

“Energy transition in the residential sector in Greece: Investing in natural gas or in electrification?”

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INTRODUCTION & PROBLEM STATEMENT (1/2)



Buildings are accounting for nearly **40%** of final **energy consumption** in the EU.



50 million consumers struggle to keep their homes **adequately** warm.



Annual renovation rate of the building stock varying from **0.4** to **1.2%**.

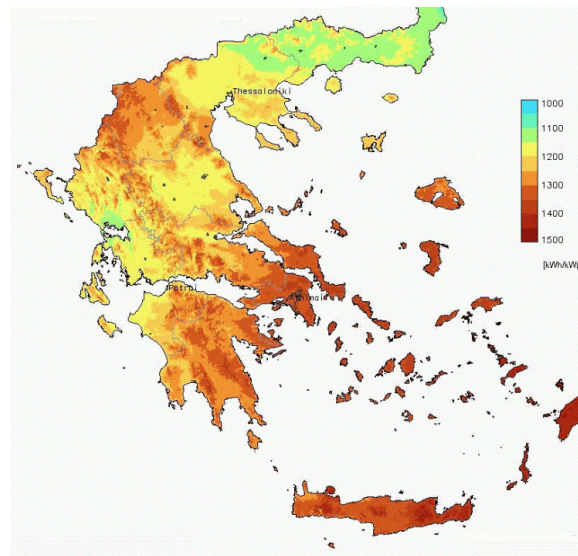


Need for smarter & more energy-efficient buildings in Greece

Building sector has significant room for decarbonisation.

Six out of ten buildings have been constructed **before 1981**.

25-30% of the final energy is consumed at the **residential** sector.



Need of immediate renovations



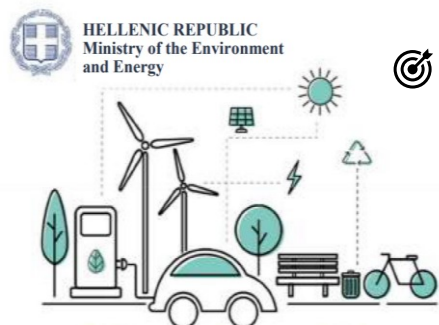
The SENTINEL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837089.



INTRODUCTION & PROBLEM STATEMENT (2/2)

Towards the decarbonisation of the Greek residential sector...

🎯 **Renovation** and **replacement** of residential buildings with new **nearly zero-energy** buildings, which could in aggregate amount to **12-15%**.



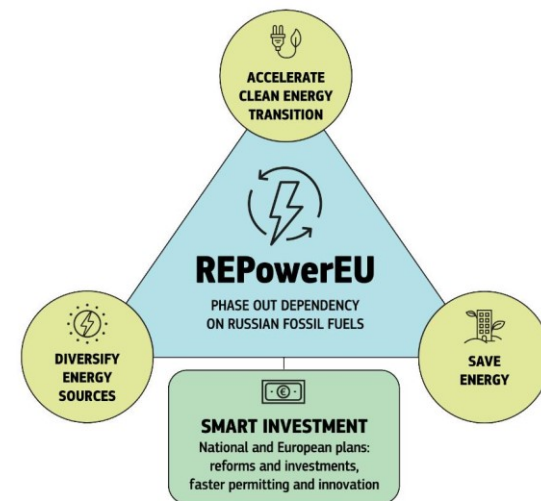
National Energy Climate Plan
(NECP) 2019

🎯 An average of **60,000 buildings** or building units upgraded **annually** in terms of energy.

🎯 The energy upgrading of the building stock is expected to increase **added value by EUR 8 million** and create and maintain over **22 thousand new full-time jobs**.



“NextGenerationEU” Recovery Packages



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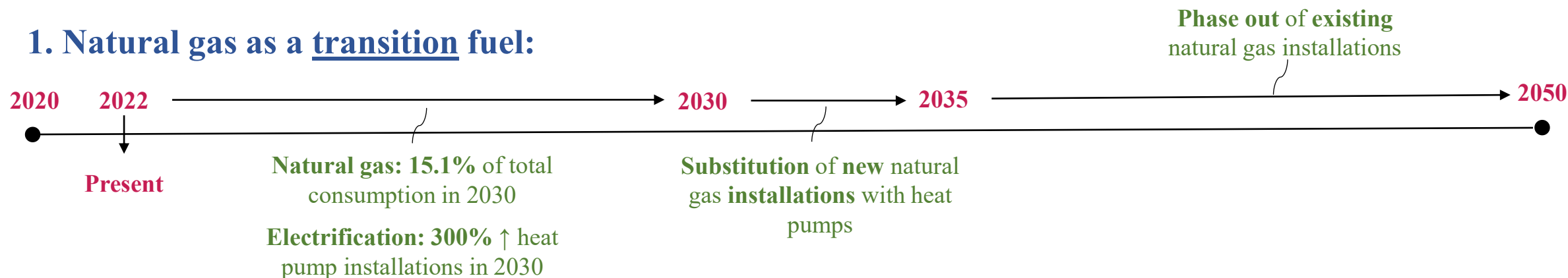
SCENARIO ANALYSIS (1/2)

60,000 renovations/year (energy efficiency upgrades in terms of heating/cooling systems and envelope):

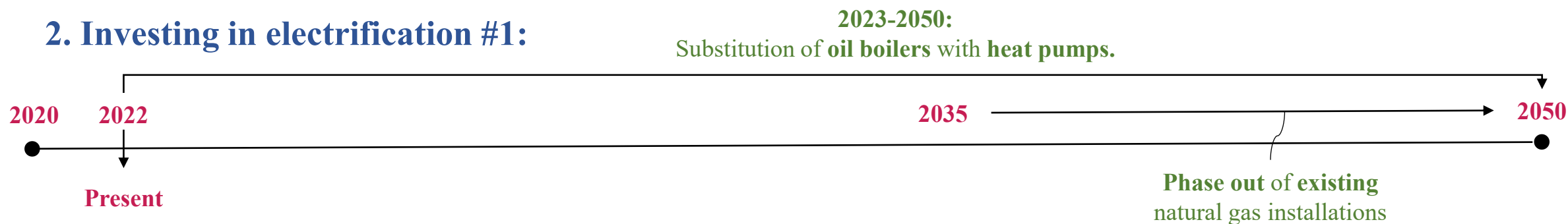
In dwellings built **before 1981**: exterior wall insulation & window replacements.

