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# A framework to analyze emissions implications of manufacturing shifts in the industrial sector through integrating bottom-up energy models and economic input-output environmental life cycle assessment models

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Future year emissions depend highly on economic, technological, societal and regulatory drivers. A scenario framework was adopted to analyze technology development pathways and changes in consumer preferences, and evaluate resulting emissions growth patterns while considering future uncertainty. The framework integrates EPA's MARKet ALlocation (MARKAL) energy systems optimization model with an economic Input-Output (I/O) Life Cycle Assessment model. The EPAUS9r database, utilized with the MARKAL model, includes technologies to represent the U.S. energy system from resource extraction, process and conversion technologies to convert resources into useful energy, to end-use technologies for meeting demands. The demands for goods and services are represented *exogenously* in MARKAL. It is important to characterize these exogenous inputs appropriately, especially for the industrial sector as energy and emissions outlooks are driven by it. An economic I/O model of the U.S. economy can provide variations in demand and the share of consumer income expended on a given good when a change in input requirements (e.g., energy intensity or a structural change in how this good is made) occurs. Linking an I/O model with MARKAL facilitates analysis of changes in technological progress and consumer preferences in a systematic manner. The framework will then be extended to track life cycle emissions associated with a good. A case study on upstream raw material manufacturing shifts induced by vehicle mass reduction activities in the automotive-industry will be used to illustrate the framework. The study will analyze life cycle emissions and economic implications of switching from steel based materials to aluminum based materials in automotive industry.