IAM COMPACT

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

Towards a decarbonised built environment in Greece

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Introduction & Problem statement (1/3)

The Greek **residential sector** accounts for **24%** of the total final energy consumption

71% of the residential sector's final energy consumption is attributed to **heating** and **cooling**

Need for decarbonisation of the residential sector

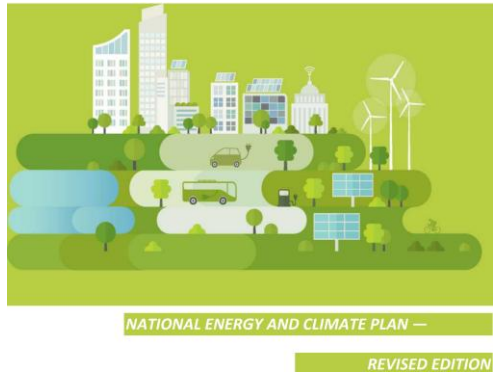
Electrification of the **heating sector** (e.g., **heat pumps**) and **energy efficiency** offer the opportunity to reduce energy consumption and carbon emissions

Replacing a gas boiler with an electric heat pump in a typical Greek household reduces carbon emissions by almost **47%**

The IAM COMPACT project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No 101056306.

National planning for the energy transition in the residential sector:

- The **2024 National Energy and Climate Plan (NECP)** sets clear targets for the reduction of **primary energy consumption** in line with the **Energy Performance of Buildings Directive (EPBD)**:
  - **16%** decrease by **2030** compared to **2020**
  - **20-22%** decrease by **2035** compared to **2020**



- Around **1,880,000 building envelope renovations** by 2050
- **Phaseout** of **oil** and **gas boilers** & significant increase of **heat pump installations**

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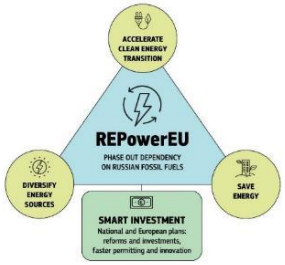
Further **modelling** of NECP-2024 targets is needed to:

- Quantify evolving **CO_2 footprint**
- Assess **economic benefits** of the residential energy transition
- Provide **actionable insights** for policymakers



Why it matters:

- Provides the **pathways** to meet national **decarbonisation goals**
- Ensures alignment with **broader EU objectives**

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Model application (1/2)

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DREEM
Dynamic High-Resolution Demand-Side Management Model

Building sector

Energy demand simulation model

Benefits & **limitations** of demand flexibility, mainly for **consumers** & **other power actors** involved

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ELSEVIER
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

ELSEVIER
Energy Conversion and Management
Volume 324, 15 January 2025, 119235

Research Paper

Towards decarbonisation or lock-in to natural gas? A bottom-up modelling analysis of the energy transition ambiguity in the residential sector by 2050

Dimitris Papantonis, Vassilis Stavrakas, Dimitra Tzani, Alexandros Flamos

ELSEVIER
Energy
Volume 326, 1 July 2025, 136314

Expanding natural gas infrastructure in Greece: Good practice or missed opportunity of a green and inclusive transition?

Dimitris Papantonis [a], Vassilis Stavrakas [a], Vlasios Oikonomou [b], Alexandros Flamos [a]

Model application (2/2)

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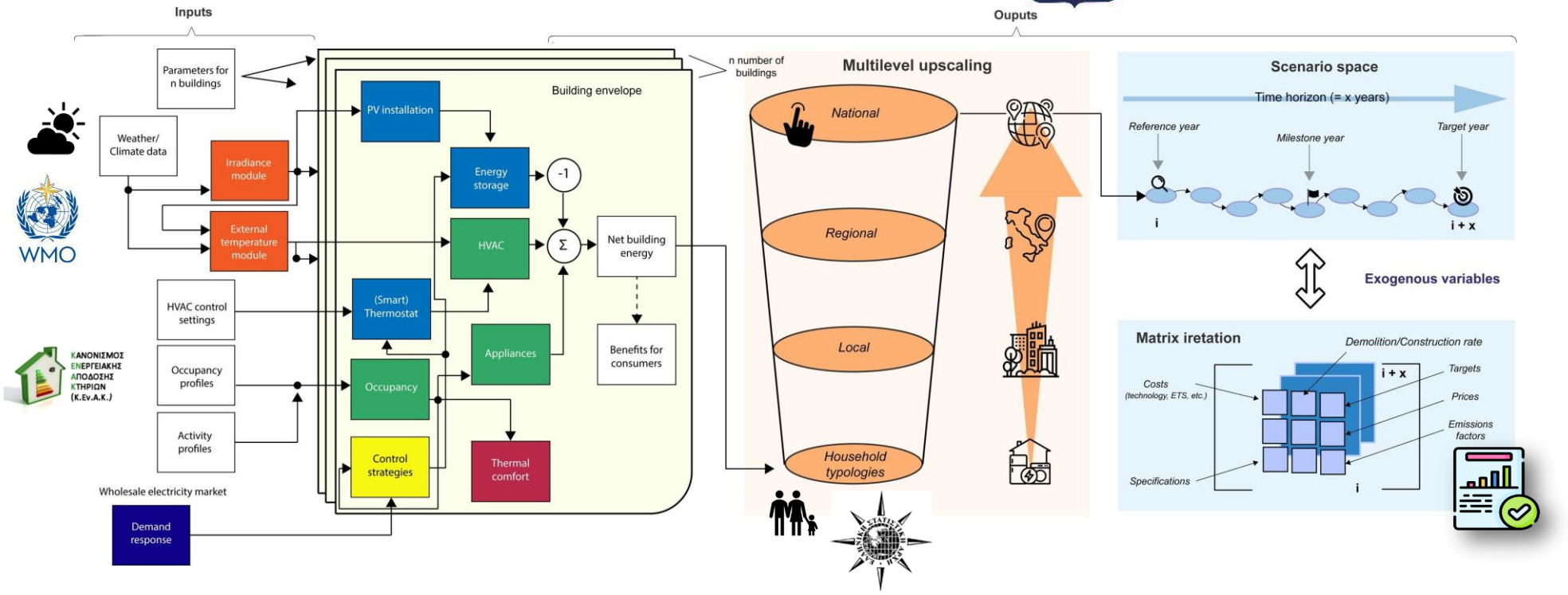
Bottom-up approach using a modular structure

