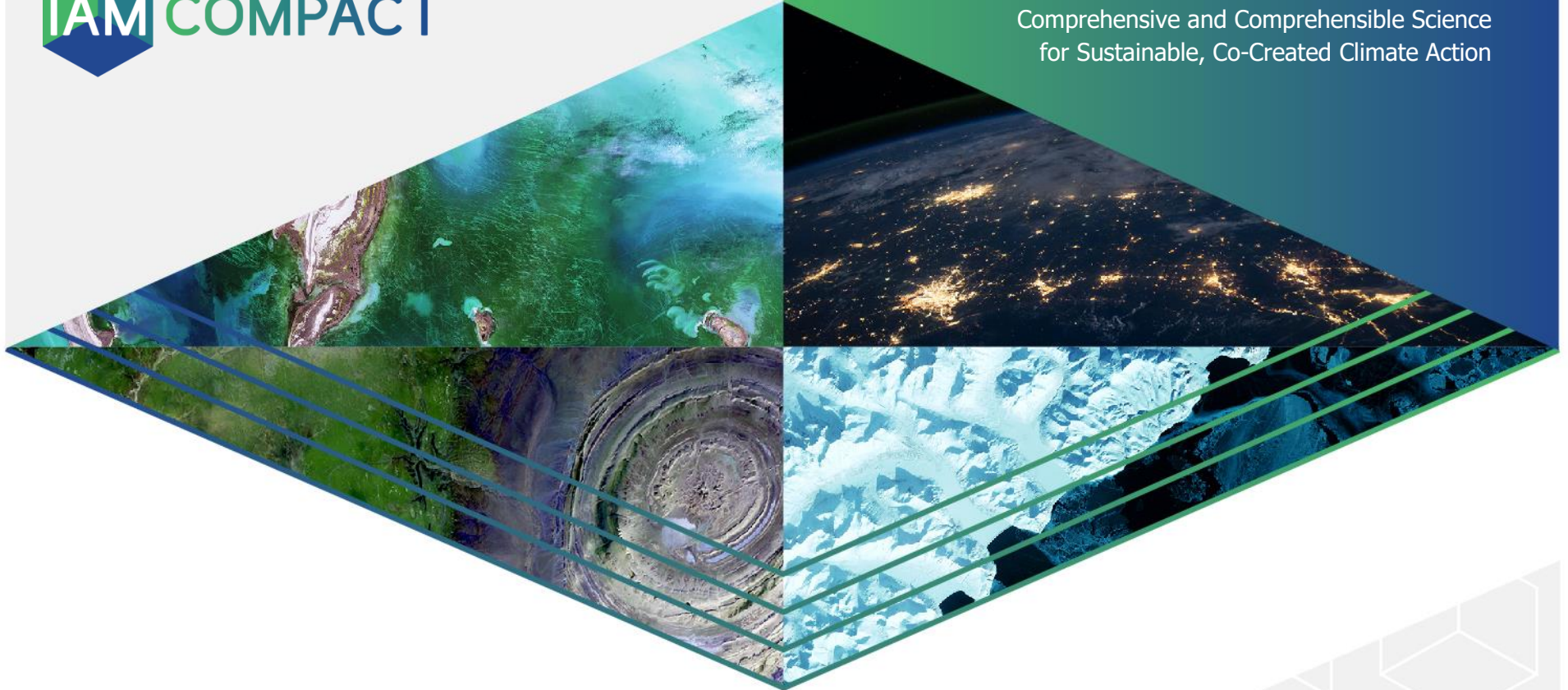




Expanding Integrated Assessment Modelling:  
Comprehensive and Comprehensible Science  
for Sustainable, Co-Created Climate Action



## 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

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Technoeconomics of Energy Systems laboratory (TEESlab), University of Piraeus Research Centre (UPRC)



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~\$895 billion



## Recovery and Resilience Facility (RRF)

- **Recovery packages:** ~\$395 billion grants and ~\$325 billion loans to support reforms and investments in the EU Member States
- February **2020** - December **2026**
- **National recovery and resilience plans** (NRRPs) submitted to the European Commission

Largest recovery project in Europe since the **Marshall Plan** in 1948!



Can the **recovery packages** provided by the **RRF** be used as **opportunities** to foster **low-carbon energy transitions** in different EU Member States?



**Issue of high concern for policymakers from national governments and the European Commission.**

**"NextGenerationEU" Recovery Packages**





~\$20 billion grants and ~\$14 billion loans from **RRF** budget



## Green Transition Pillar (~\$7 billion grants)

- **"Power up"** component: ~\$1.3 billion grants in support of the energy transition in the power sector.
- **"Renovate"** component: ~\$3 billion grants in support of the energy transition in the building sector → National renovation target (~60,000 renovations/year).

> **60%** of the total **green recovery funding** allocated to the **power** and the **building** sectors!

To support the implementation of ...



... the Greek **National Energy and Climate Plan (NECP)**



**97.5%** greenhouse gas (GHG) emissions reduction by **2050** compared to **1990**





Most **ambitious short-term** targets in the **power** and **building** sectors

- **67.4% renewable energy sources (RES)** in **buildings** by **2030**
- **76.8% RES** in **total electricity generation** by **2030**



**Modelling work** for the impacts of the announced **green recovery packages**  
in terms of future **economic** and **emission-related** developments!



**Research Question** part of  
the Horizon Europe project:



“Is RRF’s funding enough to drive a green transition in the  
**Greek residential** and **power sectors**, and what are the  
respective **short-** and **long-term impacts?**”



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### Why these tools?

Open-source, well documented, transparency, replicability, scalability, fast learning curve, high resolution, modularity



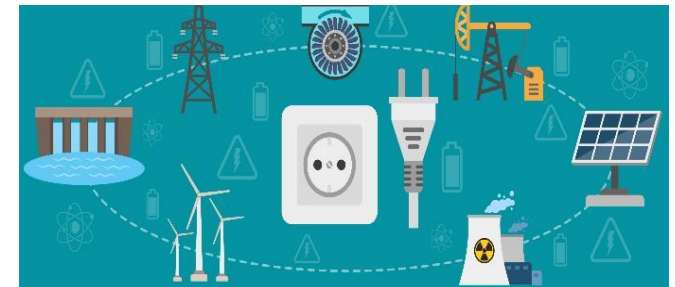
#### Energy demand & demand-side management model (bottom-up simulation)



Building sector

&

#### Capacity expansion model (bottom-up cost optimisation)



Power sector

For impact assessment of NRRP's green recovery measures in the **residential** and **power** sector transition pathways!







