Hybrid Life Cycle Analysis of Shale Gas Industrial Processes

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In the U.S., the shale gas production contribution to total natural gas production has increased from less than 5% to 35% from 2005 to 2012, and it is expected to reach 50% by 2035. Despite potentially positive impacts of shale gas development, one major concern in the industry is the actual life cycle greenhouse gas (GHG) emissions associated with shale gas production. Small rates of methane emissions could have a large influence on the greenhouse gas footprints. Therefore, climate benefits of shale gas compared to traditional fossil fuels depend on overall GHG emission of the whole system.

Existing studies focus on evaluating the life cycle carbon footprint of shale gas through the life cycle assessment (LCA) approach. LCA is a well-recognized tool for evaluating the environmental impacts throughout a product's life cycle. A classical LCA study consists of four phases, namely goal and scope definition, inventory analysis, impact assessment, and interpretation. There are three common approaches for developing the life cycle inventory at the second phase, namely process-based, input-output (IO)-based, and hybrid LCA. As the dominant LCA method, process-based LCA provides more accurate and detailed process information. Nevertheless, this "bottom-up" method results in system boundary truncation and underestimation of the true impact. In contrast, IO-based LCA is a "top-down" method that coarse and simplifies models derived from highly aggregated empirical data. However, it lacks details at the process scale. Hybrid LCA combines the strengths of both process-based LCA and IO-based LCA and addresses their respective shortcomings, thus enabling us to quantify both direct and indirect environmental impacts in a detailed and comprehensive manner. Therefore, the primary goal of this project is to evaluate the true life cycle GHG emission of shale gas by using hybrid LCA approach and provide a better understanding on the future of shale gas industry.

To address this problem, we will (1) build a complete direct requirement matrix for industrial sectors in the US economy; (2) extract appropriate GHG emission factors for all the shale gas processes and industrial sectors through database searching techniques; (3) derive correct mapping relationships between shale gas processes and related industrial sectors; (4) summarize and analysis results based on real world industrial cases; and (5) explore potential applications in optimization models.