DREEM
Dynamic High-Resolution Demand-Side Management Model



Indicative parameters

- Weather & Climate data
- Building characteristics
- Heating and cooling systems
- Demographic characteristics
- Exogenous variables (cost developments, emission factors)

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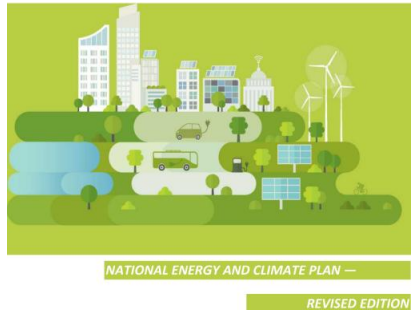
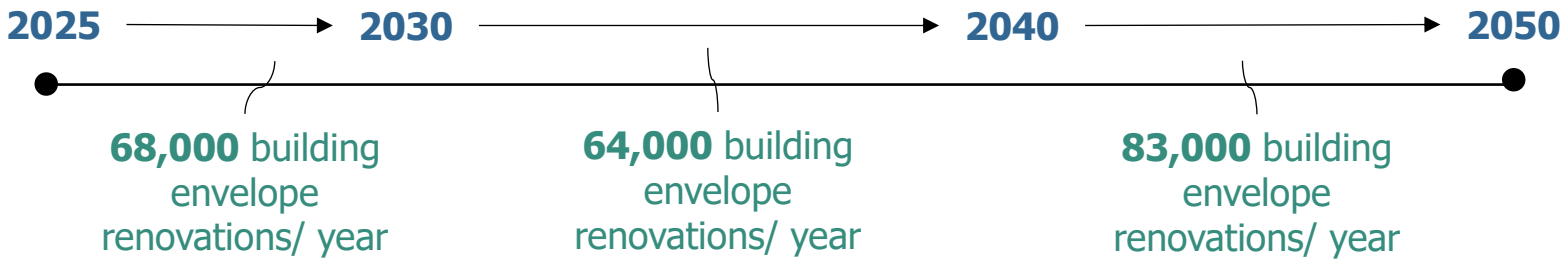
Application to the Greek residential sector:



The model was parameterised using:

1. Energy consumption trends and renovation **targets** from the **NECP-2024**

2. Data on **heat pump adoption** from consultation with the **Ministry of Environment & Energy**



DREEM
Dynamic High-Resolution Demand-Side Management Model

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Cost parameters

Prices of energy commodities (€/MWh)

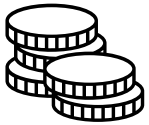
	2030	2040	2050
Oil (Diesel heating oil)	111	118	143
Electricity	139	117	95
Natural gas	38	38	38
Biomass	63	56	53

Source: NECP-2024

Technology intervention costs (€/intervention)

	2030	2050
Natural Gas boiler	2,752	2,472
Heat Pump	7,736	3,848
Biomass boiler	14,850	11,708
Envelope and windows upgrade	13,912	13,912

Source: EU Reference Scenario 2020



Residential sector's ETS price evolution (€/tn)

2030	2035	2040	2045	2050
60	140	290	430	490

Source: Consultation with the Ministry of Environment & Energy

All costs in the analysis have been discounted!