Building sector

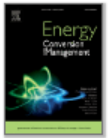
Energy demand simulation model

Benefits & limitations of demand-flexibility primarily for consumers & other power actors involved



Energy Conversion and Management

Volume 205, 1 February 2020, 112339



A modular high-resolution demand-side management model to quantify benefits of demand-flexibility in the residential sector

Vassilis Stavrakas, Alexandros Flamos

Currently applied and further developed in multiple EC-funded H2020, HE, and LIFE projects

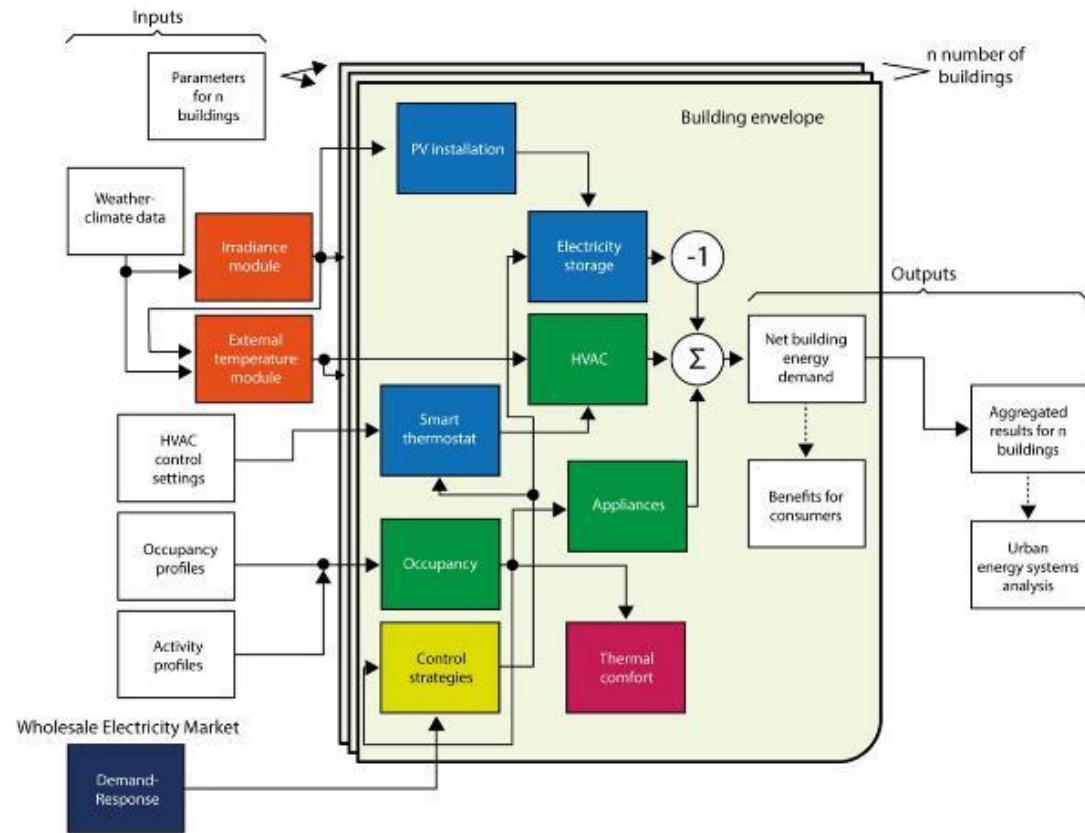


LOCAL AUTHORITIES TACKLING ENERGY POVERTY IN PRIVATE MULTI-APARTMENT BUILDINGS



Main principles of component- & modular-based system modelling approach

- ❖ **Interdependence of decisions within** modules
- ❖ **Independence of decisions between** modules
- ❖ **Hierarchical dependence of modules on components** embodying standards & design rules

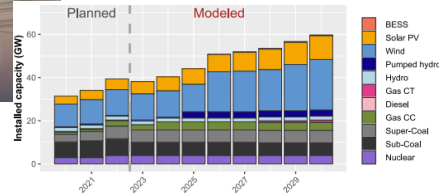
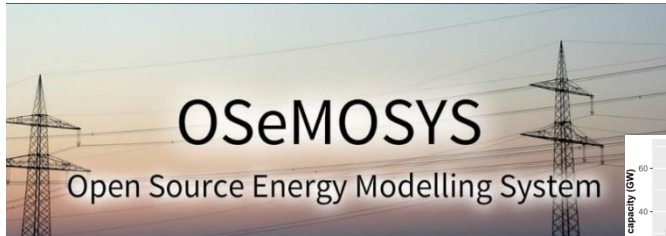


**Modular structure**



Funded by the European Union

## Capacity Expansion Model (CEM)



Delivery of long-term decarbonisation pathways



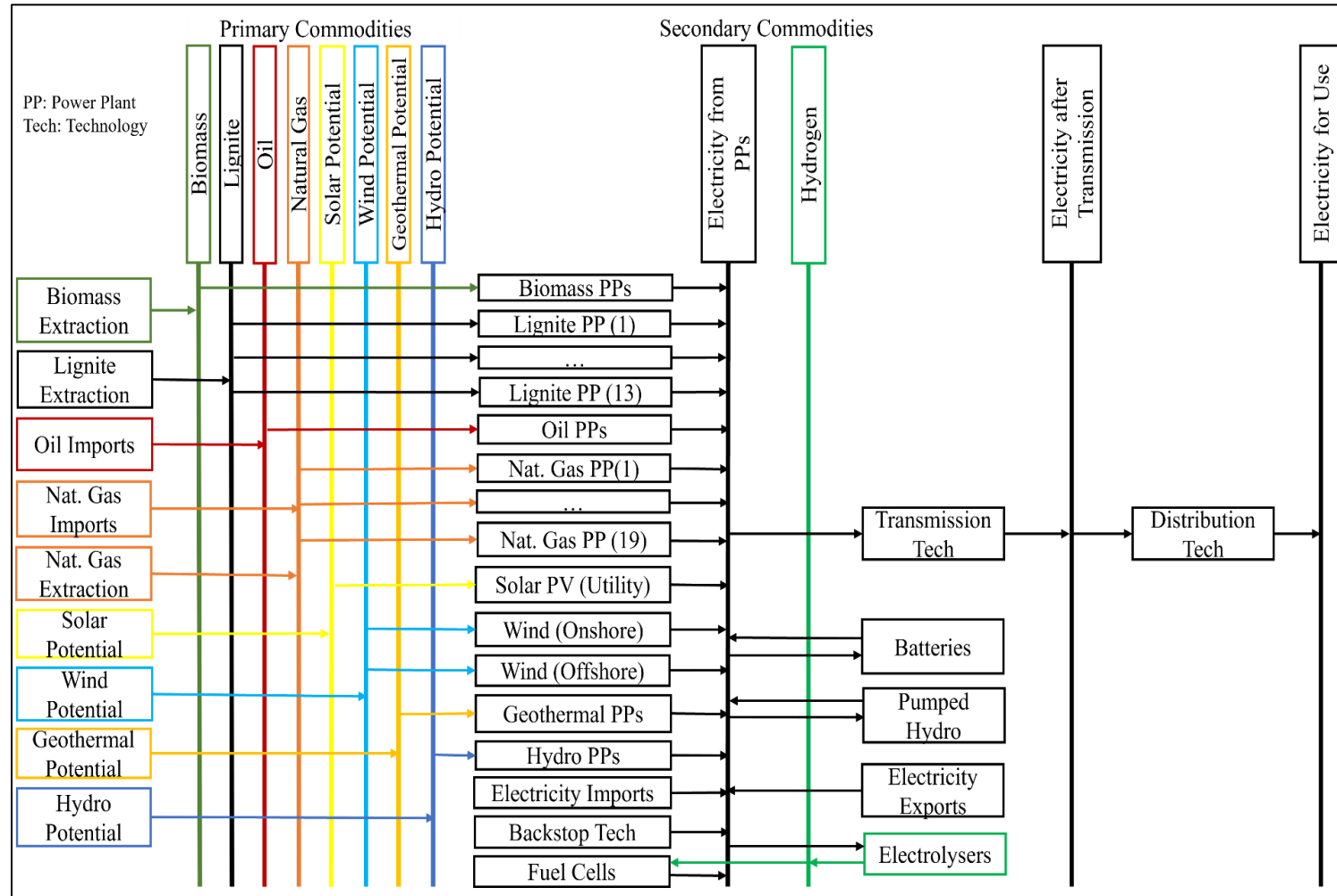
*Satisfaction of specific **emission** and **RES** targets*

