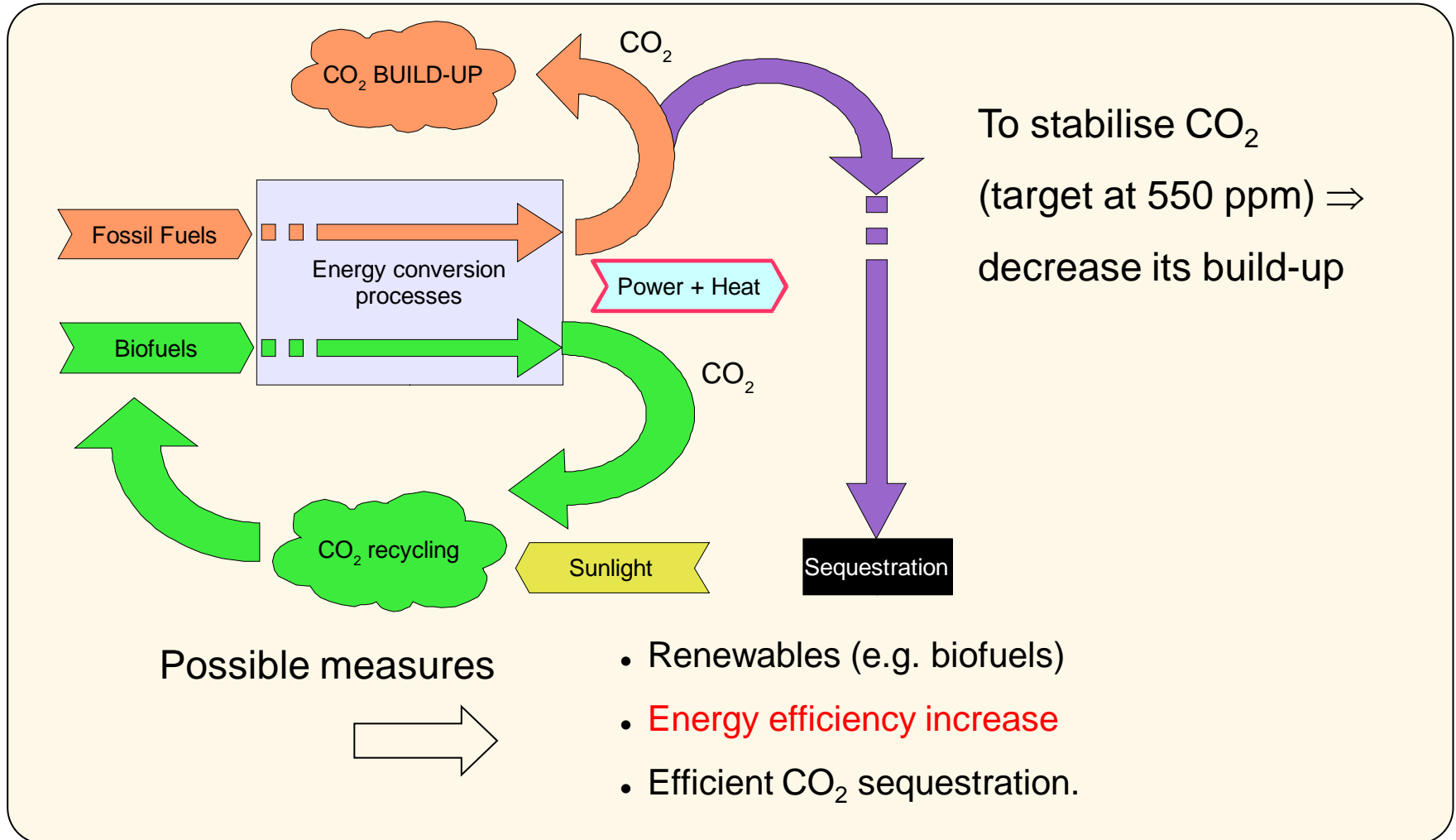
Life cycle analysis (LCA) and supply chain analysis



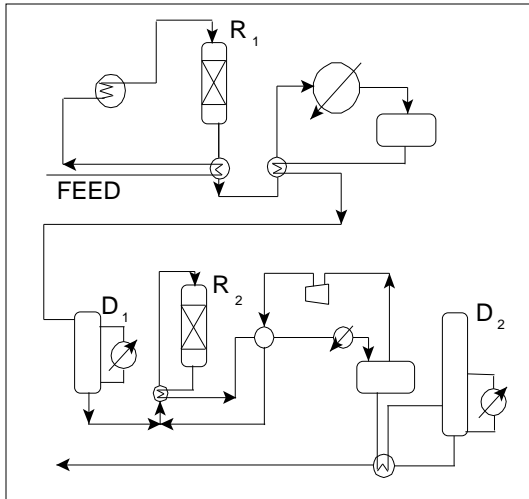
Regional Resource Management Composite Curve