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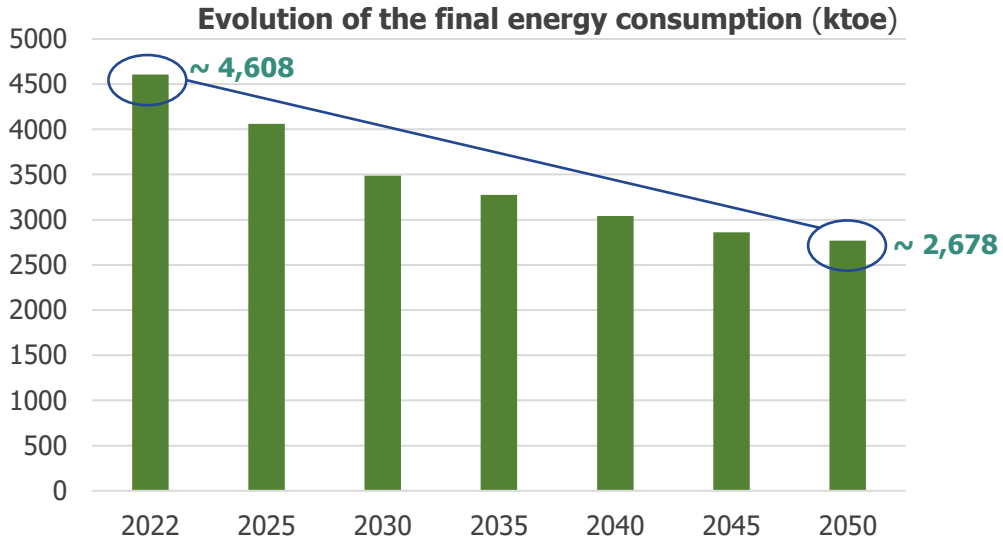
Final energy consumption and energy mix

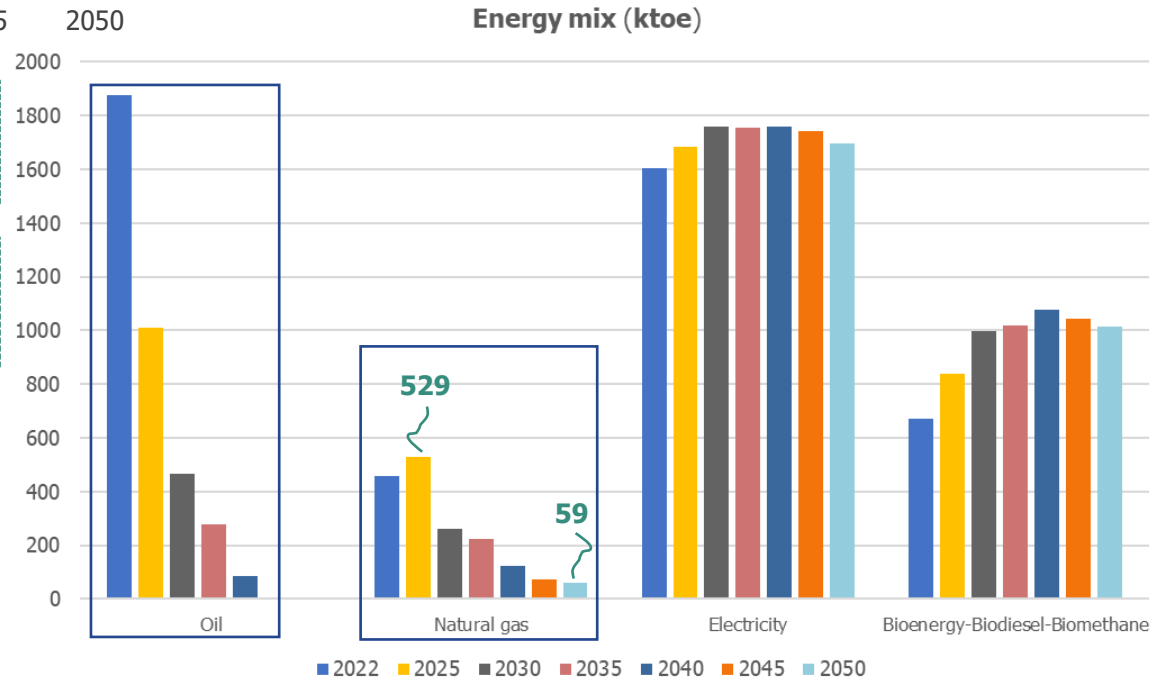


~42% reduction in final energy consumption by **2050** compared to **2022**

✓ Complete phaseout of oil from the energy mix before **2045**

✓ **~89%** reduction in natural gas consumption from **2025** to **2050**

Natural gas accounts for **~2%** of the total final energy consumption in **2050**



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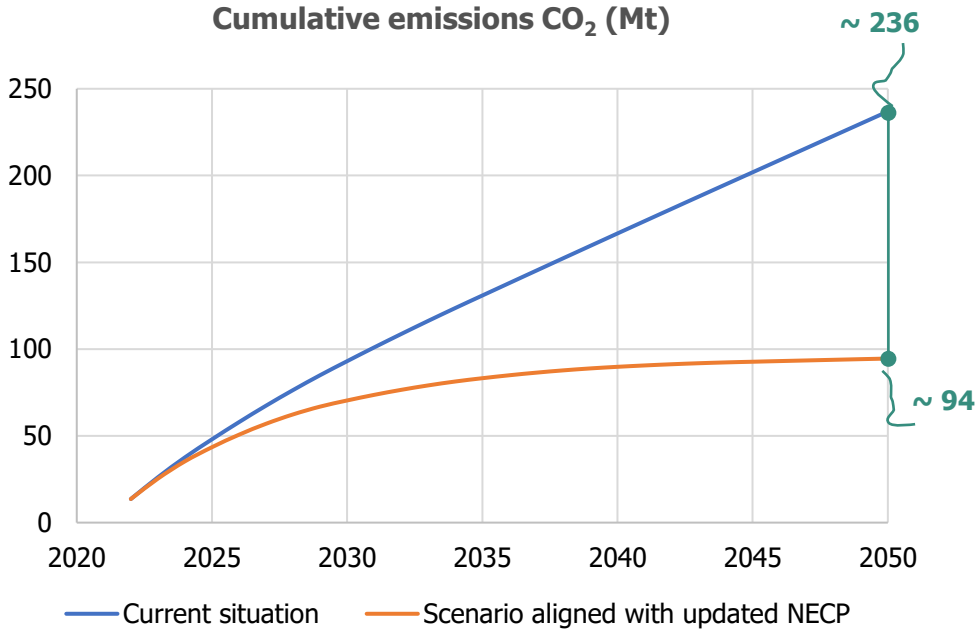
Environmental footprint