*Identification of **capacity requirements** to achieve emission and RES targets*

*Assessment of potential **costs** of different technology configurations*

## Reference Power System

- **Fossil-fired power plants:** lignite, natural gas, and oil.
- **RES:** hydro, wind onshore & offshore, solar PV, biomass & geothermal.
- **Energy storage:** battery & pumped hydro.
- **Hydrogen production & consumption:** electrolysers & fuel cells.
- **Interconnections** with neighbouring countries.
- **Transmission & distribution losses.**



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## Measures modelled in the “Renovate” component

Measure	Short description	Budget allocated (\$ million)
Energy renovation on residential buildings (“Saving at home”)	Energy efficiency interventions & upgrade of heating systems to enhance the uptake of energy efficiency and RES investments in the residential sector, with the aim of saving energy by at least 30%.	1,199
Energy and entrepreneurship	Enhance the uptake of actions to improve the energy efficiency of SMEs with the aim of saving at least 30%.	500
Energy upgrade of public buildings	Renovations of public infrastructure & buildings, energy upgrade of public lighting.	222

Contribute to the **15%** of the **NECP’s target** by **2030** (**60,000 renovations/year**)

~ **\$1.2 Billion** for a green transition in the residential sector!



Assessing the impacts of the NRRP’s green recovery funding!

## Measures modelled in the “Power up” component

Type of measure	Measure	Technology	Budget allocated (\$ million)	Total capacity
Investment	Support of the installation of storage systems.	Batteries/ pumped hydro	500	1.38 GW
Reform	Enhancement of the “RES-CHP Account’s” revenues.	Wind onshore/ solar PV	New investments will be triggered by facilitating new RES projects financing.	3 GW
Reform	Simplification of licensing procedure for RES.			

RES & storage capacities modelled exogenously



**OSeMOSYS-GR**

Linear Optimization Energy Planning Model



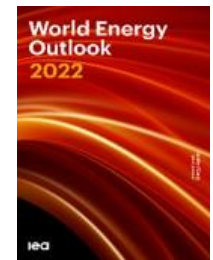
Assessing the impacts of the NRRP’s green recovery funding!



- Electricity demand, NG price, and ETS CO<sub>2</sub> emission allowance **prices**.
- **Data** concerning the **fossil-fired power plants**, such as capacities, minimum stable generation, efficiencies, minimum uptimes/ downtimes, their availabilities considering planned commissioning and de-commissioning of generating capacity.
- **Technological data**, e.g., capital costs, fixed and variable O&M costs, efficiencies, capacity factors.
- **Residual capacities** of existing electricity generation technologies.
- **Import capacity** from interconnections.



*EU Reference Scenario 2020*



*World Energy Outlook 2022*



*10-year development plan of the Greek **I**ndependent **P**ower **T**ransmission **O**perator*





## ➤ "Scenario 1":

- National renovation target → **60,000 renovations/year (1.5%)**.
- Natural gas as a **transition fuel**.

## ➤ "Scenario 2":

- Decarbonisation by **2050**.
- National renovation target → **100,000 renovations/year (2.5%)**.

## ➤ "Scenario 3":

- Decarbonisation by **2040**.
- National renovation target → **145,000 renovations/year (3.5%)**.

### 2 transition pathways

- a. Natural gas up to 20230
- b. Electrification (heat pumps)



## □ “No NRRP” scenario

- Follows the guidelines of the NECP:
  - **Phaseout of lignite by 2028.**
  - **Carbon neutrality** in the power sector should be achieved **by 2040** (prerequisite is the **phaseout of natural gas before 2040**).
- Does not include any recovery measure.

## □ “NRRP 2023” scenario

- the NECP’s guidelines of the “**No NRRP**” scenario.
- the “**Power up**” component’s measures for RES and storage capacity expansion.



