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Circular Economy – a challenge and an opportunity for Process Systems & Chemical Engineering?

Prof. Stratos Pistikopoulos

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Abstract: Circular Economy represents an economy that is restorative and regenerative by design, which aims to be a solution to the resource challenge society is facing, by keeping products, components, and materials at their highest utility and value at all times. Circular Economy operates at three levels, the micro-level (products, companies, consumers), meso-level (processes, eco-industrial parks) and macro-level (city, region, nation and beyond) – based on four actions: reuse, repair, remanufacturing, and recycling. These actions close loops and connect different stages of the supply chain of a product that in a linear economy are typically discrete. These interconnections along with the various players and stakeholders involved in them make decision making for Circular Economy supply chains very challenging. A holistic systems engineering approach may thus be required to navigate the multi-scale, multi-faceted and interconnected circular economy supply chain, identify opportunities for synergistic benefits and systematically explore interactions and trade-offs.

In this presentation, we first address the questions of (i) *what is the relevance and links of Circular Economy to Process Systems & Chemical Engineering?*, and (ii) *what Process Systems & Chemical Engineering can offer to Circular Economy?* We then present the foundations of a **Circular Economy Systems Engineering** framework towards the analysis and trade-off optimization of interconnected resource networks to potentially achieve a circular economy. The framework combines data analytics, mixed-integer modelling and multi-objective superstructure-based optimization methods to establish (i) the interconnections between different stages of the circular supply chain, involving alternative processes, materials, resources and technological options, (ii) the potentially competing interests amongst various stakeholders, and (iii) policy, regulation and societal issues. Links to multi-scale energy systems engineering (for example carbon monetization), reverse supply chains, green chemistry, life-cycle and sustainability analysis and the Food-Energy-Water Nexus are also discussed. Finally, we highlight possible advantages, limitations, and open questions of circular economy systems engineering through a number of representative case studies.



Prof. Stratos Pistikopoulos

Professor Pistikopoulos is the Director of the Texas A&M Energy Institute and a TEES Eminent Professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University. He was a Professor of Chemical Engineering at Imperial College London, UK (1991-2015) and the Director of its Centre for Process Systems Engineering (2002-2009). At Texas A&M Energy Institute, he is the Course Director of the Master of Science in Energy, the co-director of the Southern Regional Manufacturing Centre, the director of the Data Sciences Core of the Texas A&M SUPERFUND research center, and the Texas A&M Principal Investigator of the RAPID Institute on process intensification, co-leading the Modeling & Simulation Focus Area.

He holds a Ph.D. degree from Carnegie Mellon University and he worked with Shell Chemicals in Amsterdam before joining Imperial. He has authored or co-authored over 450 major research publications in the areas of modelling, control and optimization of process, energy and systems engineering applications, 10 books and 2 patents. He is a co-founder of Process Systems Enterprise (PSE) Ltd, a Fellow of AIChE and IChemE and the current Editor-in-Chief of Computers & Chemical Engineering. He is a past Chair of the Computing and Systems Technology (CAST) Division of AIChE and he serves as a trustee of the Computer Aids for Chemical Engineering (CACHE) Organization. In 2007, Prof. Pistikopoulos was a co-recipient of the prestigious MacRobert Award from the Royal Academy of Engineering. In 2012, he was the recipient of the Computing in Chemical Engineering Award of CAST/AIChE. He received the title of Doctor Honoris Causa from the University Politehnica of Bucharest in 2014, and from the University of Pannonia in 2015. In 2013, he was elected Fellow of the Royal Academy of Engineering in the UK.

For more information:

Hamad Farooqi | hamad.farooqi@qatar.tamu.edu | Phone +974 44230309