In dwellings built in the period **1981-2000**: exterior wall insulation.

1. Natural gas as a transition fuel:



2. Investing in electrification #1:



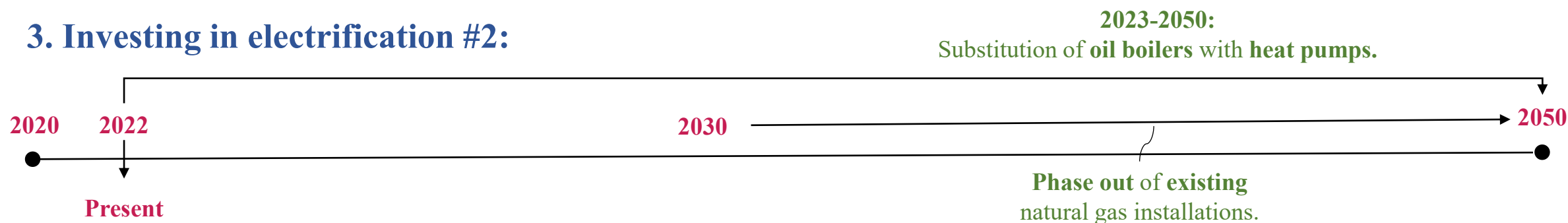
SCENARIO ANALYSIS (2/2)

60,000 renovations/year (energy efficiency upgrades in terms of heating/cooling systems and envelope):

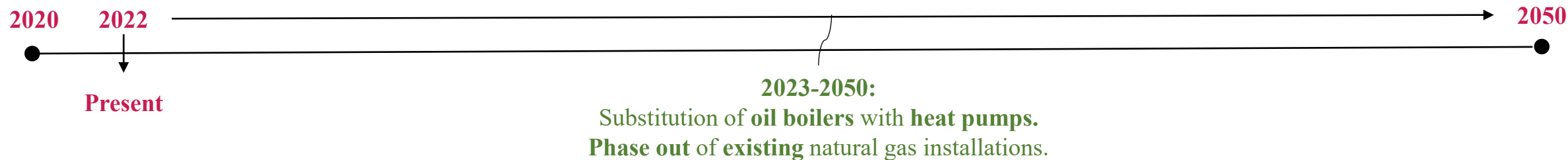
In dwellings built **before 1981**: exterior wall insulation & window replacements.

In dwellings built in the period **1981-2000**: exterior wall insulation.

3. Investing in electrification #2:



4. Complete independence in natural gas as soon as possible:



MODEL APPLICATION



Building sector

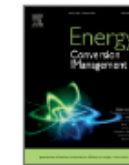
*Energy demand
simulation model*

*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  





Energy Policy

Volume 161, February 2022, 112759



Monetising behavioural change as a policy
measure to support energy management in the
residential sector: A case study in Greece

Konstantinos Koasidis ^a  , Vangelis Marinakis ^a, Alexandros Nikas ^a, Katerina Chira ^a, Alexandros Flamos ^b, Haris
Doukas ^a



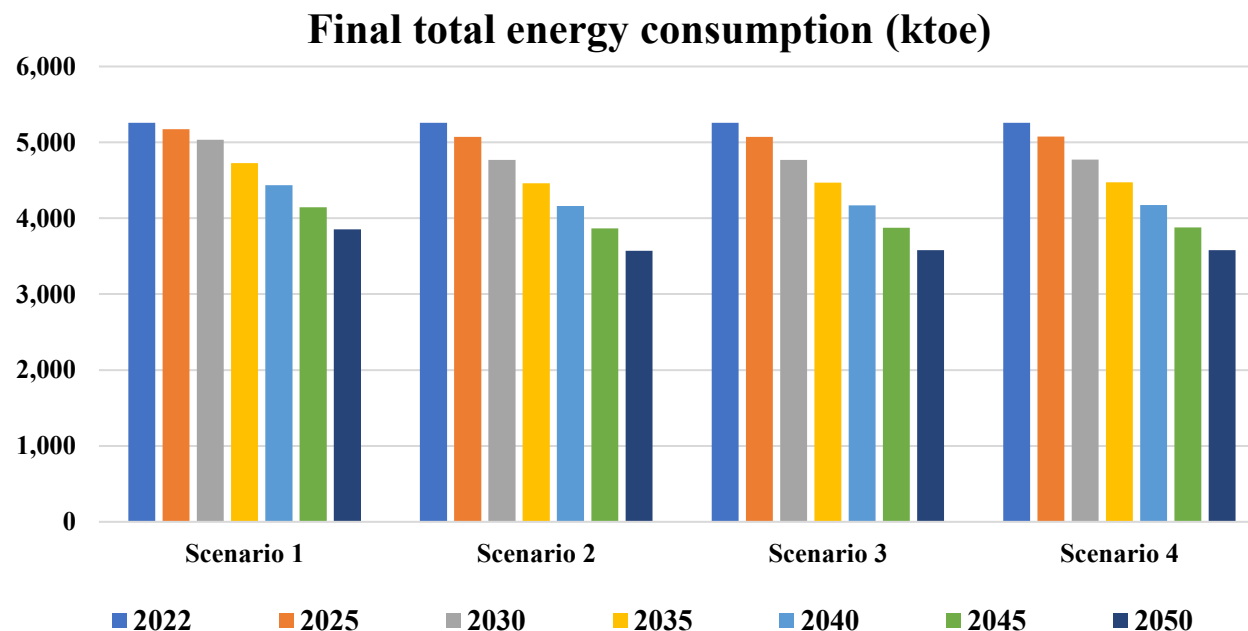
The SENTINEL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837089.