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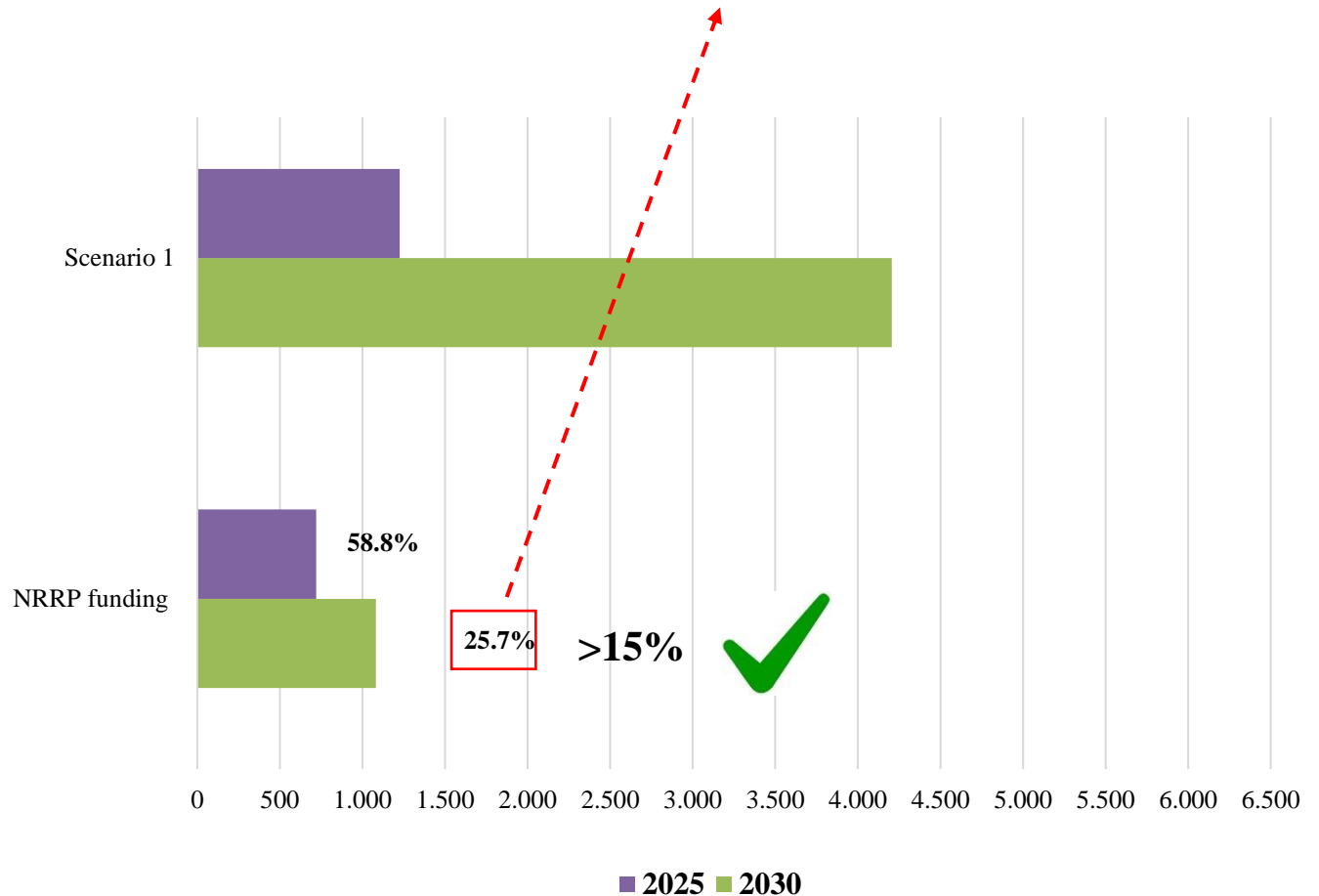
The NRRP achieves its target of contributing to the 15% of the national renovation target (**60,000** renovations/year).



However, the current renovation rate as envisioned by the NECP **does not lead to decarbonisation** in the residential sector.



Total renovation costs (€ million)

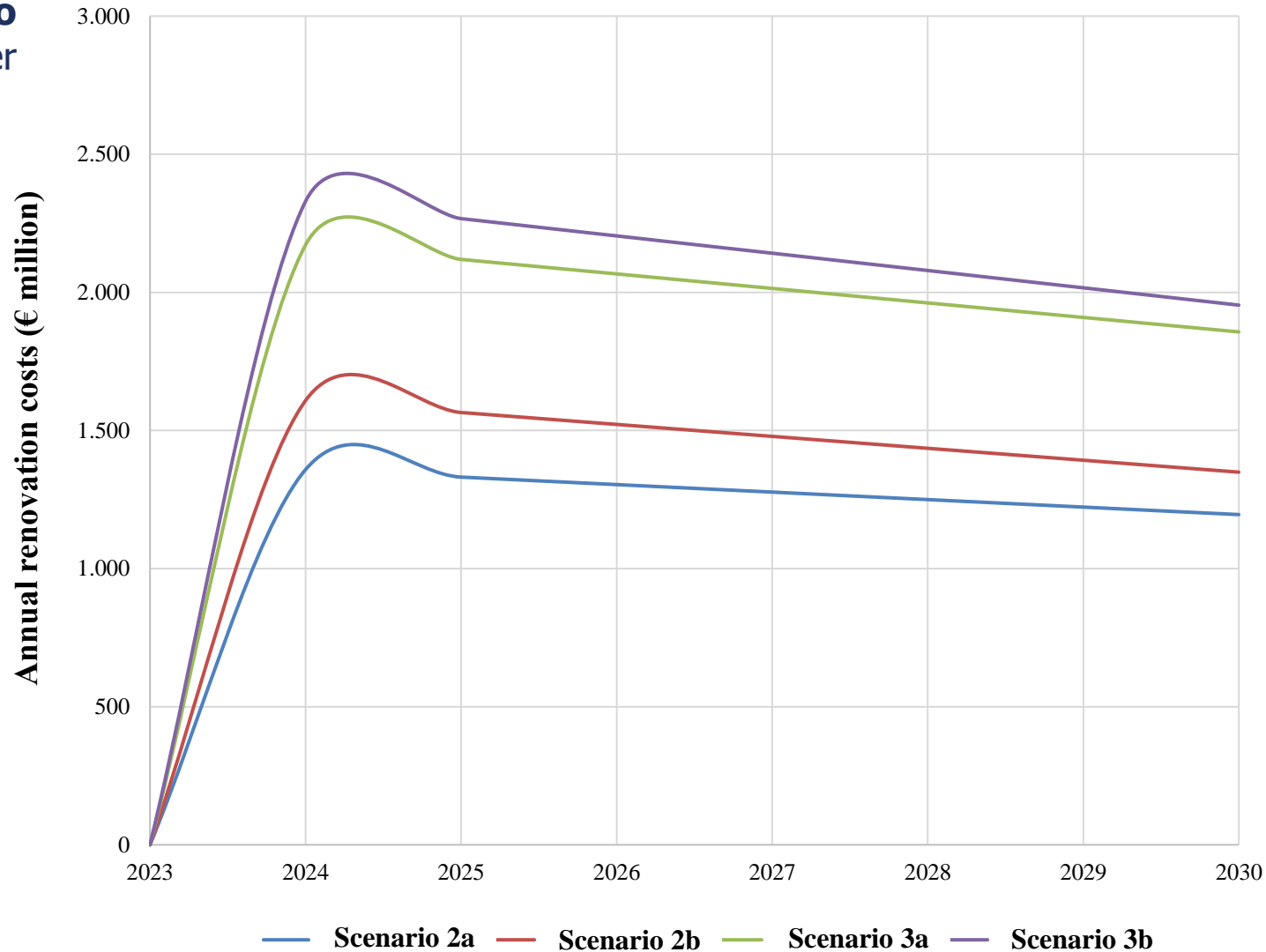
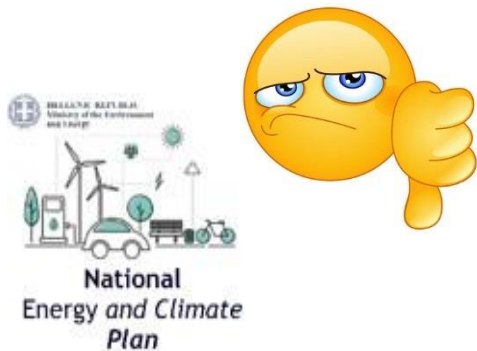


## However...

When it comes to decarbonisation by either 2050, or 2040...



