A Multi-scale Energy Systems Engineering Approach Towards Optimal Energy Transition Strategies

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Multi-scale Energy Systems Engineering provides a methodological, generic framework to arrive at realistic integrated solutions to complex energy problems by adopting a holistic, system-based approach. This framework address the complex energy and environmental problems existing in design, control and operation of energy systems and their supply chains in an integrated manner, by producing optimal design and operational plans for systems ranging from nanoscale, micro-scale, mesoscale to mega-scale levels over horizons that range from milliseconds to months or years.

Methodologies in multi-scale energy systems engineering include superstructure optimization with high-fidelity models & data-driven modeling, mixed integer linear/non-linear optimization strategies, integrated design, control & operations under uncertainty, and life-cycle assessment. Such an approach is particularly suitable and powerful to analyze future energy scenarios towards establishing viable and business-sensible energy transition strategies. We will illustrate the concepts and methods of such a holistic strategy by its application to (i) natural gas utilization example focusing on the synthesis of ammonia-methanol coproduction, where the potential use of renewable resources will be also studied, and (ii) renewable resources utilization focusing on the production & delivery of hydrogen-based Dense Energy Carriers, where issues related to intermittency and geographical variability, storage options and transportation will be addressed.