Reducing greenhouse gas emissions, while improving the global standard of living, is one of the key fundamental challenges of the 21st century. One of the options that has been proposed to reduce greenhouse gas emissions is the conversion of carbon dioxide and water into fuels and chemicals.

In the first part of this talk, we present a systems-level analysis for a solar thermochemical production of synthesis gas (a mixture of CO and H2) from CO2 and H2. We consider the solar thermochemical subsystem integrated into a facility that includes separation subsystems as well as reaction subsystems for the conversion of syngas to liquid fuels. We show that in a well-designed system, sunlight, or more precisely the cost associated with the solar conversion subsystem, is a dominant factor, and the focus of this and similar development efforts should largely be on increasing the efficiency of this component.

In the second part of this paper, we develop a general framework for the analysis of a general solar refinery. We first review the state-of-the-art in solar energy collection and conversion to solar utilities (heat, electricity, and as a photon source for photo-chemical reactions), CO2 capture and separation technology, and non-biological methods for converting CO2 and H2O to fuels, including (1) catalytic conversion using solar derived hydrogen and (2) direct reduction of CO2 using H2O and solar energy. We then utilize process modeling to assess the energy efficiency and economic feasibility of a general solar refinery. The analysis demonstrates that the realization of a solar refinery is contingent upon significant technological improvements in all areas described above.

Bio: Christos was born in Athens, Greece. He obtained his Diploma in Chemical Engineering at the National Technical University of Athens, an MSc in Operational Research from the London School of Economics (London, UK), and a PhD from Carnegie Mellon University. He joined the Department of Chemical and Biological Engineering at the University of Wisconsin – Madison in 2004, where he is now the Executive Officer and Vilas Distinguished Achievement Professor. He is the recipient of an NSF CAREER award, the 2008 David Smith and the 2013 Outstanding Young Researcher Awards from the Computing and Systems Technology division of the American Institute of Chemical Engineers. Christos’ research interests lie in the areas of a) chemical production planning and scheduling; b) supply chain optimization; c) chemical process synthesis and analysis, with focus on energy systems; and d) computational methods for novel material discovery.