CO_2 emissions (Mt)				
2030	**2035**	**2040**	**2045**	**2050**
3.55	1.90	0.92	0.39	0.35

~ **90.1%** reduction of total CO_2 emissions during 2030-2050

~ **142 Mt** CO_2 emissions avoided due to the interventions



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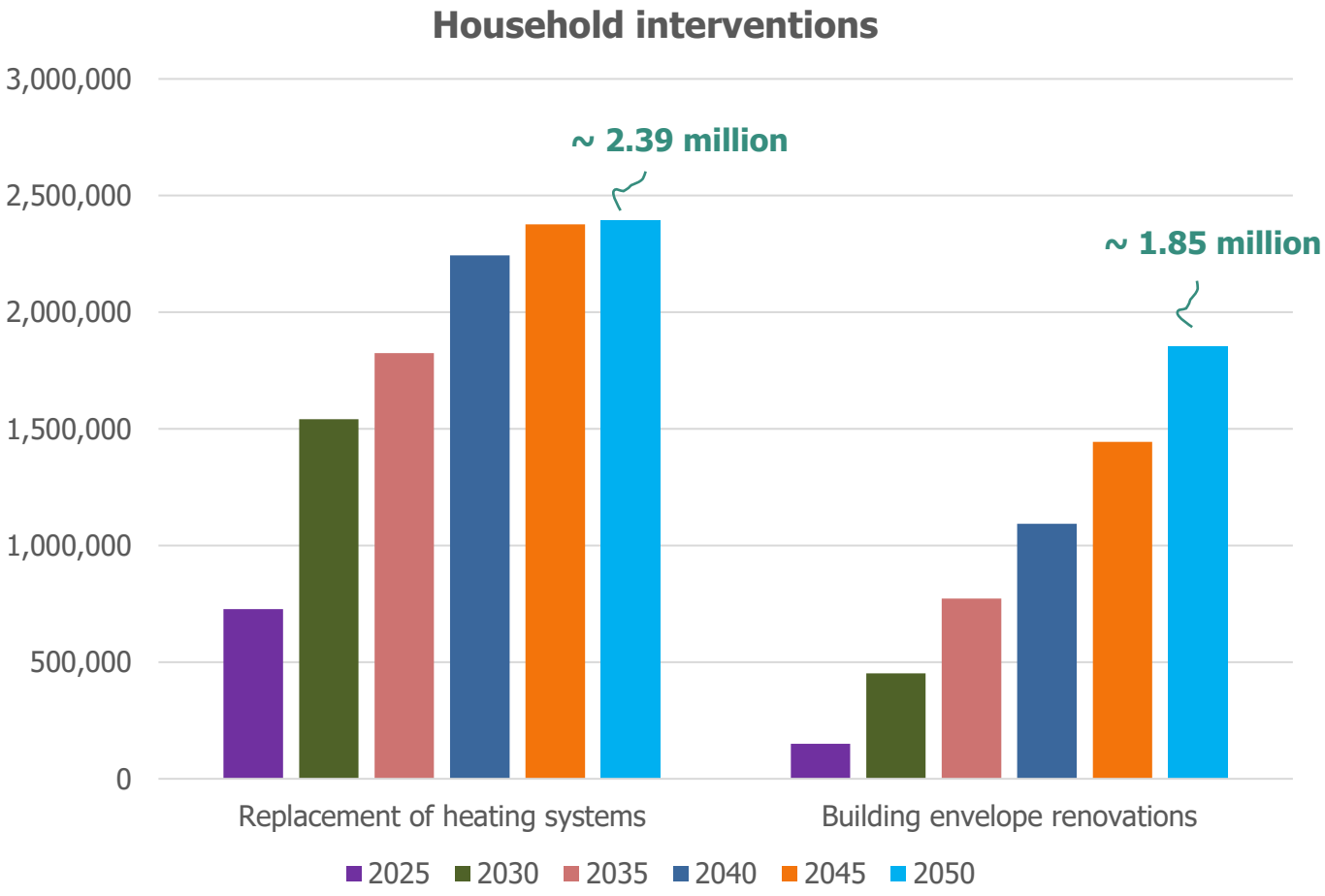
Required interventions