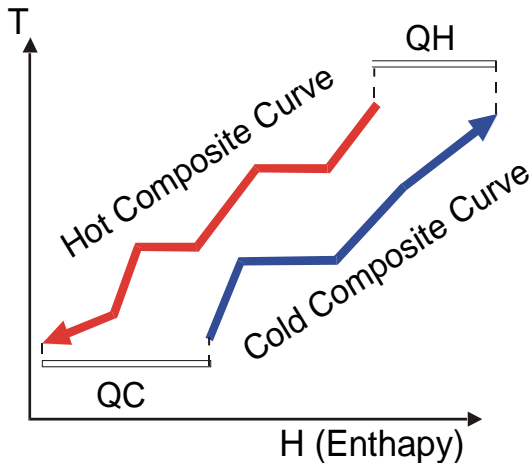
# CO<sub>2</sub> Emissions Reduction



# Existing Process Integrating Technologies



Process Integration is a long-established technology initially developed (Centre for Process Integration, The University of Manchester) for single process analysis, design and understanding



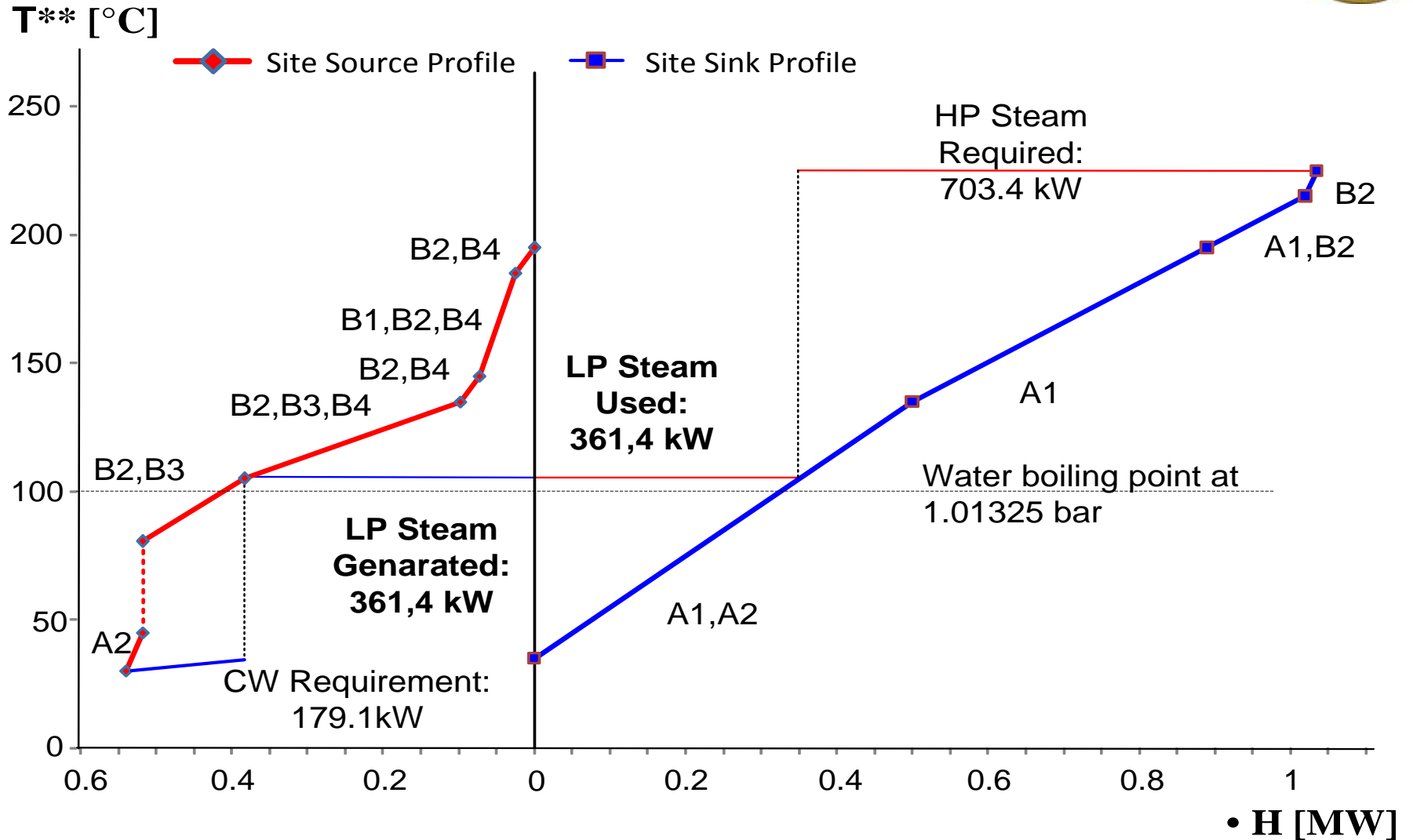
*Linnhoff, B. and D. R. Vredeveld, 1984, Pinch Technology has Come of Age, Chemical Engineering Progress, July 1984, 33-40.*