RESULTS (1/7)

Final energy consumption towards 2050 in the Greek residential sector:

	2022	2025	2030	2035	2040	2045	2050
Scenario 1	5,257.1	5,173.3	5,033.6	4,726.7	4,435.0	4,143.8	3,854.8
Scenario 2	5,257.1	5,073.0	4,766.1	4,459.1	4,162.7	3,866.7	3,573.0
Scenario 3	5,257.1	5,073.0	4,766.1	4,468.1	4,170.1	3,872.7	3,577.5
Scenario 4	5,257.1	5,074.4	4,772.9	4,474.0	4,175.0	3,876.6	3,580.4



Scenarios 2, 3, & 4 lead to approximately the same final energy consumption.



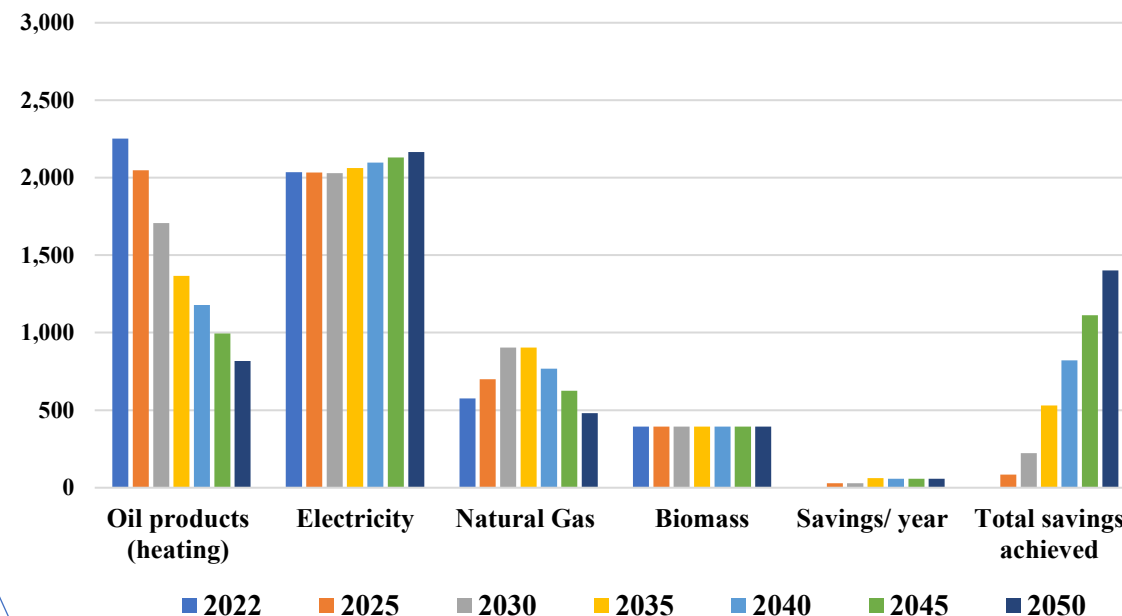
RESULTS (2/7)

Energy mix towards 2050 in the Greek residential sector:

Scenario 1: Natural gas as a transition fuel

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	2,047.9	1,707.1	1,366.2	1,178.2	995.2	816.5
Electricity	2,035.6	2,033.2	2,029.1	2,063.0	2,097.0	2,131.0	2,164.9
Appliances and Cooling	1,338.3	1,334.4	1,328.0	1,300.3	1,272.6	1,245.0	1,217.7
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	2.7	5.1	66.7	128.3	190.0	251.1
Natural Gas	576.0	699.2	904.4	904.4	766.7	624.6	480.4
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	27.9	27.9	61.4	58.3	58.1	56.6
Total savings achieved	0.0	83.8	223.5	530.5	822.2	1,113.3	1,402.3

Energy mix & savings (ktoe) - Scenario 1



1,296.9 ktoe
of fossil fuels by 2050.



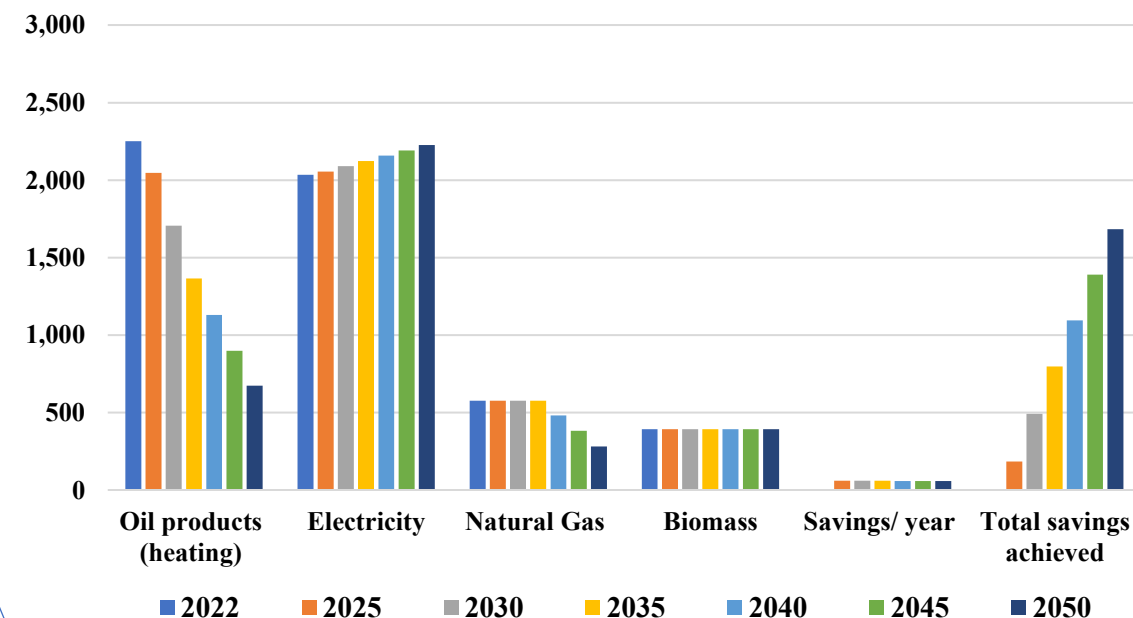
RESULTS (3/7)