...the NRRP's funding **does not sufficiently** support the renovation rates **required**.





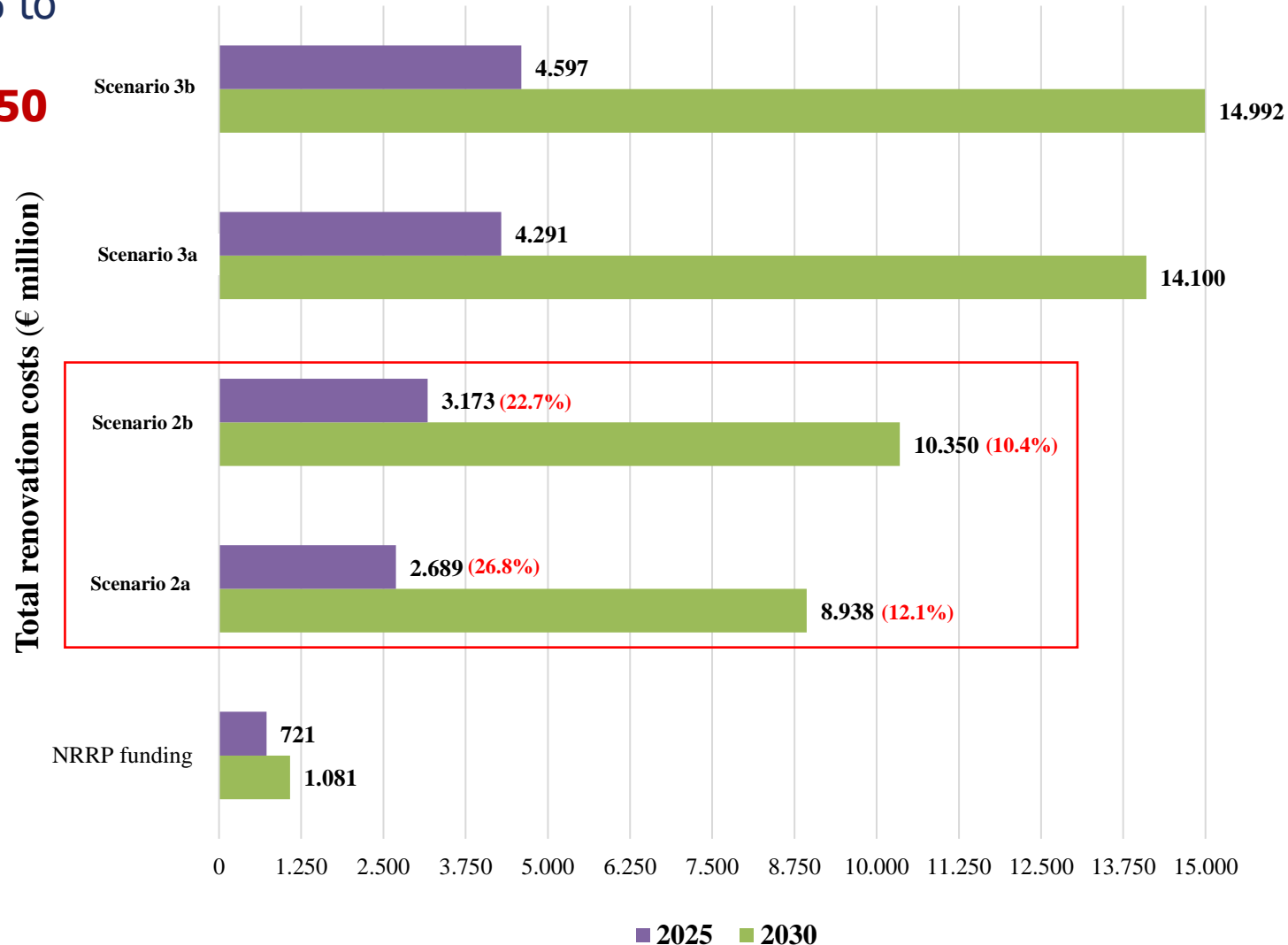
**NRRP's funding** would need to **increase by >19%** to sufficiently support **decarbonisation by 2050**

~\$0.2 billion

- **19%** if the focus is on investing in **natural gas** as a **transition fuel**