Heating systems are replaced in **55%** of Greek households

Building envelope renovations are foreseen in **43%** of Greek households

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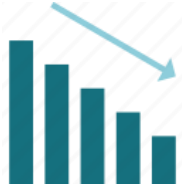
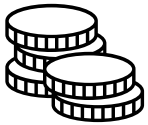
Discounted fuel & electricity costs

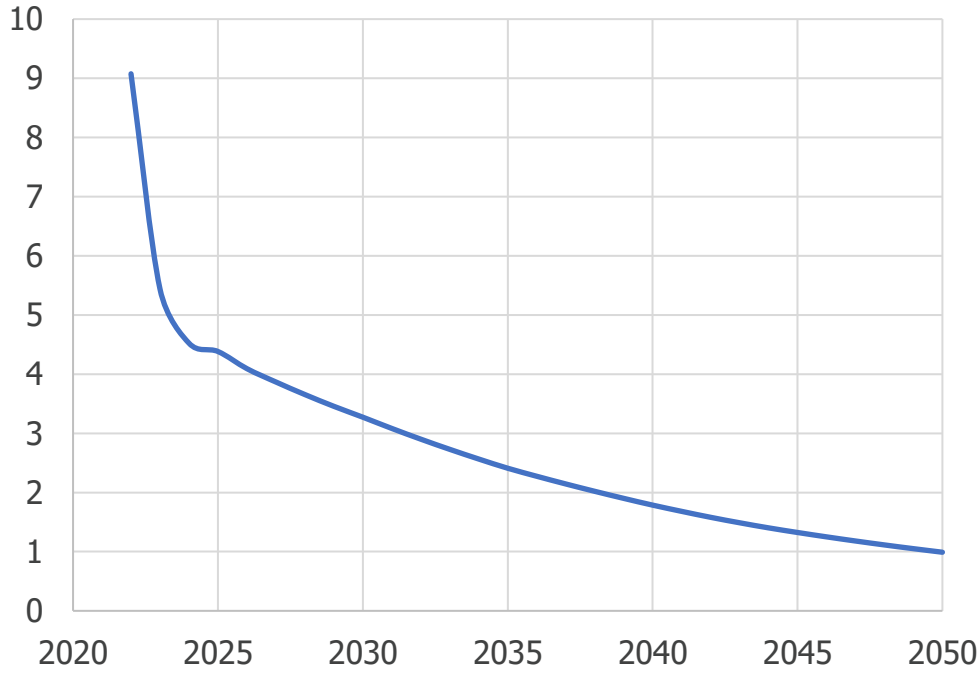
2022	2025	2030	2035	2040	2045	2050
9.1 B.	4.4 B.	3.3 B.	2.4 B.	1.8 B.	1.3 B.	1 B.





Discounted annual fuel costs are significantly reduced in 2050 due to the **elimination of oil** from the energy mix, **declining electricity prices**, and **reduced energy consumption**

Discounted annual fuel & electricity costs (billion €)