Energy mix towards 2050 in the Greek residential sector:

Scenario 2: Investing electrification & Phasing out of natural gas starting in 2036

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	2,047.9	1,707.1	1,366.2	1,130.4	899.4	673.0
Electricity	2,035.6	2,056.0	2,090.0	2,123.9	2,157.9	2,191.9	2,225.7
Appliances and Cooling	1,338.3	1,321.7	1,294.0	1,266.4	1,238.7	1,211.0	1,183.8
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	38.2	99.9	161.5	223.1	284.8	345.9
Natural Gas	576.0	576.0	576.0	576.0	481.3	382.4	281.3
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	61.4	61.4	61.4	59.3	59.1	57.5
Total savings achieved	0.0	184.2	491.1	798.0	1,094.5	1,390.4	1,684.1

Energy mix & savings (ktoe) - Scenario 2



954.2 ktoe
of fossil fuels by 2050.



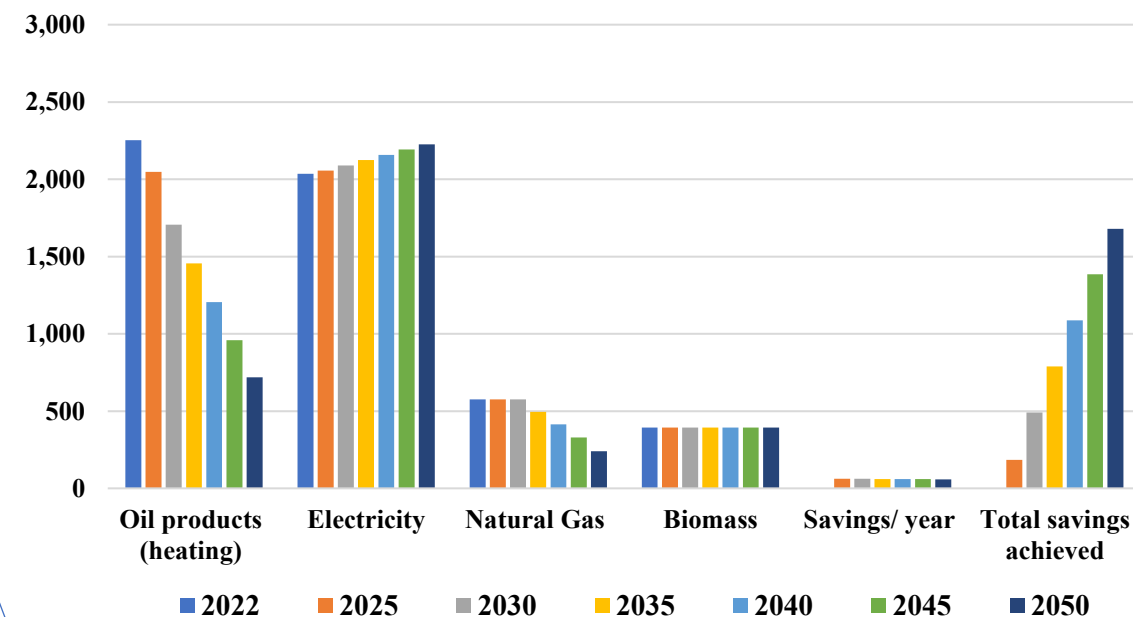
RESULTS (4/7)

Energy mix towards 2050 in the Greek residential sector:

Scenario 3: Investing electrification & Phasing out of natural gas starting in 2031

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	2,047.9	1,707.1	1,456.2	1,205.3	959.3	717.8
Electricity	2,035.6	2,056.0	2,090.0	2,123.9	2,157.9	2,191.9	2,225.7
Appliances and Cooling	1,338.3	1,321.7	1,294.0	1,266.4	1,238.7	1,211.0	1,183.8
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	38.2	99.9	161.5	223.1	284.8	345.9
Natural Gas	576.0	576.0	576.0	494.9	413.8	328.5	240.9
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	61.4	61.4	59.6	59.6	59.4	57.8
Total savings achieved	0.0	184.2	491.1	789.0	1,087.0	1,384.4	1,679.7

Energy mix & savings (ktoe) - Scenario 3



958.7 ktoe
of fossil fuels by 2050.

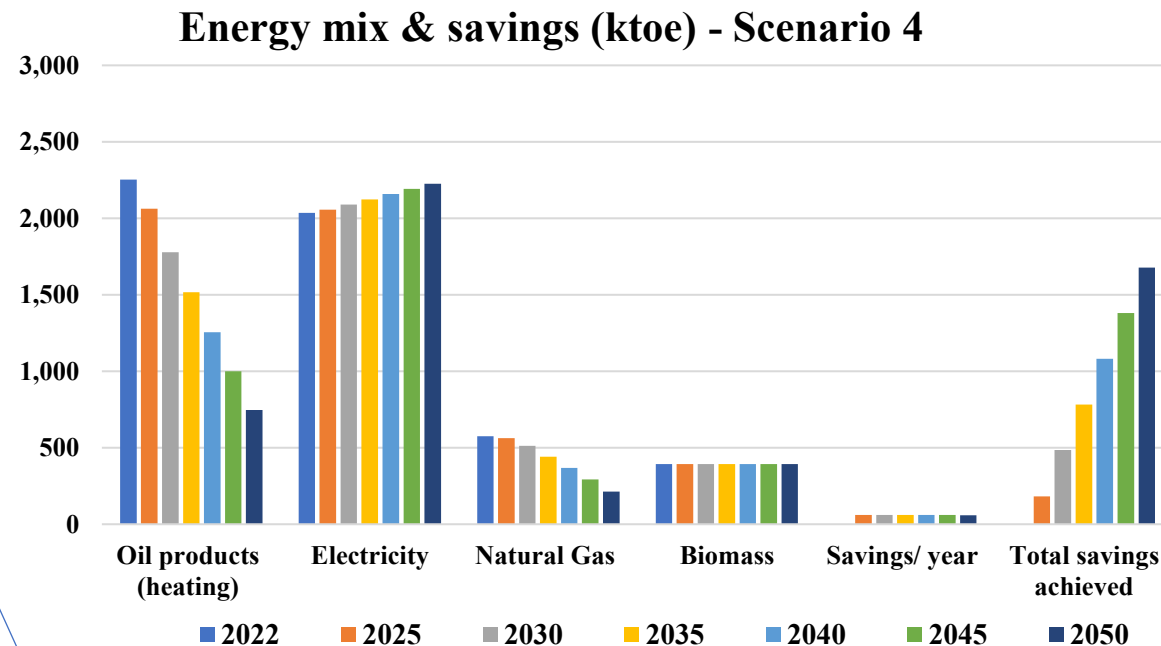


RESULTS (5/7)

