PhD Topic 7: Decarbonization and Efficiency Revolution

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Primary Field	Green Business
Secondary Field	Governance and Decision Support
Interdisciplinary References	C3, C4, E1, E2, E4

A number of PhD topics are possible in the broad challenge of transforming energy systems to meet the multiple challenges of the 21st century. The text below raises a number of salient issues that could together or jointly be a subject of a dissertation.

Fundamental, game-changing transformations are needed for a shift toward more sustainable development pathways. By significant investment in new technologies and decarbonization multiple co-benefits can be achieved – from provision of affordable access to modern energy and creation of new business and economic opportunities to addressing the threat of climate change. Convergence and integration of energy, mobility and information infrastructures is needed for achieving such transformational change toward sustainable futures.

Decarbonization of the global economy toward a carbon-free future is such a paradigm-changing transformation. In the energy area, this implies a shift from traditional energy sources, in the case of those who are excluded from access, to clean fossils and modern renewable energy, and in the more developed parts of the world a shift from fossil energy sources to carbon-free and carbon neutral energy services. In all cases this means a vigorous improvement of energy efficiencies, from supply to end use, expanding shares of renewables, more natural gas and less coal, vigorous deployment of carbon capture and storage, and (where it is socially acceptable and economically viable) also nuclear energy.

All of these energy supply technologies need to mesh with emerging innovations in energy networks and end use in direction of smart integration and super grids. This would occur at a number of levels, from local and distributed to centralized systems. The very nature of energy end use is undergoing fundamental transformation as well toward more self-organization and internet-like structures and integration. At the same time, the increasing complexity from energy supply to end use poses high demands for new and more integrated infrastructures for energy, mobility and information and their convergence in fundamentally new systems and services. Energy infrastructures are becoming ever more outdated for the current needs of

increasing energy trade, more intermittent sources and higher and higher demands from energy end use. They are fundamentally inadequate for the emerging future needs to decarbonize energy and integrate different systems locally and across the continents.

The emergence of new energy systems and infrastructures require two complementary co-evolutions – one is technological and the other institutional. The third one may be behavioral. With new technologies and systems, new business models and institutional arrangements will emerge. All of these complementary and co-evolving transformations will require market, regulatory and behavioral changes.

The cumulative nature of technological and associated institutional change, all compounded by deep uncertainties, require innovations to be adopted as early as possible in order to lead through experimentation and evolutionary changes to lower costs and wider diffusion in the following decades. The longer we wait to introduce these advanced technologies, the higher the required costs and emissions reduction will be as well as the "lock-in" into the old structures. The transformational change toward more sustainable futures requires enhanced research, development and deployment (public and private) efforts as well as early investments to achieve accelerated diffusion and adoption of advanced energy technologies and systems.