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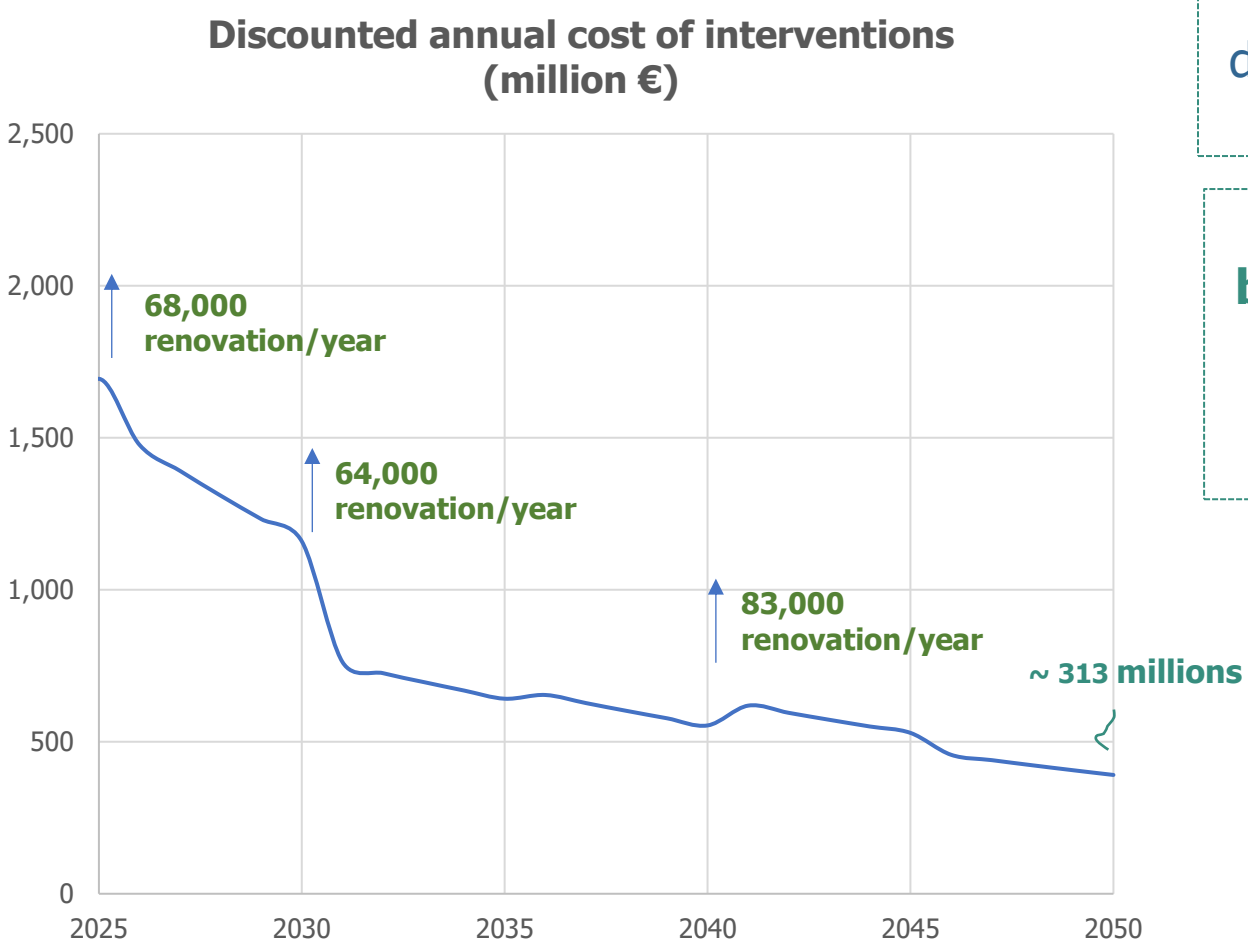
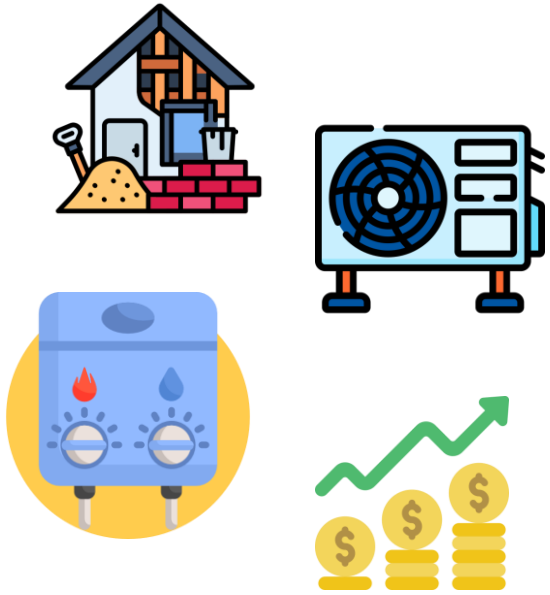
Discounted intervention costs



The total cost of interventions during 2025-2050 is estimated at **~ 20 billions**.

More than one third (**~7 billions**) will be required **during 2025-2030**. More than half (**~11 billions**) will be required **during 2025-2035**.



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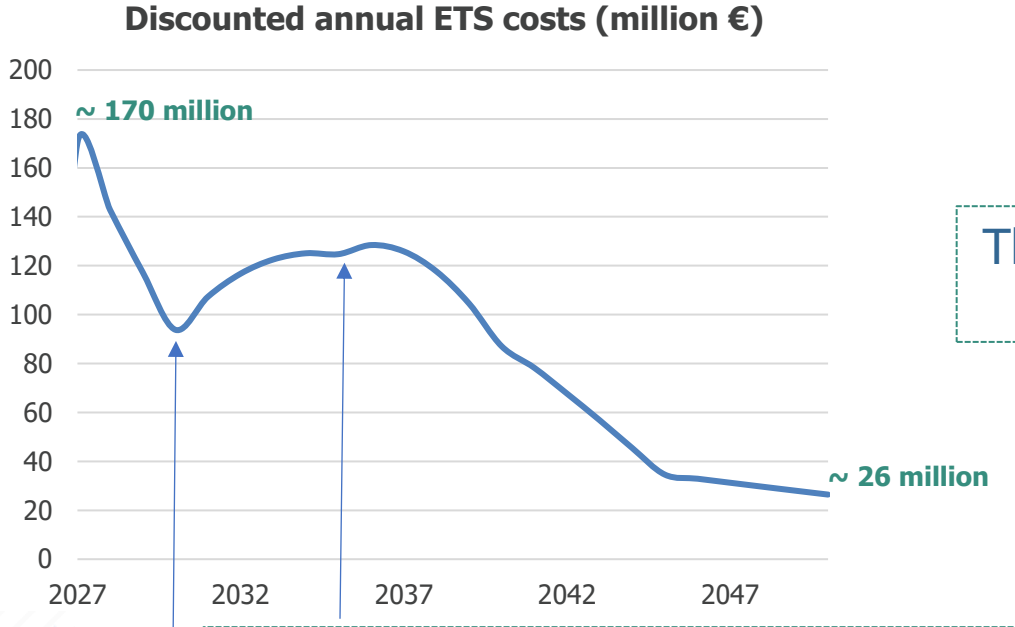
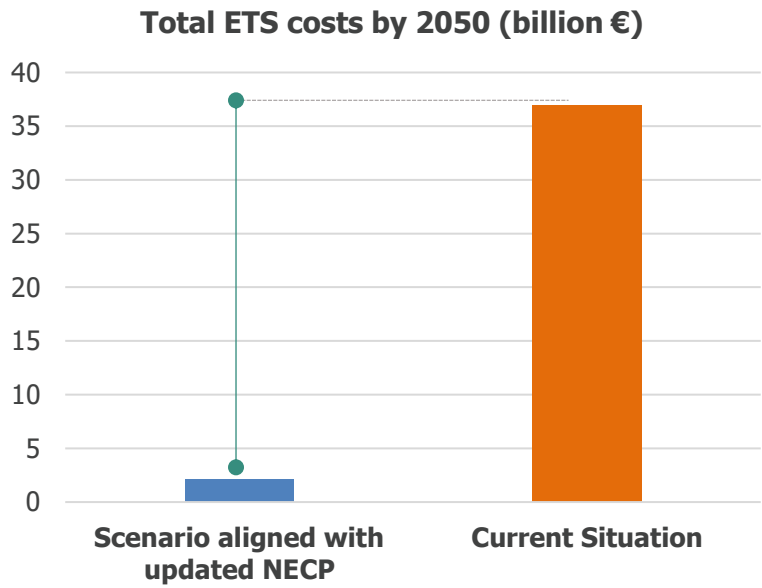
Discounted ETS costs

