



## Retrofitting of process plants and Total Sites for improved sustainability

L. Čuček<sup>1</sup>, J. J. Klemeš<sup>2</sup>, Z. Kravanja<sup>1</sup>

<sup>1</sup>University of Maribor; Faculty of Chemistry and Chemical Engineering  
Smetanova 17, 2000 Maribor, Slovenia

<sup>2</sup>University of Pannonia; Centre for Process Integration and Intensification – CPI<sup>2</sup>; Research Institute of Chemical and Process Engineering – MÚKKI; Faculty of Information Technology  
Egyetem utca 10; 8200 Veszprém; Hungary  
lidija.cucek@um.si

### Abstract

Sustainability has become very important issue in the last decades, especially during the last years. Hot topics today are related to decreasing of carbon footprint, to job creations, economic stability/growth and security of energy supplies. Those issues are combined within one word: sustainability. Sustainability accounts for three equivalent pillars: social ('People'), economic ('Prosperity' or 'Profit'), and environmental ('Planet'). However, it should be noted that actual measuring of sustainability and/or sustainable development remains an open question (Čuček et al. 2012). Many different methods and tools have been developed over recent decades for measuring and monitoring sustainability and sustainable development to assess and evaluate progress toward more sustainable systems (De Benedetto and Klemeš, 2008).

High potential for improved sustainability lies also within industry. Industrial sector namely has the largest share of total energy consumption amongst all the sectors (US EIA, 2014). Industry is also among the main water consumption sectors especially in high-income countries (WBCSD, 2006). Therefore, it is important for industry to move towards more sustainable operation. In general, two situations exist: grassroots (new processes or Total Sites (TSs)) and retrofits (modifications made within existing processes and/or TSs). It should be noted that new grassroots plants and TSs should (and could) be designed in a way to consider sustainability, however existing plants and TSs should be retrofitted for improved sustainability.

Different concepts and methods will be presented for measuring sustainability, especially for measuring environmental sustainability. The focus will be especially on new developments (Čuček et al., 2015). Furthermore, several practical examples will be shown regarding process plants and TSs which have great potential for sustainability improvement.

### Acknowledgements

The authors acknowledge the financial support from EC FP7 project ENER/FP7/296003/EFENIS 'Efficient Energy Integrated Solutions for Manufacturing Industries' – EFENIS, and from the Slovenian Research Agency (programs P2-0032 and P2-0377).

### References

1. Čuček, L., Klemeš, J.J., Kravanja, Z., 2012. A Review of Footprint analysis tools for monitoring impacts on sustainability. *Journal of Cleaner Production* 34, 9-20.
2. Čuček L., Klemeš J.J., Kravanja Z., 2015, Overview of Environmental Footprints, In: J.J. Klemeš (Editor), *Assessing and Measuring Environmental Impacts in Engineering*: Chapter 5, Elsevier



**CAPE Forum 2015**  
**Computer Aided Process Engineering**  
**University of Paderborn**

**April 27-29, 2015**  
**Paderborn**  
**Germany**

3. De Benedetto, L., Klemeš, J., 2008. LCA as environmental assessment tool in waste to energy and contribution to occupational health and safety. *Chemical Engineering Transactions* 13, 343-350.
4. US EIA (U.S. Energy Information Administration), 2014, How much energy is consumed in the world by each sector? <[www.eia.gov/tools/faqs/faq.cfm?id=447&t=1](http://www.eia.gov/tools/faqs/faq.cfm?id=447&t=1)> Last accessed: 29/10/2014
5. WBCSD (The World Business Council for Sustainable Development), 2006, Facts and trends, water <[www.unwater.org/downloads/Water\\_facts\\_and\\_trends.pdf](http://www.unwater.org/downloads/Water_facts_and_trends.pdf)> Last accessed: 29/10/2014