Green transition reforms in Greece: Evaluating the effectiveness of the National Recovery and Resilience Plan towards the achievement of national determined contributions and net-zero targets

Vassilis Stavrakas*, Nikos Kleanthis, Dimitris Papantonis, Alexandros Flamos

[1] Technoeconomics of Energy Systems laboratory (TEESlab), Department of Industrial Management and Technology, University of Piraeus, Karaoli & Dimitriou 80, Piraeus 18534, Greece.

Summary

As part of the EC-funded "**IAM COMPACT**" project[1], we aim at assessing the effectiveness of Greek Covid-19 green recovery measures reported in the National Recovery and Resilience Plan (NRRP) towards achieving sectoral targets articulated in the National Energy and Climate Plan (NECP). To do so, we first create policy packages by analysing the NRRP and bringing together the identified green recovery measures per sector. We then utilise two sectoral models to simulate scenarios including the developed policy packages and highlight impacts on the energy mix and required investments in the residential and power sectors.

Abstract

The "Greece 2.0" NRRP aims to transform the economy, institutions, and society of Greece and increase its resilience to such shocks as the COVID-19 pandemic. The NRRP supports Greece's energy transition and is in line with the objectives of the European Green Deal, the NECP, and the aim for climate neutrality by 2050. In this study, we seek to find the impacts of the measures related to the energy transition in the Greek residential and power sectors, as outlined by the NRRP, according to the transition pathways derived from sectoral models.

The NRRP measures required to meet Greece's climate targets have been organised into four components. In this study, we focus on the following two:

→ **"Renovate"**: Includes measures that promote building renovation and energy efficiency upgrades as well as urban and spatial planning implementation (**Table 1**).

→ **"Power up"**: Includes measures that improve the capacity and energy storage of the electricity system, enabling for higher penetration of renewable energy sources (RES) in the energy mix (**Table 2**).

Table 1. Funding instruments and financing mechanisms focused on renovations in the building sector under the "Renovate" component of the Greek National Recovery and Resilience Plan.

Sector	Short description	Budget allocated (€ million)
Energy renovation on residential buildings ("Saving at home")	Enhance the uptake of energy efficiency actions in the residential sector, with the aim of saving energy by at least 30%.	1,081
Energy and entrepreneurship	Enhance the uptake of actions to improve the energy efficiency of small and medium enterprises with the aim of saving at least 30%.	450
Energy upgrade of public sector buildings	Renovations and energy upgrade of public infrastructure and buildings, energy upgrade of public lighting.	200

Table 2. The measures focused on renewable energy and storage capacity expansion under the "Power up" component of the Greek National Recovery and Resilience Plan.

Type of measure	Measure	Short description	Budget allocated (€ million)
Investment	Support of the installation of	Installation of electricity storage	450

* Corresponding author: vasta@unipi.gr

[1] *https://www.iam-compact.eu/*

	storage systems.	capacity (700 MW).	
Reform	Enhancement of the "RES-CHP Account's" revenues.	Integration of at least 1 GW of new RES capacity per year from 2023 until 2025.	New investments will be indirectly triggered by facilitating new RES projects financing.
Reform	Simplification of licensing procedure for RES.		

Our study first seeks to explore the energy transition of the Greek residential sector towards 2050, simulating different scenarios using the **D**ynamic high-**R**esolution d**E**mand-sid**E** **M**anagement (DREEM) model [1]. To design the scenarios, a reverse engineering approach is applied so that DREEM calculates the exact renovation rate required to achieve decarbonisation in the Greek residential sector by 2050 and 2040 (more ambitious target), respectively (**Table 3**).

Table 3. Transition scenarios in the Greek residential sector by 2050.

Reverse engineering scenarios		
1. "Decarbonisation by 2050: Focusing on natural gas by 2030"	(2023-2030)	Annual natural gas penetration according to the current NECP 2030 targets.
	(2031-2050)	Phaseout of existing oil and natural gas boilers with heat pumps.
2. "Decarbonisation by 2050: Focusing on electrification"	(2023-2050)	Substitution of oil and natural gas boilers only with heat pumps.
3. "Decarbonisation by 2040: Focusing on natural gas by 2030"	(2023-2030)	Annual natural gas penetration according to the current NECP 2030 targets.
	(2031-2040)	Phaseout of existing oil and natural gas boilers with heat pumps.
4. "Decarbonisation by 2040: Focusing on electrification"	(2023-2040)	Substitution of oil and natural gas boilers only with heat pumps.

