Supply chain implications of energy investments to reach a 1.5 °C target

Introduction

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). This transition to an energy system where electricity is produced by renewables, reduces trade dependency, fosters cheaper electricity in the long-term, and promotes competitiveness gains for first movers (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 the additional energy investments to the economy under a 1.5 °C cost-efficient global temperature stabilization scenario. We use an updated investment matrix to capture in more detail the link between investing sectors and the sectors supplying the purchased investment goods (Norman-López et al., 2023). We pay particular attention to the effects arising from investments in power generation technologies. We use the aggregate sectors of a macroeconomic computable general equilibrium (CGE) model, the JRC-GEM-E3 (Capros et al., 2013), to assess the effects of global energy investments throughout the supply chains over the next decade. Our analysis takes a macroeconomic perspective, with a specific focus on the associated supply chain effects in capital and labour, including the impacts on both direct and indirect employment.

Methodology

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

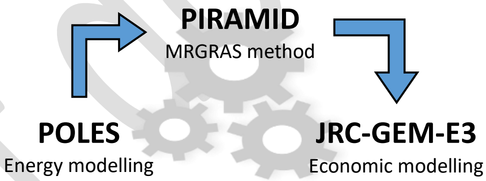

Figure 1. Modelling toolbox. Bottom-up energy system and top-down global economic modelling combined.

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, providing full energy and emission balances for 66 countries/regions worldwide and energy trade flows from producers to consumers for oil, gas, coal, bioenergy and hydrogen (Keramidas et al., 2022).

JRC-GEM-E3 is a multi-regional, multi-sectoral, recursive dynamic 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, including the effects on employment (Weitzel et al., 2023; Garaffa et al., 2023).

The PIRAMID tool links the POLES-JRC and the JRC-GEM-E3 models (Wojtowicz et al., 2019), reconciling the energy balances from POLES-JRC with the economic structure from the Global Trade Analysis Project (GTAP) 10 Power database (Aguiar et al., 2019; Chepeliev 2020). The PIRAMID tool is based on the multi-regional generalized RAS method (Temursho et al., 2020), which ensures that the JRC-GEM-E3 is aligned with the energy use and GHG emissions projected in POLES-JRC. In this integration process, consistent Input-Output tables and Social Accounting Matrices (IOTs/SAMs) are projected forward in time, providing a fully consistent baseline (current policy scenario) for economic analysis.

We run a 1.5°C scenario compatible with a global temperature increase above pre-industrial levels of 1.5°C by the end of the century. The global carbon budget (cumulated net CO_2 emissions) in this scenario is of approximately 530 $GtCO_2$. 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). We further impose a global uniform carbon price to capture the remaining costs of decarbonization. Several improvements in the soft-link with the POLES-JRC model were implemented to better represent additional investment needs in the CGE model. For the power generation technologies, this is captured through the capital expenditures on the additional installed capacities required to reach the 1.5°C target. We also harmonize investments in other sectors (e.g., buildings, transport) using the capital cost from the POLES-JRC model.

We use an investment matrix to capture the heterogeneity in the delivery of investments across sectors. The investment matrix is built using Eurostat data for non-power sectors and bottom-up cost data for power sectors (Norman-López et al., 2023). A RAS-balancing procedure aligns the aggregate sectoral investment supply of the investment matrix with the investment supply from the GTAP database. 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 (referred as 'delivering sectors') needed to build this new physical infrastructure. The sectoral demand for investment in the JRC-GEM-E3 model is then determined by changes in the output of the 'investing sectors' and the cost of capital goods over time.

Based on the multi-regional Input-Output tables projected by JRC-GEM-E3, we calculate the number of jobs in the energy sectors, including direct jobs from the operation and maintenance of power generation technologies and indirect jobs that are created from the additional investment in those technologies. To calculate the number of direct jobs, we multiply the share of labour in the total value added of energy sectors by the employment factors from the literature (e.g., the number of direct jobs per unit of energy produced). We also project the number of indirect jobs, which are the ones created in the delivering sectors. We use the investment matrix to calculate the investment needs of individual sectors to various delivering sectors, which we further convert to the number of indirect jobs created using the delivering sector's wages and the employment compensation from JRC-GEM-E3.

Results

Here we present a summary of the main macroeconomic results and the effects on investment and employment in the 1.5°C scenario. At the macro level, global GDP decreases slightly but never exceeding 2% compared to the Reference scenario. This means that the ratio of mitigation costs to GDP is rather low. In the 1.5°C scenario, global GDP decreases by 1.65% compared to the Reference scenario in 2050, reflecting the mitigation costs needed to achieve this ambitious target. 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. The relative increase in investment is driven by the expansion of renewable power generation and electricity supply. The increase in investments however leads to a decline in private consumption due to crowding out, due to the JRC-GEM-E3 assumption that the economy is supply constrained. Within the consumption category, we observe a shift to durable consumption goods, with additional expenditures for buildings' renovations, including heating equipment, and purchase of electric vehicles, resulting in a decline of final energy consumption due to electrification and greater energy efficiency associated with it.

Figure 2 shows the distribution of global deliveries for annual economy-wide investment in the year 2040 in the 1.5°C scenario. Delivering sectors are shown on the left and investing sectors on the right side of the figure. While there is a large relative increase in energy investment, these additional investments constitute only a fraction of the aggregate investment. This explains why economy-wide investment activity increases by only a small amount. The electricity generation and transmission and distribution (T&D) sector amounts to USD 990 billion, representing just 2.6% of total global investments. 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. At the same time, 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).

Changes on investment also affect sectoral employment. 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. However, fossil fuel sectors do not represent a big share of the overall labour market, and the deployment of renewables and greater electrification 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.

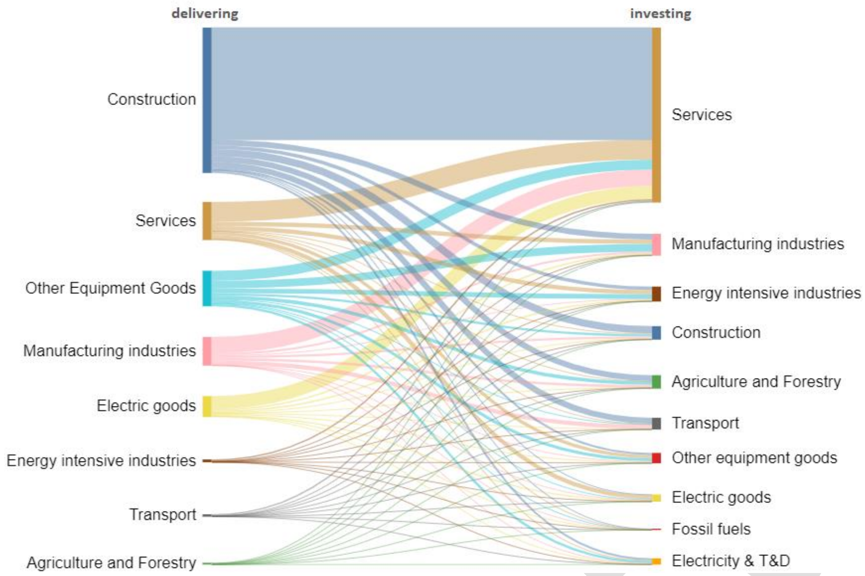

Figure 2: Global investment in 2040 by delivering (left) and investing (right) sectors in the 1.5°C scenario

Conclusions

This paper shows how the investment in low-emission technologies stimulates output, while promoting investment and employment in adjacent sectors that supply equipment and services to the energy sector. Decarbonisation creates job opportunities both in the energy sector and in adjacent sectors. 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. 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.

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