The NECP aligned scenario leads to ETS-related cost savings of **~ 35 million**



Increase due to the abrupt rise of ETS prices during **2030-2040**

Decrease due to the initially **lower ETS prices** and the fossil-fuel boiler phaseouts.



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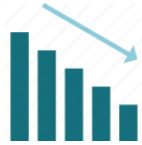
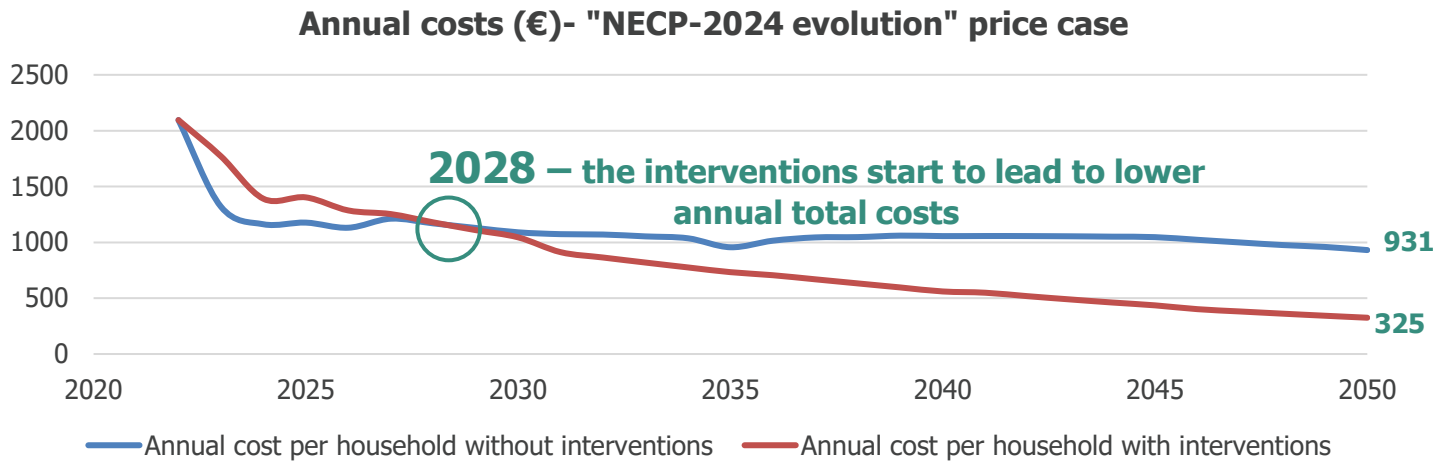
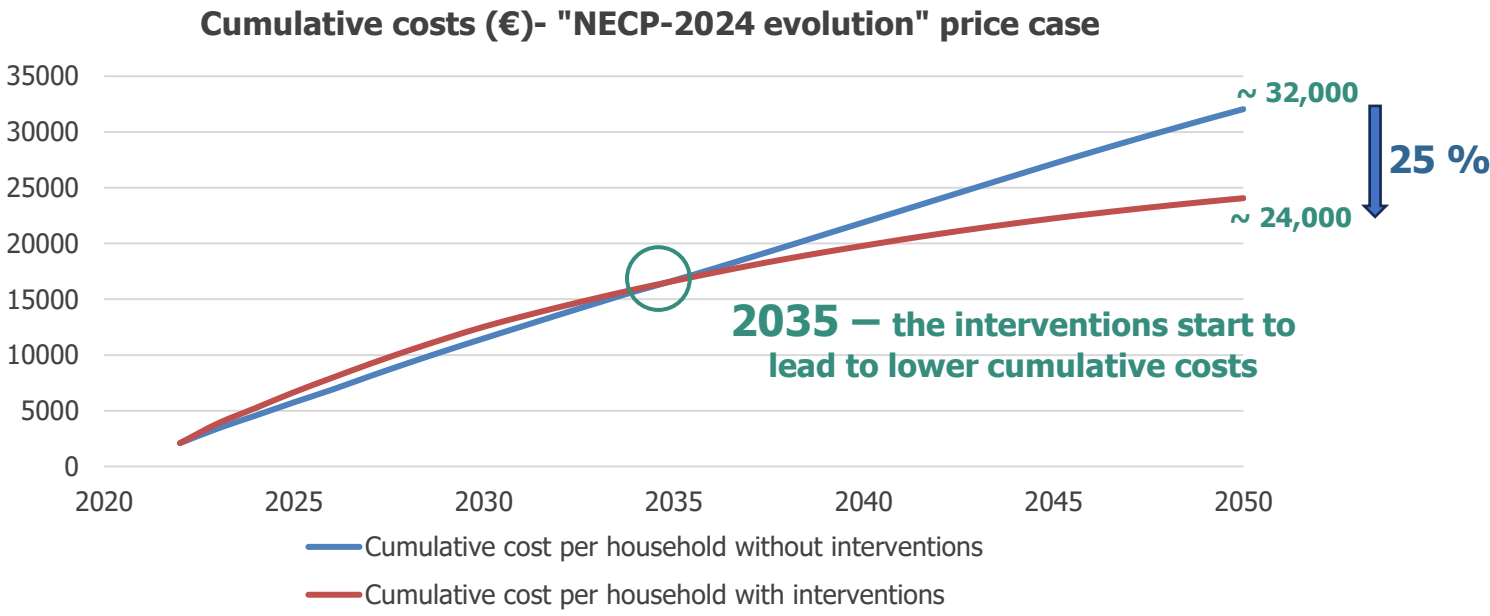
Expected Costs – Household level