We also explore least-cost capacity expansion and electricity mixes that lead to a carbon-neutral power sector in Greece, according to key input assumptions, as these have been partially articulated in the revised draft NECP. We simulate the recovery measures as exogenous capacity additions for low-carbon technologies with a country-specific implementation of the **O**pen-**S**ource **e**nergy **MO**deling **SYS**tem (OSeMOSYS)[2], OSeMOSYS-GR. In total, we define three scenarios that differ in terms of the simulated recovery measures. The green recovery scenarios studied are:

- "**NDC_LTT**": Baseline scenario following the CO_2 emission and RES expansion targets articulated in the revised draft NECP.
- "**NDC_LTT_GR_21**": Builds on the baseline and includes the "Support of the installation of storage systems" measure.
- "**NDC_LTT_GR_23**": Builds on "NDC_LTT_GR_21" and includes two additional measures: "Enhancement of the "RES-CHP Account's" revenues" and "Simplification of licensing procedure for RES".

We find that to achieve decarbonisation by 2050, around 100,000 dwellings should be renovated annually; in contrast, if decarbonisation by 2040 is the goal, 145,000 dwellings must be renovated annually (**Fig. 1**).

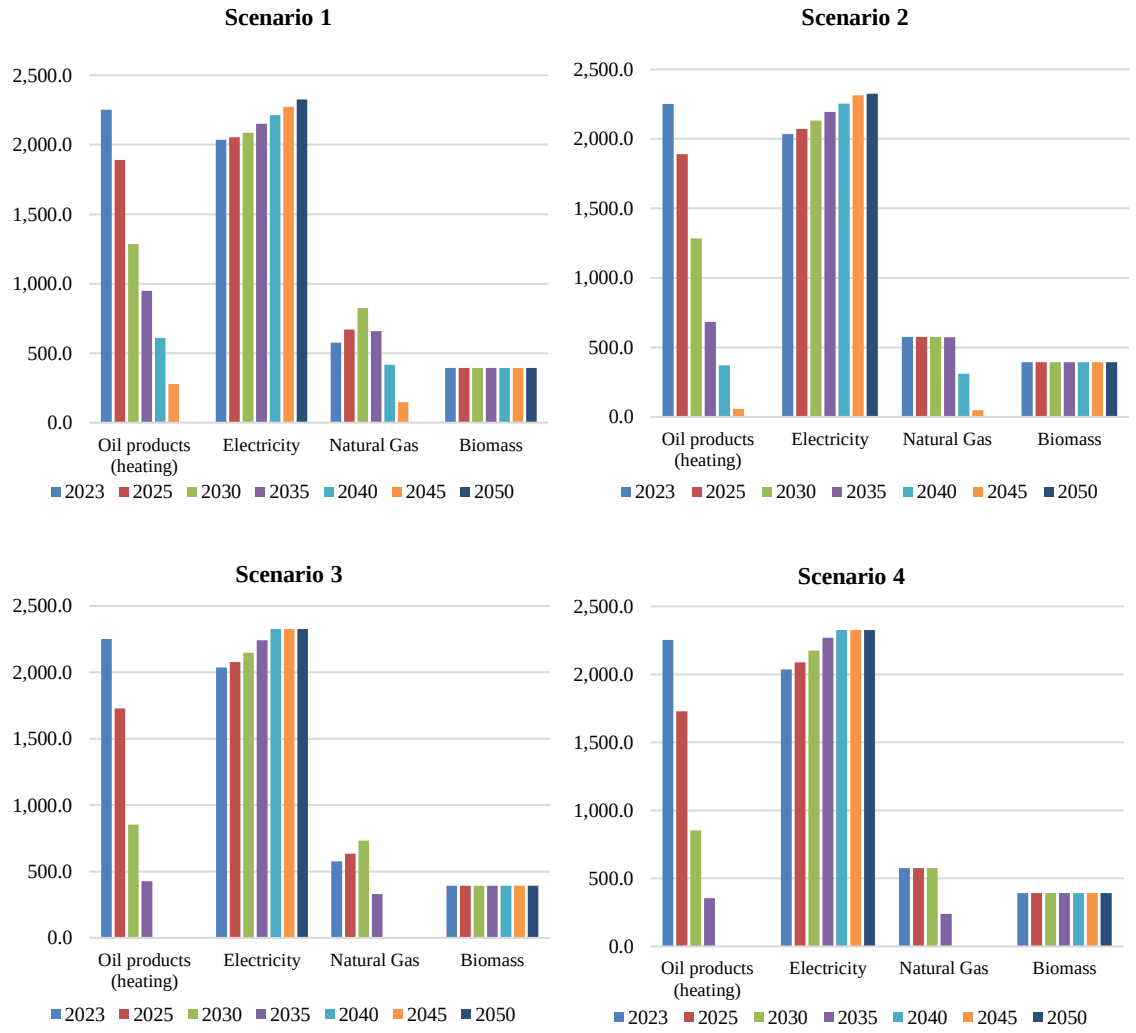

Fig. 1. Final energy mix (ktoe) for decarbonisation scenarios in the Greek residential sector by 2050.

In the case of decarbonisation scenarios by 2050 and 2040, we see that the current NRRP's funding does not meet the goal of covering 9,000 household renovations annually, i.e., 15% of the NECP target for the energy-efficiency upgrades in the residential sector (**Table 4**).