Energy mix towards 2050 in the Greek residential sector:

Scenario 4: Complete independence in natural gas as soon as possible

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	2,062.0	1,777.1	1,516.2	1,255.3	999.2	747.6
Electricity	2,035.6	2,056.0	2,090.0	2,123.9	2,157.9	2,191.9	2,225.7
Appliances and Cooling	1,338.3	1,321.7	1,294.0	1,266.4	1,238.7	1,211.0	1,183.8
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	38.2	99.9	161.5	223.1	284.8	345.9
Natural Gas	576.0	563.4	512.8	440.8	368.8	292.5	214.0
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	60.0	61.4	59.8	59.8	59.6	58.0
Total savings achieved	0.0	182.8	484.2	783.2	1,082.1	1,380.5	1,676.8



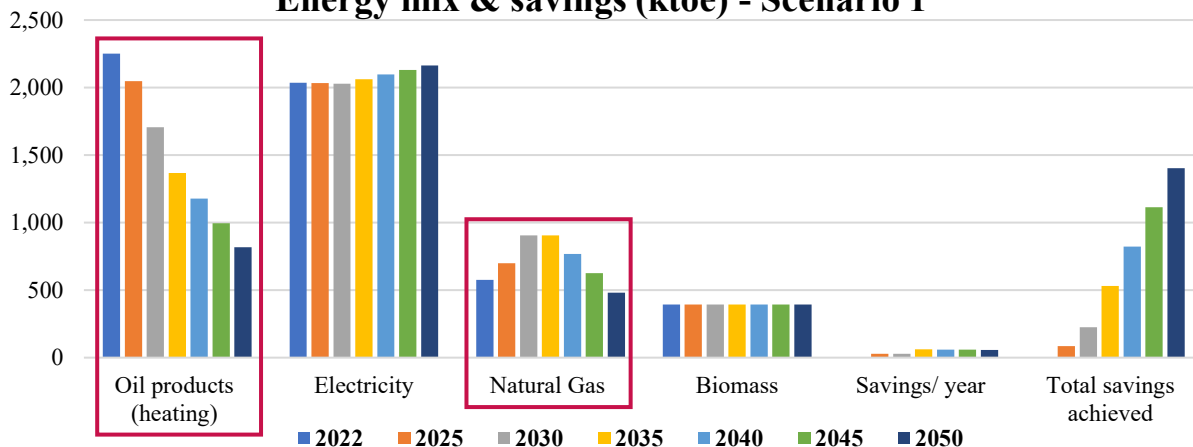
961.6 ktoe
of fossil fuels by 2050.



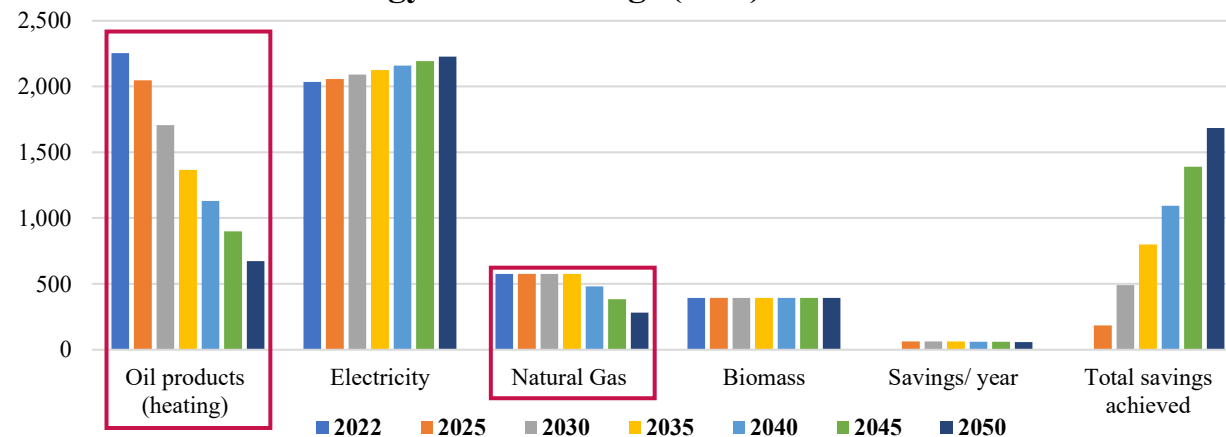
RESULTS (6/7)

Energy mix towards 2050 in the Greek residential sector – Cross-scenario comparison:

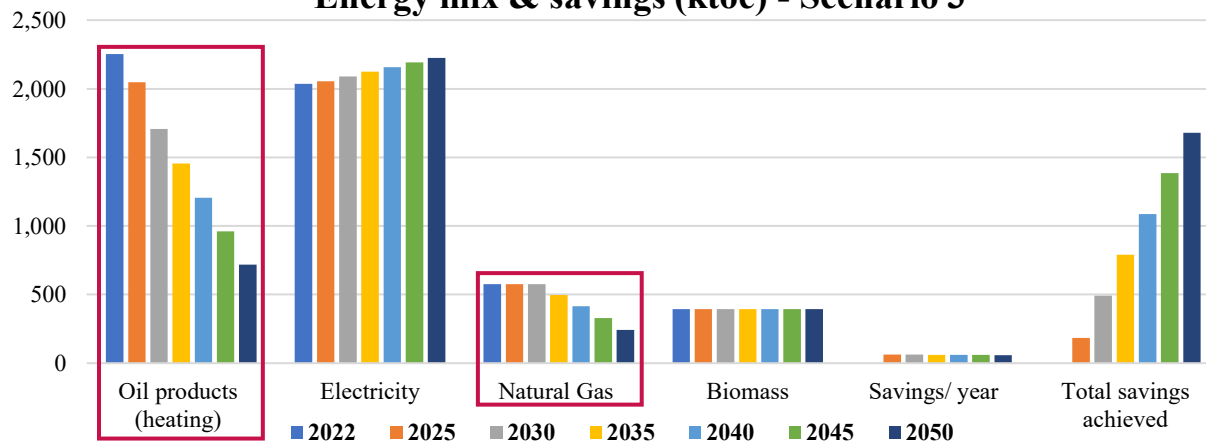
Energy mix & savings (ktoe) - Scenario 1



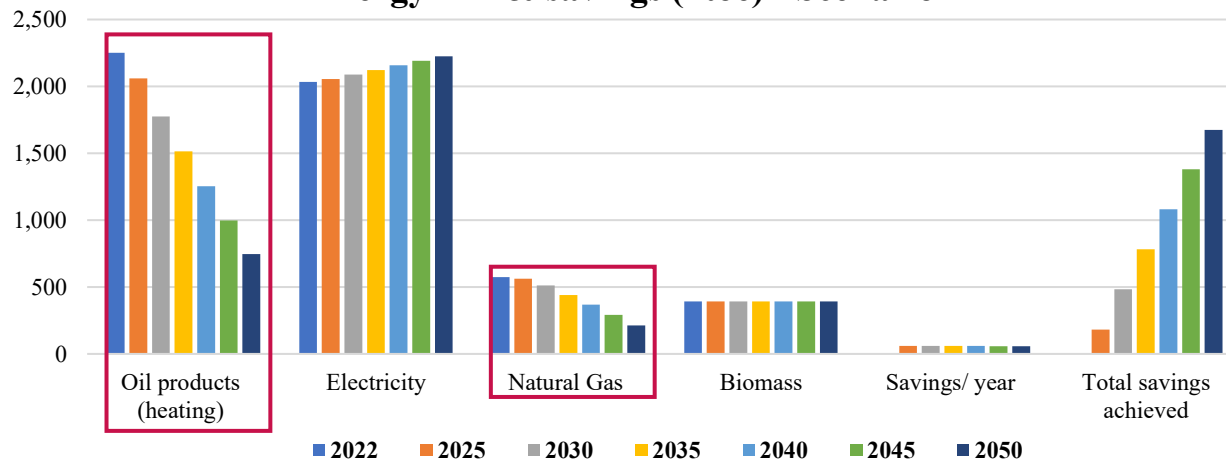
Energy mix & savings (ktoe) - Scenario 2



Energy mix & savings (ktoe) - Scenario 3



Energy mix & savings (ktoe) - Scenario 4



With the NECP renovation rates (60,000/year)

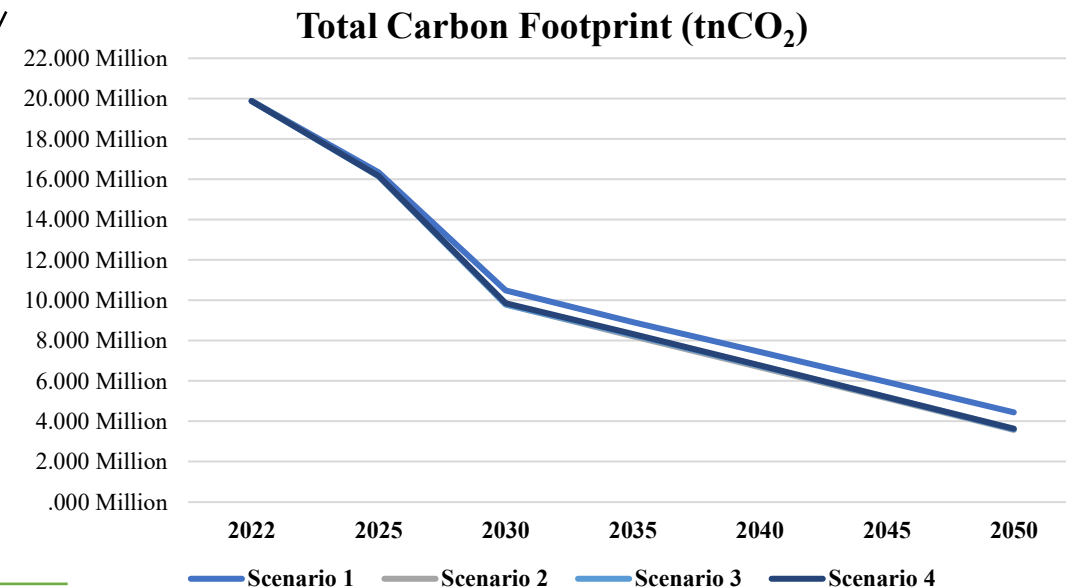
we are not able to achieve **decarbonisation**.

