MACROECONOMIC IMPLICATIONS OF ENERGY INVESTMENTS TO REACH A 1.5 °C TARGET

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Overview

Investment can promote economic growth by increasing the capital stock and the productive capacity of the economy and, therefore, its aggregate income. Investments in renewables have been exponentially growing over the last years, anticipating an upcoming shift in the energy mix (IEA, 2023), and avoiding the lock-in on emissions-intensive technologies (Bertram et al., 2021). The transition to an energy system, where electricity is produced by renewables, promotes energy security by reducing trade dependency and fosters cheaper electricity and competitiveness in the long-term (Keramidas et al., 2022). Policy support, technological development and shifting investor preferences appear to align with a strengthened ambition to deploy new technologies and effectively reduce emissions, while promoting economic activity (Keramidas et al., 2023). For example, investing in wind energy brings positive economic effects to sectors that produce investment goods, such as the manufacturing sector for equipment goods, like nacelles, rotors and generators.

Here we examine the effects of additional energy investments to other sectors in the economy under a 1.5 °C cost-efficient global temperature stabilization scenario. We use an investment matrix to create a detailed link between investing sectors and sectors supplying the purchased investment goods (Norman-López et al., 2023). This captures heterogeneity across investing sectors, particularly arising from investments in power generation technologies. We use the aggregate sectors of a Computable General Equilibrium (CGE) model, the JRC-GEM-E3 model (Capros et al., 2013) to assess the effects of global energy investments throughout the supply chains. Our analysis takes a macroeconomic perspective, with a specific focus on the associated supply chain effects in capital and labour over the next decade, including the impacts on both direct and indirect employment.

Methods

The paper builds on the most updated version of the modelling toolbox used in the European Commission's energy and climate policy assessments, covering the impacts on the energy system, transport, agriculture, and the macro-economic effects over multiple sectors, including employment and social welfare (Weitzel et al., 2023). Figure 1 presents the modelling toolbox, including the bottom-up energy system and top-down global economic modelling combined.

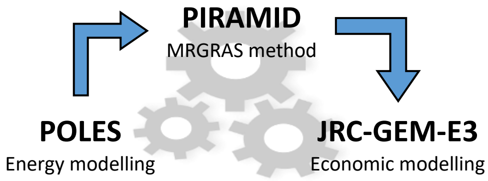

Figure 1. Modelling toolbox. Bottom-up energy system and top-down global economic modelling combined.

The POLES-JRC model is a global partial equilibrium simulation model of the energy sector, covering a wide range of activities from upstream production to final user demand (Després et al., 2018). The model describes how multiple energy resources are put into production, resulting in trade flows from producers to consumers (for oil, gas, coal, bioenergy, hydrogen), and providing full energy and emission balances for 66 countries and regions worldwide.

JRC-GEM-E3 is a multi-regional, multi-sectoral, recursive dynamic Computable General Equilibrium (CGE) model (Capros et al., 2013). The model has been extensively used for policy analysis and impact assessment, being particularly valuable in capturing the effects of the transformation of the energy system and of climate-related policies over the macroeconomic aggregates (Weitzel et al., 2023).

The PIRAMID tool (Wojtowicz et al., 2019) is based on the multi-regional generalized RAS (MRGRAS) method (Temursho et al., 2020) and reconciles the multi-regional input-output (MRIO) economic structure from the JRC-GEM-E3 model with the energy balances from the POLES-JRC model. In this integration process, consistent MRIO tables derived from the Global Trade Analysis Project (GTAP) 10 Power database (Aguiar et al., 2019; Chepeliev 2020) are projected forward in time, providing a fully consistent baseline (Reference scenario, current policies) for policy analysis.

For the 1.5 °C scenario, we use a soft-link approach to impose transitions projected in the POLES-JRC model to the JRC-GEM-E3 model. In this approach, we adjust the parameters that describe the decarbonization of key energy sectors (e.g. electricity, transport, heating), taking into account additional costs (e.g. from higher capital expenses). For the power generation technologies, we represent the additional investment needs in the CGE model through the capital expenditures in the additional installed capacities required to reach the 1.5 °C target. For other sectors, such as buildings and transport, we use the capital costs from POLES-JRC to harmonize investments in the CGE model.

