Process design methods for sustainable energy systems

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Today, energy is the driver of the modern society, allowing for transforming raw materials and resources into "useful" products and services. Concerns on climate change and resources scarcity together with the increasing importance put on the environmental impacts are redefining the problem of the energy usage in the society. In this context, developing a sustainable energy systems means designing the system that will convert in an optimal way the available resources into useful products and services, reaching the maximization of the resources productivity and minimizing its environmental impact.

In a given socio-economical and environmental context, the goal of the process design is to select the type and the size of the technologies, the way they are interconnected and the way they are operated.

A computer aided methodology and the corresponding process system engineering tools for the analysis and the synthesis of efficient processes and energy conversion systems will be presented. It combines the use of thermo-economic and environomic models of sub-systems that are structured in an equipment data base. These models include the representation of the possible interfaces that a technology will present when it is integrated to build the integrated system. A systematic method based on process integration and optimization techniques is then used to generate process superstructure and process configurations. Models are then used to calculate the system performances in terms of thermodynamic performances, operating and investment cost together with Life cycle impact assessment indicators. Multi-objective optimization techniques are then used to decide the best values of the design decision variables and to generate thermo-economic Pareto sets of process configurations where the trade-off between economical criteria and thermodynamical or environmental impact criteria are represented.

Such tools are used to support decisions in the process engineering work. In this iterative procedure, one has to recognize that the problem is never perfectly defined at the beginning of the project. The methodology includes therefore solutions analysis tools such as exergy analysis and sensitivity analysis and graphical representations that are used to understand the energetics of the solutions and refine the process design problem definition.

The tools developed are applied in different fields : rational use of energy, water and

waste management in the industrial processes, energy conversion systems design like power plants with CO_2 capture, fuel cell systems and biofuels production and in the study of urban energy systems. In the presentation, examples of the biofuel production process design will be used to illustrates the different steps of the methodology and demonstrate the role of process design in the development of sustainable energy systems.

Biography : Francois Marechal

Francois Marechal holds a process engineering degree (1986) and a Ph D from University of Lige in Belgium, where he realized a Ph D. in the field of process integration of industrial sites under the supervision of Prof. B. Kalitventzeff. In 2001, he moved to Ecole Polytechnique Fdrale de Lausanne in Switzerland where he joined the Industrial Energy Systems Laboratory. He is now heading a research group conducting research in the field of the analysis and the design of sustainable industrial energy systems. His activities are focussing on the development of computer aided methods applying process integration and optimization techniques. He has produced more then 100 scientific papers in the field of energy efficiency in the industry, process system design for biofuels and electricity production, industrial ecology and sustainable energy systems in urban areas studying the optimal integration of renewable energy resources. He is member of the scientific committee of IFP nergies nouvelles and representative of Switzerland in the working party on the use of computers in chemical engineering of the european federation of chemical engineering.