RESULTS (7/7)

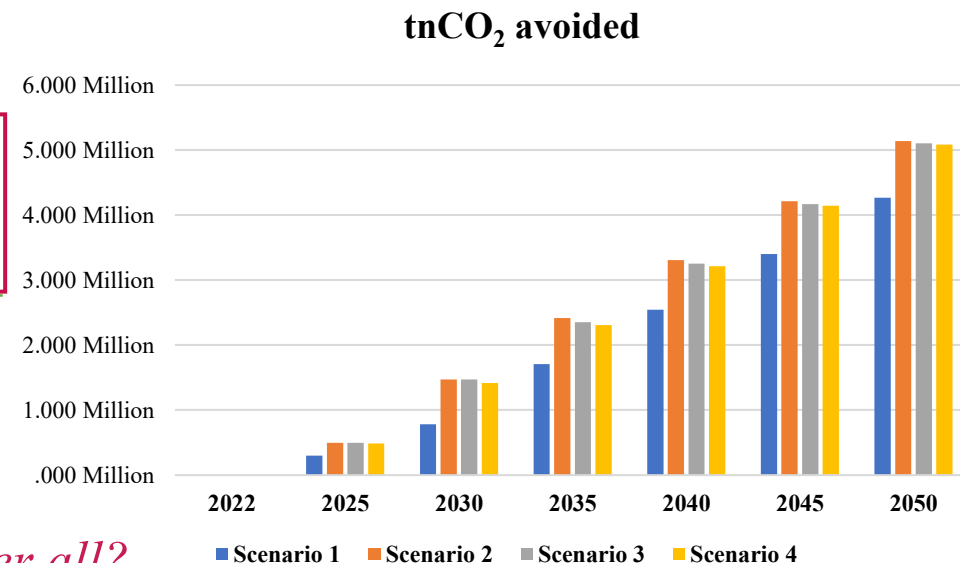
Environmental Footprint

Scenarios 2, 3, & 4 lead to **less** CO₂ emissions than the NCEP scenario

	2022	2025	2030	2035	2040	2045	2050
Total tnCO ₂							
Scenario 1	19.88M.	16.35M.	10.48M.	8.92M.	7.44M.	5.95M.	4.44M.
Scenario 2	19.88M.	16.15M.	9.80M.	8.22M.	6.69M.	5.14M.	3.58M.
Scenario 3	19.88M.	16.15M.	9.80M.	8.28M.	6.74M.	5.18M.	3.61M.
Scenario 4	19.88M.	16.16M.	9.85M.	8.32M.	6.78M.	5.21M.	3.63M.
tn CO ₂ without renovations	19.88M.	16.65M.	11.27M.	10.63M.	9.99M.	9.35M.	8.71M.



	2022	2025	2030	2035	2040	2045	2050	Total
tnCO ₂ avoided								
Scenario 1	.00M.	.30M.	.78M.	1.71M.	2.54M.	3.40M.	4.27M.	56.21M.
Scenario 2	.00M.	.50M.	1.47M.	2.41M.	3.30M.	4.21M.	5.13M.	74.34M.
Scenario 3	.00M.	.50M.	1.47M.	2.35M.	3.25M.	4.17M.	5.10M.	73.43M.
Scenario 4	.00M.	.49M.	1.42M.	2.30M.	3.21M.	4.14M.	5.08M.	72.53M.



HOWEVER, if we invest in electrification:

the **earliest** the phase out of natural gas
the **less** tnCO₂ avoided.



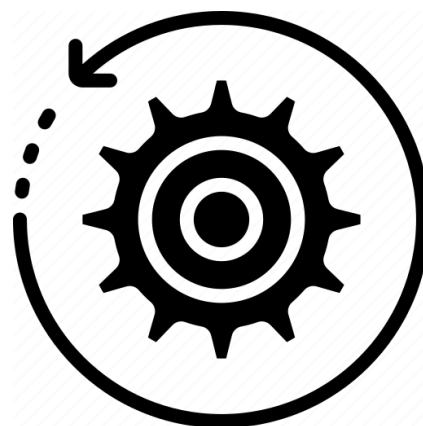
Is this a paradox ???

Or not that much after all?

BUT HOW...



... could we achieve decarbonisation in the Greek residential sector?



**Reverse
Engineering**

*New scenarios beyond the
specifications of the*



**National Energy Climate Plan
(NECP) 2019**



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NEW SCENARIO ANALYSIS (1/2)

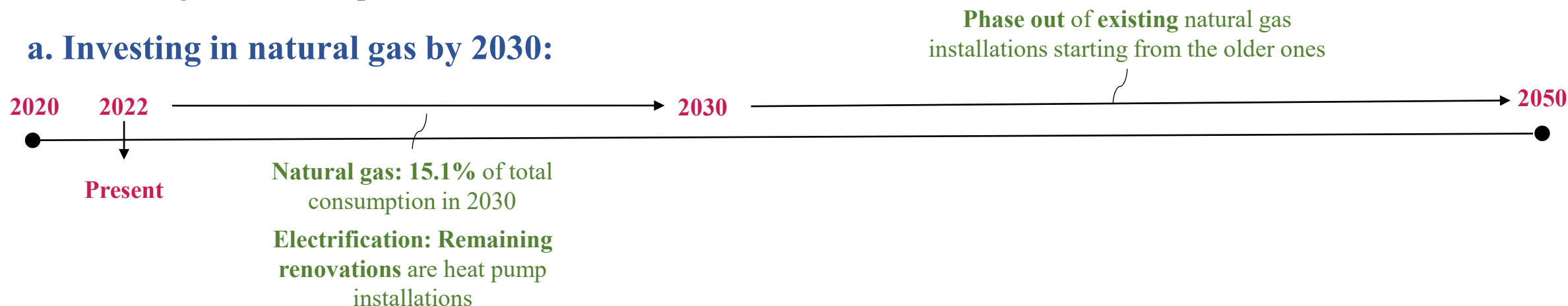
Scenario 5: Decarbonisation by 2050:

100,000 renovations/year (energy efficiency upgrades in terms of heating/cooling systems and envelope):

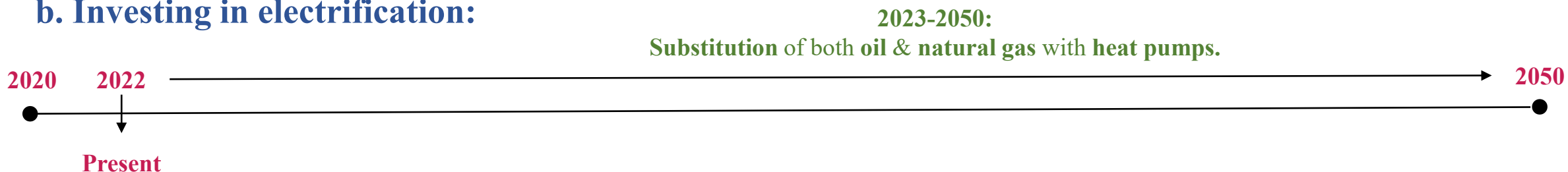
In dwellings built **before 1981**: exterior wall insulation & window replacements.

