Integrating solar PV supply chain into EXIOBASE to assess EU Net-Zero Industry Act impacts

Topic: Input-Output Modelling: Energy policies (1)
Author: Lorenzo Rinaldi
Co-Authors: Camilla Citterio, Raffaele Merletti, NicolÃ² Golinucci, Matteo Vincenzo Rocco

The rapid expansion of solar photovoltaic (PV) deployment has intensified concerns about the geographic concentration of manufacturing activities and the resulting dependencies along global supply chains. In recent years, production of key PV components has become highly concentrated in a limited number of countries, exposing importing regions to geopolitical risks, trade disruptions, and price volatility. In response, the European Union has introduced the Net Zero Industry Act (NZIA), which sets a target of meeting at least 40% of European PV demand through domestic manufacturing by 2030, with the broader objective of strengthening strategic autonomy, industrial resilience, and clean technology leadership. This study assesses the environmental, economic, and social implications of relocating PV manufacturing activities to the European Union in line with this policy objective, explicitly accounting for global supply chain interactions and international trade linkages.

The analysis adopts an integrated hybrid life cycle assessment framework that embeds detailed, process-based representations of the crystalline silicon PV supply chain within a multi-regional inputâ€“output model. Newly defined PV industries, covering polysilicon purification, ingot and wafer production, cell manufacturing, module assembly, installation, operation, and end-of-life management, are incorporated into the EXIOBASE supplyâ€“use structure using the MARIO modelling platform. This enhanced sectoral disaggregation allows for a transparent mapping of material and energy flows across production stages and regions. The approach combines technological specificity with economy-wide completeness, enabling the simultaneous evaluation of life-cycle greenhouse gas emissions, basic prices, value added, employment, and trade flows across regions. Process-level life cycle inventories are primarily sourced from the IEA Photovoltaic Power Systems Task 12 database and complemented with data from the National Renewable Energy Laboratory for balance-of-system components and service activities. All datasets are harmonised, regionalised, and integrated into an updated version of EXIOBASE reflecting recent electricity generation mixes, sectoral productivity trends, and trade patterns.

A policy scenario reflecting the NZIA reallocates regional production shares along the PV supply chain while holding final electricity demand constant, thereby isolating the systemic effects of manufacturing reshoring from demand-side dynamics and installation growth. Counterfactual comparisons with a baseline scenario based on current trade structures allow for the identification of distributional effects across regions and supply chain stages. Results indicate that reshoring PV manufacturing to the EU yields modest but positive gains in European GDP and employment, driven largely by higher labour income and domestic value creation in selected upstream and midstream segments. However, a substantial share of value added continues to accrue to foreign suppliers due to persistent dependence on imported intermediates, particularly for energy-intensive materials, metallurgical inputs, and capital goods. From an environmental perspective, the NZIA scenario leads to a moderate reduction in consumption-based carbon emissions, reflecting the comparatively lower life-cycle carbon intensity of EU-produced PV modules and the cleaner electricity mix in several Member States, although part of the emissions burden is reallocated rather than eliminated.

The main contribution of this work lies in the explicit integration of a highly disaggregated global PV supply chain into a multi-regional inputâ€“output framework tailored to forward-looking policy analysis. By addressing structural aggregation biases typical of conventional top-down databases

and enabling consistent scenario design, the proposed approach supports a comprehensive assessment of industrial reshoring strategies. It provides quantitative evidence on the trade-offs between strategic autonomy, environmental performance, economic outcomes, and global emission redistribution in the European solar sector under alternative supply chain configurations.