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How clean is your ‘clean’ energy? The ENVIRO module for energy system models

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A decarbonized, renewable energy system is generally assumed to represent a cleaner and more sustainable one. However, while they do promise day-to-day reductions in carbon emissions, many other environmental impacts could occur, and these are often overlooked. Indeed, in the two documents that form the EU Energy Union Strategy (COM/2015/080) the words ‘water’, ‘biodiversity’ or ‘raw materials’ do not appear. This ‘tunnel vision’ is often also adopted in current energy systems models, which do not generally provide a detailed analysis of all of the environmental impacts that accompany different energy scenarios. Ignoring the trade-offs between energy systems and other resources can result in misleading information and misguided policy making.

The environmental assessment module ENVIRO combines the bottom up, high resolution capabilities of life cycle assessment (LCA) with the hierarchical multi-scale upscaling capabilities of the Multi-Scale Integrated Assessment of Socioecosystem Metabolism (MuSIASEM) approach in an effort to address this gap. ENVIRO also takes the systemic trade-offs associated with the water-energy-food-(land-climate-etc.) nexus from MuSIASEM while considering the supply chain perspective of LCA. The module contains a built-in set of indicators that serve to assess the constraints that greenhouse gas (GHG) emissions, pollution, water use and raw material demands pose to renewable energy system scenarios. It can be used to assess the coherence between energy decarbonization targets and water or raw material targets; this can be extended to potentially any economic or political target that has a biophysical component.

In this work, we introduce the semantics and formalization aspects of ENVIRO, its integration with the energy system model Calliope, and the results of a first testing of the module in the assessment of decarbonization scenarios for the EU. The work is part of the research developed in the H2020 Project SENTINEL: Sustainable Energy Transition Laboratory (contract 837089).