~\$0.4 billion

- **30%** if the focus is on **electrification** and diffusion of **heat pumps**





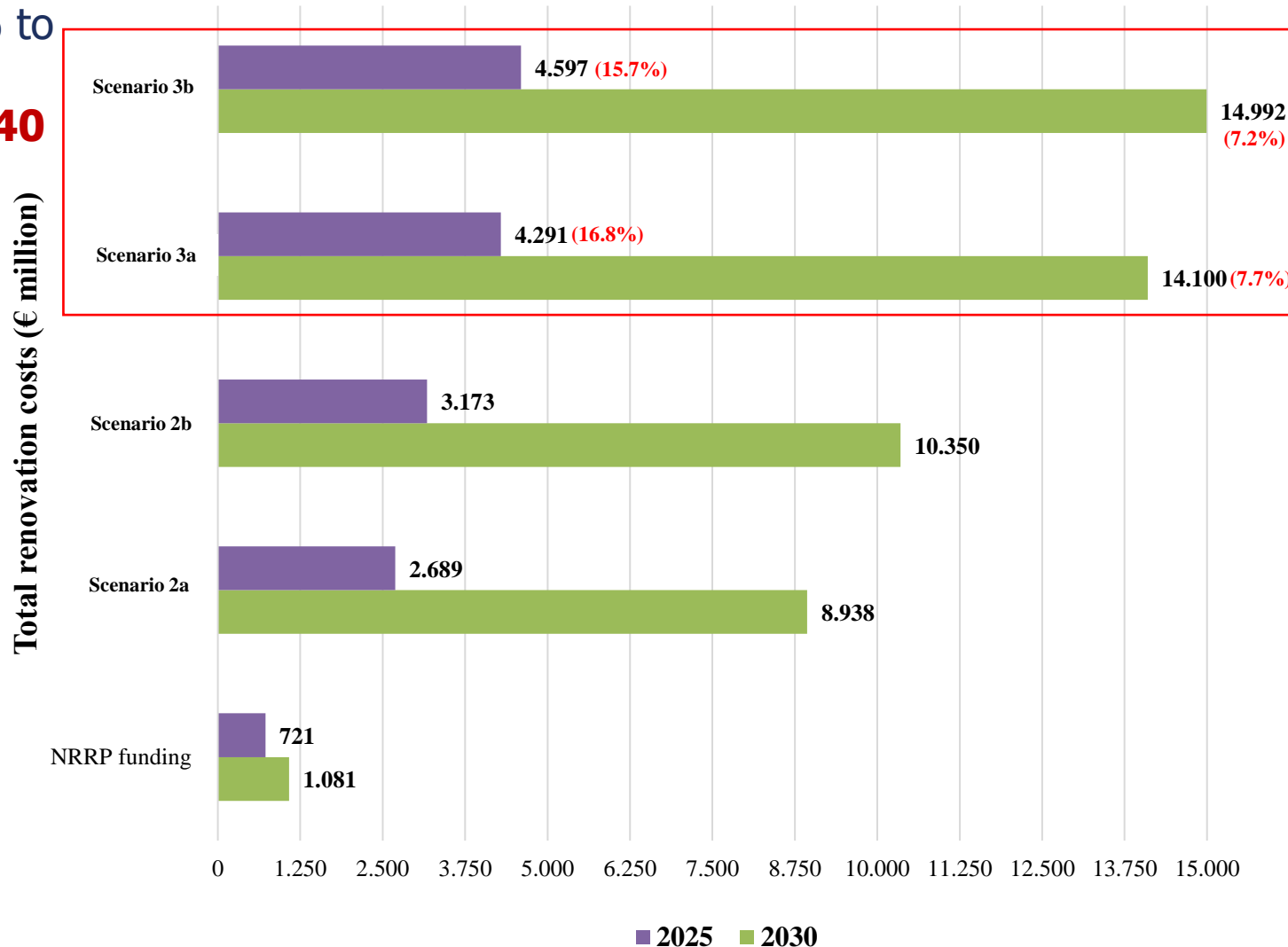
**NRRP's funding** would need to **increase by >49%** to sufficiently support decarbonisation by **2040**

~\$0.6 billion

- **49%** if the focus is on investing in **natural gas** as a **transition fuel**

~\$0.6 billion

- **52%** if the focus is on **electrification** and diffusion of **heat pumps**



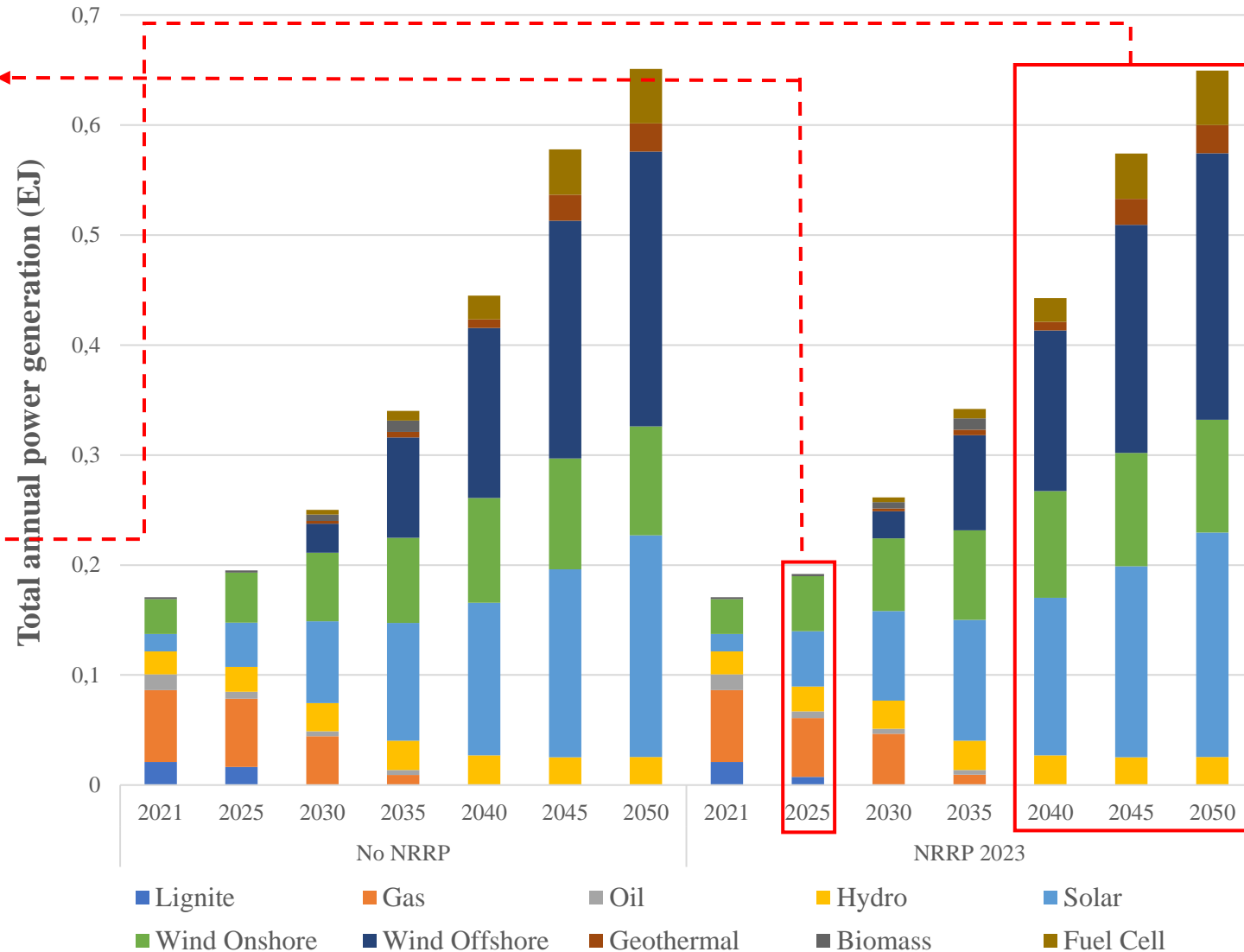
# Evaluating the effectiveness of the National Recovery and Resilience Plan in boosting renewable energy and storage capacity expansion in the power sector (1/4)



By **2025**, “**NRRP 2023**” achieves radical reduction in electricity from **lignite** (**54.5%**) compared to “**No NRRP**”.



