How Green is A Smart Grid?
A Multi-Agent Life-Cycle Approach

Richard Wang, Shu-Chien Hsu
Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University
Hong Kong

Keywords: *Smart grids, agent-based modelling, life cycle assessment, hybrid life cycle assessment*

Abstract:

Smart grids are considered to be the next generation of electrification due to their improved energy efficiency and better management of renewable energy with the aid of information and communication technologies. Heterogeneous electricity consumers with different demand profiles are fed with information about the fluctuating renewable energy supply via notification or price signals and are advised to adjust demand (advancing or postponing consumption), making the smarts grids extremely complex which depends on both demand and supply of electricity.

Even though the technologies for smart grids (eg. smart meters) are under rapid development in recent years, the environmental impacts of smart grids remain to be uncertain. So far, little evidence has been published to support the implementation of smart grids over other electrification or conventional methods from an environmental point of view.

This study aims to investigate the environmental impacts of smart grids taking into account of their system dynamics in the belief that the environmental impacts will depend on the consumers' behaviour. This is because as consumers face fluctuating renewable energy supply, they may alter their demand to match the energy available. Thus, the environmental impacts change as the dynamics caused by different consumers' behaviour build up within the smart grids. To evaluate the environmental impacts of systems with such complexity resulted by interactions involving heterogeneous consumers, an assessment tool going beyond the tradition static scenarios will be required.

This study will employ a hybrid environmental impact assessment model combining two tools: 1) Life cycle assessment (LCA) is a traditional tool used to evaluate the environmental impacts of a product from its cradle to grave, 2) Agent based modelling (ABM) is a computational tool used to study complex systems and address the socio-technical complexity, using its ability to digest the interaction between heterogeneous actors and their behaviours which leads to large-scale outcomes. Cumulating these two tools is a hybrid ABM / LCA model which can be developed to capture the dynamics in complex systems and present more accurate results of environmental impacts compared to traditional static LCA models.

The contribution of this study is envisaged to be a hybrid ABM / LCA model which can embrace both interdependent components and environmental information for decision-making in highly complex smart grids. The model can be applied to 1) already-established smart grids to identify the most carbon-intensive components for improvements based on operational data and 2) predict consumers' behaviour and associated environmental impacts when designing future smart grids.