Technology Scenarios, Economic Modeling and Life-Cycle Inventories

Topic: Environmantal Life Cycle Assessment analyses
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Ample experience with life-cycle assessment (LCA) shows that two factors critically influence the amount of emissions caused during the life-cycle of a products: (a) The emissions and energy/resource use by the foreground system, that is the product system investigated, and (b) the emissions intensity of the background system which provides energy, materials, services and other inputs. The degree of responsibility of those two elements varies among different cases, but it is clear that both elements need to be considered. In a prospective assessment of economic activity and environmental impact caused by the future, large-scale application of (novel) technologies, both elements may change and they hence need to be specified.

In a new EU project - PROSUITE - the strategy in the modeling is to integrate the modeling of the value chains of product systems shaped by novel technologies and the modeling of the background economy through a hybrid of product-chain analysis and economic input-output modeling. The foreground system is defined as the parts of the value chain that are specific to the case investigated. The background system is the system that is modeled on a generic basis common for many cases.

The use of technology performance and cost information in scenario development. Scenarios for the evolution of the background economy will be developed. In these scenarios, a prospective future economy will be described in the form of an input-output table. The input-output table contains information on the requirements of energy, some materials and other environmentally important inputs to the economy, as well as information on economic activity and employment triggered by the demand for output from various sectors. There will be several scenarios describing different, alternative futures. Scenarios will be developed for the economy in 2020, potentially extended also to 2030, and taken from key existing models.

There is a need to further specify the break-down of the economic activity in the original IO tables on the more detailed aggregation level chosen for the specific technologies targeted in the modelling. Input from technology characterization will be used to this end:
a. A specification of important technologies which we should assume to have penetrated to significant degrees in 2020 or 2030, and a description of the degree of penetration.
b. A specification of the physical characteristics and costs of novel technologies that will have penetrated at a level significant for the performance or sustainability attributes of the overall economy. This specification should be in the form of a “production recipe” (intermediate input requirements – including capital and labor - and yield).
c. A specification of technological progress attained (decreased intermediate input or labor requirements, increased efficiencies) resulting from technology learning for important technologies.

In environmental assessments, the output of the scenario analysis will be used in the same manner as life-cycle inventory databases are used today: as background data to describe inputs of energy, materials, services and the like. These inputs can be utilized in conventional LCA software. But modeling of economic aspects and overall sustainability aspects may require an integration of the foreground technology scenario and the model of the total (background) economy. This implies that data on inputs, outputs and environmental interventions caused by the processes needs to be integrated into the model.

We conclude with a discussion of the challenges in integrating the foreground and background systems in a dynamic manner such that macro-variables of interest of the background system can be determined endogenously from the foreground system.