However, after **2030**, the recovery measures’ **impacts** are **negligible**.





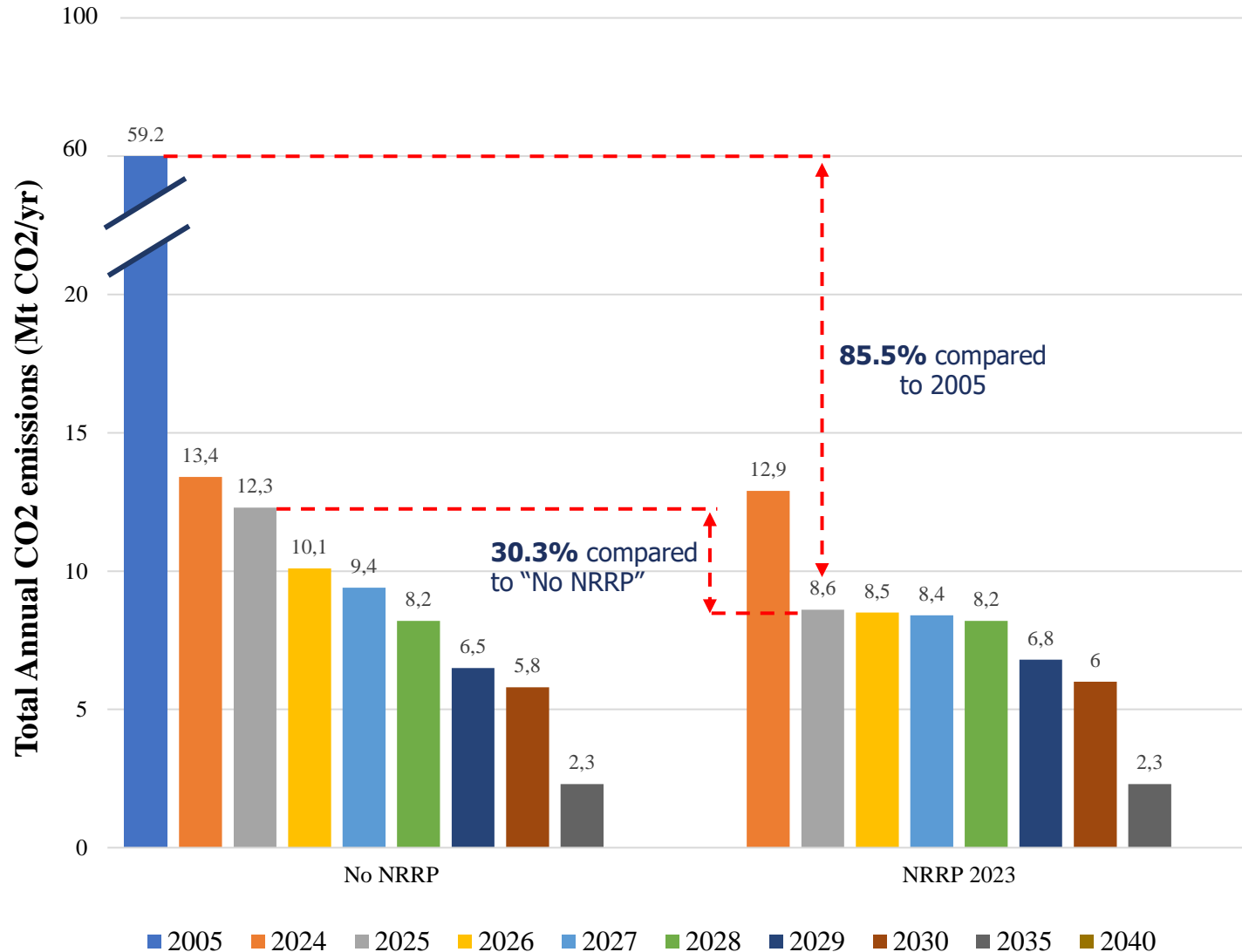
**"NRRP 2023"** scenario achieves...



... **30.3%** fewer CO<sub>2</sub> emissions in **2025** compared to the **"No NRRP"** scenario.



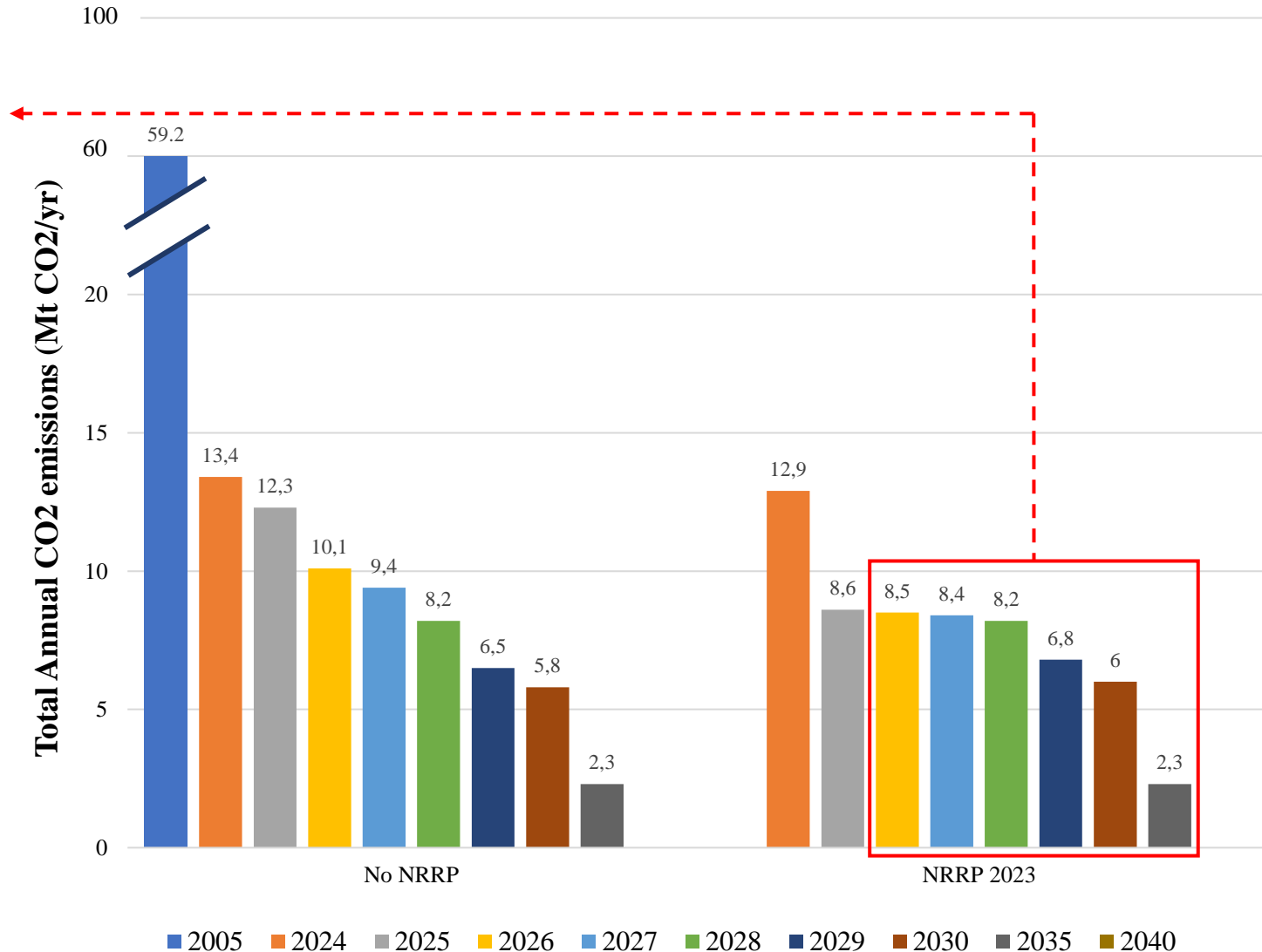
This is translated into **85.5% CO<sub>2</sub> emission reduction** compared to the CO<sub>2</sub> emission levels of **2005**.