# Novel Flexible • $T_{\min}$ Methodology

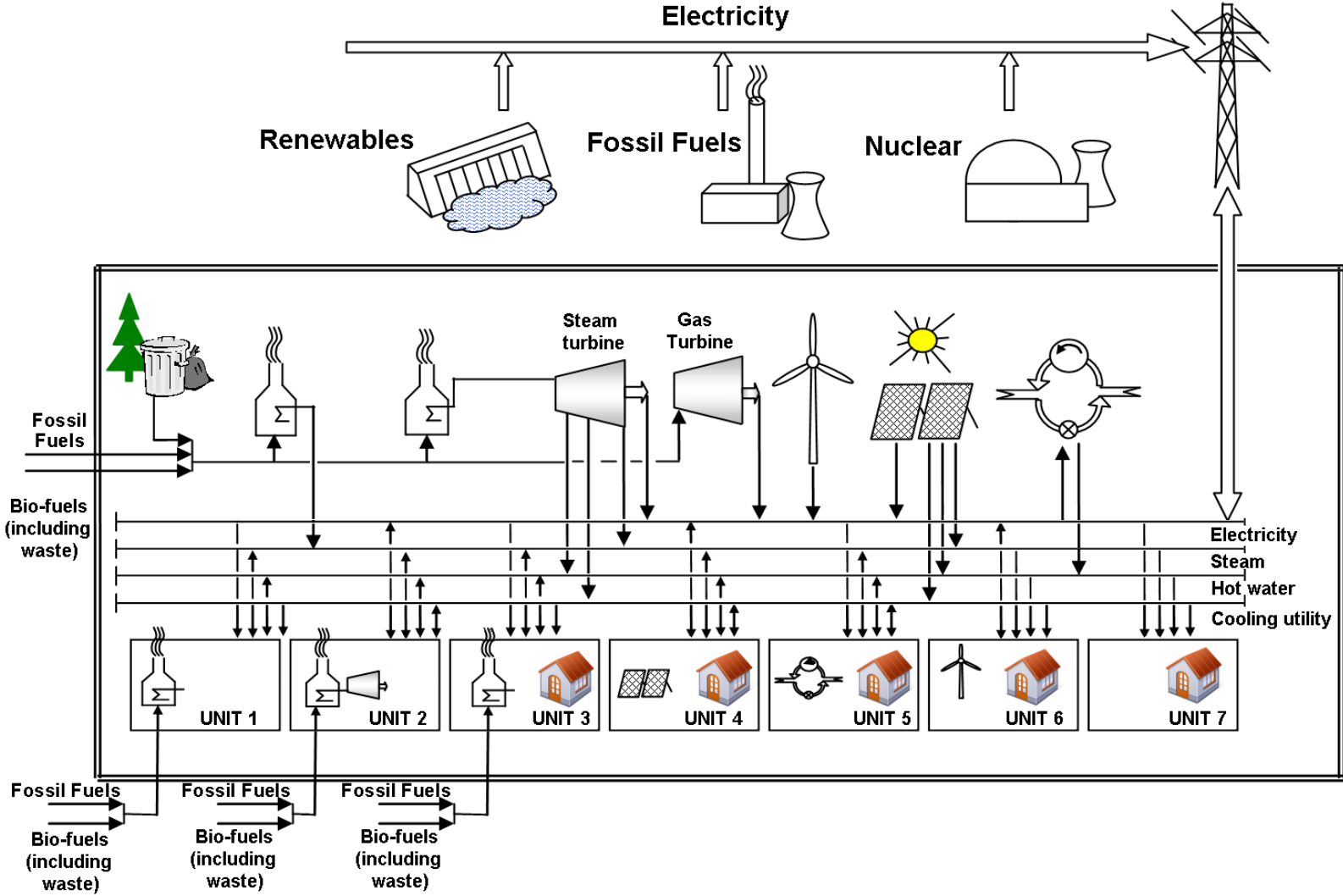


- Create GCCs for the processes using •  $T_{\min}$  for heat transfer within the same process
- Extract the heat sink and source segments from the GCCs
- Shift each of the segments to the temperature scale of the utilities
  - Shift back to the real stream temperatures (process-to-process •  $T_{\min}/2$  )
  - Shift forward to the utility temperature scale by whole •  $T_{\min}$  for process-utility heat exchange
- Build the TSP according to the original algorithm
- Identify the generation and usage of the utilities