To capture the heterogeneity in the delivery of investments across sectors, we use a sectoral detailed investment matrix built upon Eurostat data for non-power sectors and bottom-up cost data for power sectors (Norman-López et al., 2023). In the base year calibration, a RAS-balancing procedure aligns the (aggregate) sectoral investment supply of the investment matrix with the investment supply reported in the GTAP 10 database. For the projected years, changes in the output of the ‘investing sectors’ and the cost of capital goods determine the sectoral demand for investment in the JRC-GEM-E3 model. On the investment supply, when investments occur in physical infrastructure, the investing sectors rely on other sectors of the economy to deliver the goods and services (hereafter ‘delivering sectors’) needed to build this new physical infrastructure.

We project the number of workers in the energy sectors (including power generation technologies) based on the employment factors (number of direct jobs/energy unit produced). We multiply the total output of the energy sectors to calculate and project the total number of direct jobs in those sectors. We also project the number of indirect jobs, which are the ones created in the delivering sectors. Based on the investment needs of ‘investing sectors’, we calculate the number of indirect jobs created in the various ‘delivering sectors’, using wages and the share of labour in total value added.

Results

At the macro level, in the 1.5°C scenario compared to the Reference scenario, global GDP decreases slightly but never exceeding 2%. This means that the ratio of mitigation costs to GDP is rather low. The share of investment in GDP increases in the policy scenarios. By 2050, global investment as a percentage of GDP reaches 26.4% in the 1.5°C scenario, compared to 25.7% in the Reference scenario, with the expansion of renewable power generation and electricity supply driving the relative increase in investment.

While we observe a relative increase in energy investment, the additional investments constitute only a fraction of global aggregate investment. For instance, the investment in electricity generation and transmission and distribution (T&D) sector represents 2.6% of total global investments in the 1.5°C scenario, while representing about 1.5% in the Reference scenario. Energy investments however have a positive effect upstream of the value chain. The largest ‘delivering sectors’ to build additional capital stock in the economy are the construction sector (53% of global investment deliveries), the services sector (14%), other equipment goods (12%), manufacturing industries (10%) and electrical goods (8%). Together, these sectors account for 97% of total investment deliveries to build additional capital. Conversely, the services sector is by far the largest investor (64% of total investing sectors), as it takes up a large share of economic activity, followed by the manufacturing industries (8%), and construction, energy-intensive industries, and agriculture (with approximately 5% each).

Investments in fossil fuel power generation become negligible as the economy decarbonizes, whereas renewables boost investment-deliveries by different sectors in the 1.5°C scenario. For instance, the capital formation in wind power generation is delivered by 70% of equipment goods sector (e.g, wind turbines, generators), while in solar PV is composed of 60% of electrical goods sector (e.g, solar PV panels). In the case of transmission and distribution (T&D), investment mainly triggers deliveries by the construction sector, reflecting the high construction demand to build power grids.

The delivery patterns of each power sector technology contribute differently to the boost in investment-deliveries by sectors, also creating additional jobs in the economy. Energy investments shift direct jobs away from coal and gas fired generation towards wind, solar PV and biomass generation. When compared to the Reference scenario, 4.7 million additional direct jobs in renewables are created by 2050 under the 1.5°C scenario. In line with previous work (Garaffa et al., 2023; Vandyck et al., 2016), fossil fuel sectors face a substantial decrease in the number of jobs by 2050, but these sectors do not represent a big share of the overall labour market. The deployment of renewables and greater electrification also help to absorb and partially offset jobs losses in those sectors. Largely, this comes from the increase in the direct jobs, but the investment in renewables also promotes jobs in other sectors, particularly in construction and manufacturing of electrical and other equipment goods, which demand more workers in different occupations. By 2050, in the 1.5°C scenario, there are additional 590 thousand indirect jobs globally in construction for the power generation sector, with additional 800 thousand jobs in the ‘other equipment goods’ sector to produce power generation equipment.

Conclusions

This paper shows how the investment in low-emission technologies stimulates output, while promoting investment and employment globally in adjacent sectors that supply equipment and services to the energy sector. Decarbonisation creates jobs opportunities across the economy, reinforcing the importance to promote a fair transitions when design climate policies. Care must be taken by policymakers and investors to ensure that energy sector investments are 1.5°C-aligned, in order to minimise the risk of misallocated capital slowing down the energy transition. While decarbonisation leads to an increase in investments in the energy sector, the share of spending in global GDP in the future remains broadly the same as today, indicating that the global economy can manage the burden of decarbonisation.

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