Reaching climate neutrality in an isolated energy system: the case of Cyprus

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1. Overview

The climate emergency is one of the most important challenges of modern society. A transition to low-carbon economies can mitigate the impact of climate change but requires investments at an unprecedented pace and scale. At the European Union (EU) level, the European Green Deal aims to achieve a carbon-neutral regional economy by 2050 [1]. Compared to previous EU policies, the European Green Deal and the *'Fit for 55'* package of measures require additional climate change mitigation efforts from EU member states, as the targets become stricter across all sectors of the economy. This means that the policies and measures of the National Energy and Climate Plans (NECPs) need to be enriched in order to achieve the more ambitious targets and to set national economies on a path to carbon neutrality by 2050. However, at a time where economies are struggling to recover from the COVID-19 pandemic, energy and climate plans need to carefully assess the various policy proposals, so as to avoid potential adverse socioeconomic impacts. The present paper aims to provide an analysis of the implications of the more ambitious target of carbon neutrality by 2050 on the energy system of Cyprus, a geographical- and energy-island member state of the EU. Results from a set of four scenarios will be presented alongside the equivalent trajectories from the *'Planned Policies and Measures'* (PPM) scenario of the NECP of the Republic of Cyprus that was submitted to the European Commission [2]. This will allow for a direct visualization of the required additional effort and the respective investments that will be needed to conform with some of the new targets. Additionally, it will provide an estimate on the broader socio-economic impacts of achieving a carbon-neutral economy in Cyprus. Supported by the active engagement of national stakeholders, a combination of technoeconomic and macroeconomic energy system models is adopted to conduct the analysis.

2. Methods

2.1. Modelling approach

The analysis will use outputs from three separate models which are soft-linked according to the flowchart shown in Figure 1. Firstly, a long-term energy demand forecast model (model 1 in Figure 1) is used to project final energy consumption in the electricity and heating and cooling sectors (step A), which is inserted in a cost-optimisation model (model 2). The energy forecast model uses projections of national GDP and international oil prices, along with assumptions on the short-term and long-term income and price elasticities of energy consumption [3]. The energy demand forecast model also provides projections of the annual energy consumption expenditure of households (step B), which are introduced in an input-output model (model 3) to estimate the multiplier effect of changes in private consumption in the economy of Cyprus.

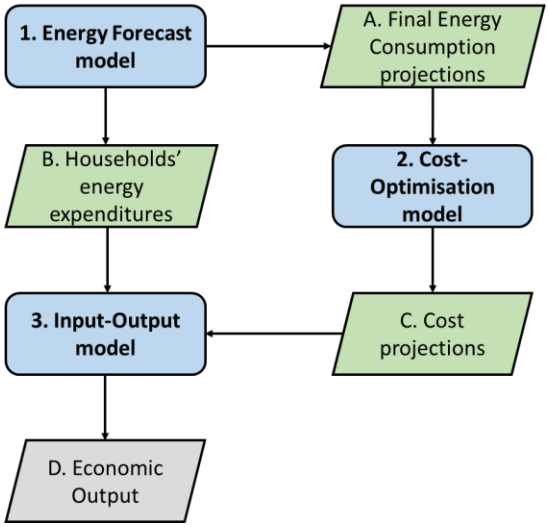

Figure 1 – Simplified flowchart with the soft-linking process for the three models [5].

In the second phase of the analysis, a technoeconomic cost-optimisation model (model 2), developed in the OSeMOSYS modelling framework [4], is used to project the technology and energy mix in the electricity supply and transport sectors, while it also facilitates the estimation of necessary investments in the heating and cooling sector to satisfy the demand projected in the first step. Finally, the associated investments outlook, along with the costs for operation and maintenance of all technology options, are quantified by the cost-optimisation model (step C) and passed on to the input-output model (model 3) to estimate the economy-wide impacts on economic growth across the different sectors of the local economy (step D). For consistency purposes, all assumptions are aligned between the three models. The adopted methodology is presented in more detail by Taliotis et al. (2020).

2.2. Scenarios

In order to extract insights on the potential impacts of the new EU legislative proposals and the target for carbon neutrality by 2050 on the energy system and the broader economy of Cyprus, a set of scenarios will be assessed; the Planned Policies and Measures (PPM) scenario of the Cypriot National Energy and Climate Plan (NECP) will be used as a base. The following scenarios will be developed with an outlook to 2050:

- **Scenario A (Revised PPM):** This scenario builds on the NECP PPM scenario, using specific updates on assumptions, such as on technology cost and performance, fuel price projections, ETS price projections, macroeconomic assumptions, and electricity demand projections based on the latest official projections. This is the scenario that is closest to the official national plans.
- **Scenario B (Extension of ETS):** Adding to scenario A, this scenario considers the potential inclusion of building and road transport sectors into a new expanded ETS scheme. It is assumed that such a taxation comes into effect in 2026, in line with the relevant European Commission proposal.
- **Scenario C (Net-zero):** This scenario assumes a full achievement of the 2030 '*Fit For 55*' targets. For instance, in the case of the CO_2 emission reduction targets, the current 2030 target for sectors falling under the ETS changes from a 43% reduction to a 61% reduction, as compared to 2005 levels. The equivalent 2030 target for sectors under the Effort Sharing Regulation (ESR) changes from a 24% reduction to a 32% reduction, as compared to 2005 levels. Similarly, a target of net-zero greenhouse gas emissions is set for 2050.
- **Scenario D (Net-zero & extension of ETS):** Building on scenario C, extension of the ETS is added to assess whether significant differences will be observed compared to the previous case in regards to technology investments and energy demand growth.

The key assumptions adopted in the above scenarios will be aligned with the outcomes of the ongoing negotiations regarding the specific targets and provisions of the '*Fit for 55*' package of measures.

3. Results

The ensemble of models employed for the analysis will produce a range of outputs, which can inform long-term planning. Specifically, the analysis will present:

a) **Projections on the technology and energy mix** across the key sectors of the energy system (i.e. electricity supply, land transport, heating and cooling), along with estimates on the evolution of primary energy supply and final energy demand. Trajectories of the renewable energy shares for the entire system and for each sector will also be presented.

b) **Greenhouse gas emission** projections and a quantification of the potential emissions gap that has to be addressed to move the country to a path compliant with the long-term carbon-neutrality target.

c) **Energy system cost** projections, providing detailed information on capital investment requirements, fuel, emission, operation and maintenance costs for each of the key sectors, as well as for key interventions separately (e.g. electricity storage, promotion of sustainable mobility, energy efficiency measures).

d) **Estimates on the economic impact of the energy transition.** The gradual decarbonisation of the energy system through deployment of low-carbon technologies will lower the dependence on fossil fuels. Along with the estimated investments in technologies, energy efficiency interventions and measures that promote sustainable mobility, this shift will lead to a substantial impact across the economy. This impact will be quantified to show changes in the economic output for each of the represented twenty overarching sectors of the Cypriot economy, while the effect on net job creation will be assessed. Similarly, the distributional impacts by household income group in the short and medium term will be explored.

4. Conclusions

The effectiveness of the EC proposed measures will be examined. Specifically, the need for the implementation of carbon taxation on the broader energy system will be assessed and the possibility of adopting this at the national rather than the regional level will be discussed.

References

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