# TSP with Flexible • $T_{min}$ Methodology



# Integrating Micro Renewable Energy Sources







# Main Cited Papers

- **Klemeš J., Dhole V.R., Raissi K., Perry S.J., Puigjaner L., Targeting and design methodology for reduction of fuel, power and CO<sub>2</sub> on total sites, (1997) Applied Thermal Engineering, 17 (8-10), 993-1003.**
- **Perry S., Klemeš J., Bulatov I., Integrating waste and renewable energy to reduce the carbon footprint of locally integrated energy sectors (2008) Energy, 33 (10), 1489-1497.**
- **Varbanov P., Perry S., Klemeš J., Smith R., Synthesis of industrial utility systems: Cost-effective de-carbonisation, (2005) Applied Thermal Engineering, 25, 985-1001.**
- **Thevendiraraj S., Klemeš J., Paz D., Aso G., Cardenas G.J. Water and wastewater minimisation study of a citrus plant (2003) Resources, Conservation and Recycling, 37, 227-250.**



# Main Cited Papers

- **Klemeš J., Bulatov I., Cockerill T., Techno-economic modelling and cost functions of CO<sub>2</sub> capture processes, (2007) Computers and Chemical Engineering, 31 (5-6), pp. 445-455.**
- **Klemeš J, Huisingh D, Economic use of renewable resources, LCA, cleaner batch processes and minimising emissions and wastewater (2008) Journal of Cleaner Production, 16 159-163.**
- **Zhu X.X., Zanfir M., Klemeš J. Heat Transfer Enhancement for Heat Exchanger Network Retrofit. Heat Transfer Engineering, No 2, 21, 2000, pp 7 – 18.**
- **Varbanov P.S., Klemeš J., Shah R.K., Shihn H., Power cycle integration and efficiency increase of molten carbonate fuel cell systems (2006) Journal of Fuel Cell Science and Technology, 3, 375-383.**



# Main Cited Papers

- Dovi V.G., Friedler F., Huisingh D., Klemeš J.J., **Cleaner energy for sustainable future (2009) Journal of Cleaner Production, 17, 889-895.**
- Masruroh N.A., Li B., Klemeš J., **Life cycle analysis of a solar thermal system with thermo chemical storage process (2006) Renewable Energy, 31, 537-548.**
- De Benedetto L., Klemeš J., **The Environmental Performance Strategy Map: an integrated LCA approach to support the strategic decision-making process (2009) Journal of Cleaner Production, 17, 900-906.**

# Presented Publications and Conferences



1. P. Varbanov, J. Klemeš, and **Z. Fodor**, “Integrating Renewable Energy Sources into Extended Total Sites,” Keynote Lecture of Special Session: Integrating Waste and Renewable Energy to reduce the Carbon Footprint Locally Integrated Energy Sectors, in *Proc. of SEDEWES 09*, p.74, Dubrovnik, Croatia, Dalmatia, September 30-October 3, 2009.
2. P. Varbanov, J. Klemeš, and **Z. Fodor**, “Extended Total with Multiply Energy Carriers,” *Chemical Engineering Transactions*, Vol.19, pp.49-54, doi: 10.3303/CET10119009 ISSN1974-9791 2010.
3. **Z. Fodor**, P. Varbanov, and J.Klemeš, “Integrating Varying Renewables into Total Sites,” in *Proc. of M•szaki Kémiai Napok – Műkki Conference of Chemical Engineering*, p. 25, Veszprém, Hungary, April 27-29, 2010.

# Presented Publications and Conferences



4. **Z. Fodor**, J.Klemeš, and P. Varbanov, “Total Site Targeting Accounting For Individual Process Heat Transfer Characteristics,” in *Proc. of 37th International Conference of SSCHE*, p. 50, Tatranské Matliare, Slovakia, May 24-28, 2010.
5. P. Varbanov, J.Klemeš, and **Z. Fodor**, “Operability and Challenges of Renewable Energy Utilisation,” in *Proc. of 23rd International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, ECOS 2010*, [lecture # 112], Lausanne, Switzerland, June 14-17, 2010.
6. **Z. Fodor**, S. Perry, P. Varbanov, and J. Klemeš, “Total Site Targeting Accounting for Individual Process Heat Transfer Characteristics,” in *Proc. of 13th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction, PRES 2010*, [lecture # 0875], Prague, Czech Republic, August 28 September 1 2010.

*Thank you for your attention!*



*Veszprém, Castle*