Table 4. Deviations from the NRRP's goal and necessary increase to boost energy efficiency in the residential sector.

(Millions)	Renovation costs by 2030	Money needed to cover NRRP's goal by 2030	NRRP's budget by 2030	Deviation	Necessary increase in the current NRRP's budget
"Scenario 1"	8,938	1,341	1,081	259.7	**19%**
"Scenario 2"	10,350	1,552		471.5	**30%**
"Scenario 3"	14,099	2,115		1,034	**49%**
"Scenario 4"	14,992	2,249		1,168	**52%**

We find that the investments and reforms of the NRRP can imply a significant short-term reduction in fossil-fuel use and CO_2 emissions from the power sector due to the increased deployment of RES (**Fig. 2**).

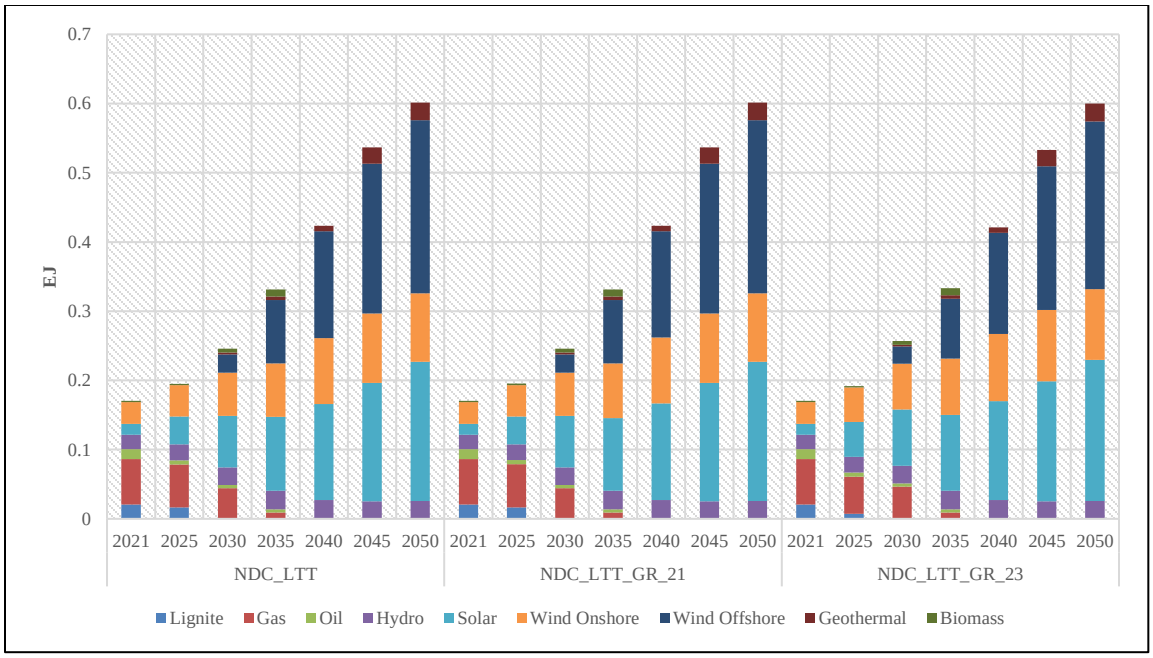

Fig. 2: Annual power generation mixes for "NDC-LTT", "NDC_LTT_GR_21", and "NDC_LTT_GR_23" scenarios.

We also observe that the recovery packages for RES and storage capacity expansion will lead to minor monetary savings, mostly in the short run (**Table 5**).

Table 5. Investment savings from the implementation of recovery measures for RES and storage capacity expansion.

Year	Total investments without recovery measures (Millions)	Investment savings with recovery measures (Millions)	Investment savings with recovery measures (% of total investments)
2025	3,005	113,3	3.77
2030	5,476	211,1	3.39
2035	5,040	161,7	3.21
2040	5,136	104,8	2.04
2045	4,286	105,8	2.47
2050	5,186	44,7	0.48

Acknowledgements

This work has received funding from the European Union's HORIZON EUROPE Research and Innovation Programme (Grant agreement No. 101056306, IAM COMPACT project). The content of this paper does not necessarily reflect the opinions of the European Commission and the responsibility for it lies solely with its authors.

References

[1] V. Stavrakas, A. Flamos, A modular high-resolution demand-side management model to quantify benefits of demand-flexibility in the residential sector, Energy Convers. Manag. 205 (2020) 112339. https://doi.org/10.1016/j.enconman.2019.112339.

[2] M. Howells, H. Rogner, N. Strachan, C. Heaps, H. Huntington, S. Kypreos, A. Hughes, S. Silveira, J. DeCarolis, M. Bazillian, A. Roehrl, OSeMOSYS: The Open Source Energy Modeling System. An introduction to its ethos, structure and development., Energy Policy. 39 (2011) 5850–5870. https://doi.org/10.1016/j.enpol.2011.06.033.