Total household savings: ~ **8k €**



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Discounted annual cost savings – Household level

Discounted annual household cost savings (€)

Intervention	2025	2030	2035	2040	2045	2050
-Building envelope renovation of household with oil boiler	**467**	438	420	454	-	-
-Building envelope renovation of household with natural gas boiler	147	159	173	207	**219**	198
-Building envelope renovation of household with heat pump	**337**	266	196	151	115	83
-Building envelope renovation of household with biomass boiler	237	**243**	195	145	111	92
-Replacement of oil boiler with heat pump	748	767	808	948	**1012**	971
-Replacement of oil boiler with biomass boiler	575	491	565	773	**878**	844
-Replacement of natural gas boiler with heat pump	-	55	175	314	**391**	378
-Replacement of natural gas boiler with biomass boiler	-	-221	-69	139	**256**	250

Building envelope renovation measures achieve most cost savings during **2025-2030**.

Replacement of heating systems achieve most cost savings around **2045**.

Replacing oil boilers with heat pumps leads to the **greatest cost savings** during the entire transition period.

Disclaimer: Although replacements of heating systems achieve most savings around 2045, they are **already attractive investment options**.

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Annual emission savings – Household level

Annual Household emission savings ($tnCO_2$)

Intervention	2025	2030	2035	2040	2045	2050
Building envelope renovation of household with oil boiler	1.25	1.25	1.25	1.25	-	-
Building envelope renovation of household with natural gas boiler	0.87	0.87	0.87	0.87	0.87	0.87
Building envelope renovation of household with heat pump	0.49	0.17	0.05	0.04	0.02	0.02
Replacement of oil boiler with heat pump	2.52	2.92	3.07	3.09	3.11	3.11
Replacement of oil boiler with biomass boiler	3.13	3.13	3.13	3.13	3.13	3.13
Replacement of oil boiler with natural gas boiler	1.01	1.01	1.01	1.01	1.01	1.01
Replacement of natural gas boiler with heat pump	-	1.91	2.06	2.08	2.10	2.10
Replacement of natural gas boiler with biomass boiler	-	2.13	2.13	2.13	2.13	2.13

Replacing oil boilers with heat pumps or biomass boilers results in the **highest emission savings.**

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- The energy transition will be frontloaded in terms of infrastructure costs.
  - **More than half** of the total intervention costs will be required **by 2035**.
  - **Significant financial support to consumers** and **regulatory measures on top of it** will be required **over the next ten years** to make investments attractive.
  - Priority should be given in the replacement of fossi-fuelled heating systems, specifically **oil** and **gas boilers**, to achieve **emission targets** and **increase cost effectiveness.**
  - Funds from the **National Strategic Reference Framework** and other national subsidy programmes, as well as **green recovery funds from Recovery & Resilience facility** should be channeled based on specific criteria (e.g., climate zone, building age, household income)

fuel costs **ETS costs**

- On average, there is potential for Greek households to achieve **notable cost savings** during the transition period.
  - Citizens should consider that **heat pumps already deliver substantial cost savings**, and they are becoming **increasingly attractive each year**.

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Thank you!

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Greek households' characteristics

Number of households per climate zone			
A	B	C	D
621,071	2,380,908	1,189,160	141,309

Number of households per construction period		
Before 1981	Between 1981-2000	After 2000
2,131,488	1,428,560	772,400

- Average Household members: **2.17**
- Employed household members: **1.08**

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