After 2025, the recovery measures do not continue with the same intensity, ...



... and thus, **additional funding** is needed to maintain the improved short-term decarbonisation trend.



The proposed investments and reforms of the NRRP considered in “**NRRP 2023**” will lead to monetary savings of national funds amounting to...

... **\$3.7 billion** by **2030** and **\$5.3 billion** by **2050** compared to “**No NRRP**”.

The cost savings due to the recovery measures as % of the cumulative total costs are larger in the short term!

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# We see that NRRP's recovery measures in Greece...

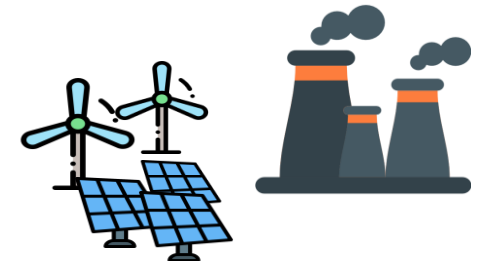
## Residential sector:

- ❑ **Can** finance the 15% of renovations required by 2030
- No decarbonisation by 2050 though!*



## Power sector:

- ❑ **Can** significantly accelerate the lignite phaseout,
- ❑ **Can** achieve significant levels of CO<sub>2</sub> emission reduction in the short term,
- ❑ **Cannot** result in significant long-term economic and emission-related impacts.



## We see that NRRP’s recovery measures in Greece...

...result in similar short-term contributions as % of the total investments to the most ambitious transition pathways (i.e., **decarbonisation by 2040**) of both sectors.

Sector	Total capital investments by 2030 (\$ billion)	Cumulative Cost Savings due to NRRP’s funding (%)
Residential	~ 4.7 - 16.7	~ 25.7 - 7.2
Power	~22.4	~8

By increasing the level of ambition (i.e., decarbonisation by 2050 or even **by 2040**), the contribution of NRRP’s recovery measures decreases, requiring additional funding measures to sufficiently support the achievement of the national and sectoral targets

We encourage...

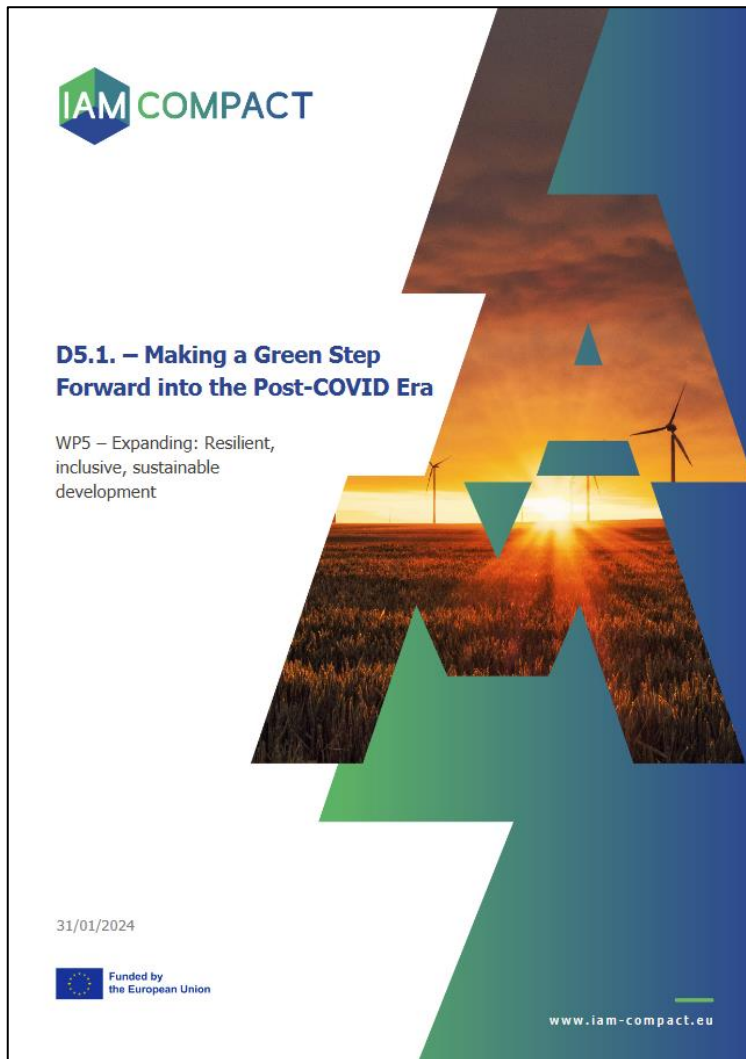


...the **replication** of our work



the application of similar models to other geographical and socioeconomic contexts of interest, **across**, and **beyond** the national level (e.g., European Union, global).





More details about this study are available in:

Fragkos, et al. (2024). IAM COMPACT D5.1 Impact assessment of COVID 19 recovery. Zenodo.  
<https://doi.org/10.5281/zenodo.13839291>

→ **Chapter 4: Deep dive into the National Recovery and Resilience Plan of Greece**

More details about IAM COMPACT:



<https://www.linkedin.com/company/iam-compact/posts/?feedView=all>



<https://www.iam-compact.eu/>



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Thank you!

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