In dwellings built in the period **1981-2000**: exterior wall insulation.

a. Investing in natural gas by 2030:



b. Investing in electrification:



NEW SCENARIO ANALYSIS (2/2)

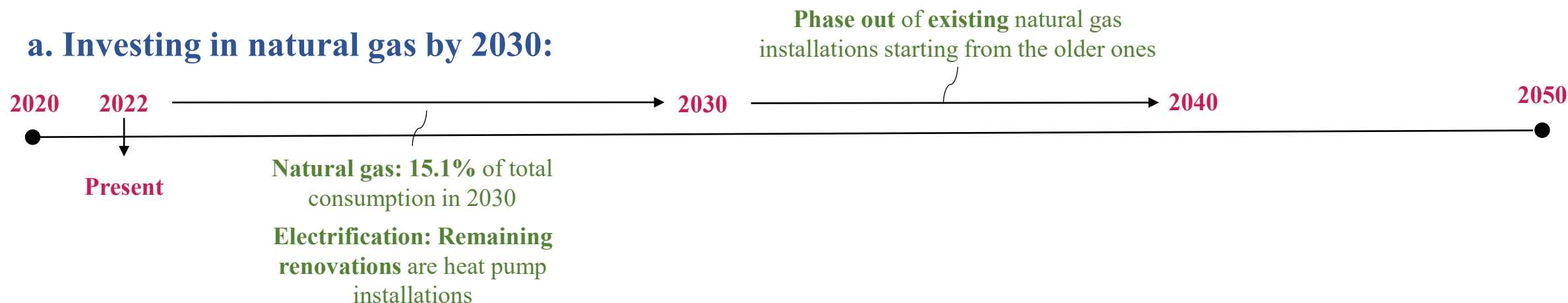
Scenario 6: Decarbonisation by 2040:

145,000 renovations/year (energy efficiency upgrades in terms of heating/cooling systems and envelope):

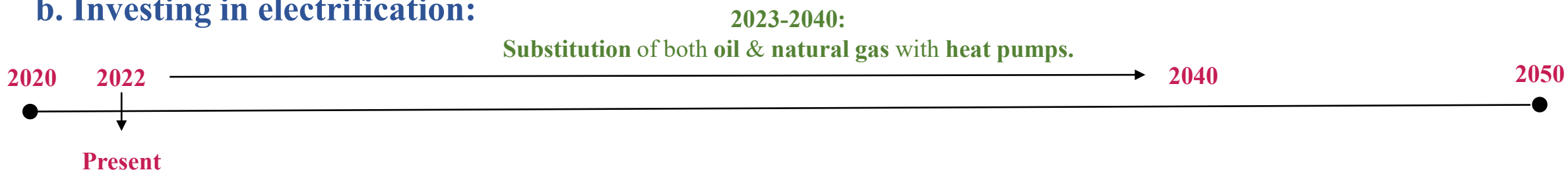
In dwellings built **before 1981**: exterior wall insulation & window replacements.

In dwellings built in the period **1981-2000**: exterior wall insulation.

a. Investing in natural gas by 2030:



b. Investing in electrification:



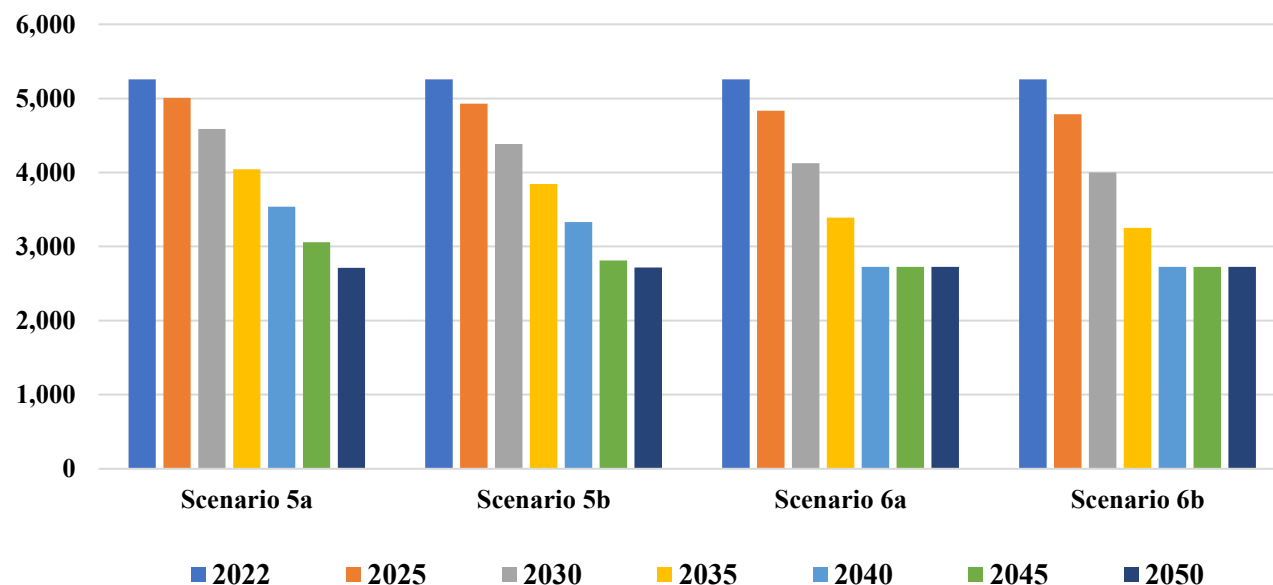
NEW RESULTS (1/14)

Final energy consumption towards 2050 in the Greek residential sector:

	2022	2025	2030	2035	2040	2045	2050
Scenario 5a	5,257.1	5,006.6	4,588.9	4,150.4	3,633.0	3,089.9	2,718.5
Scenario 5b	5,257.1	4,930.7	4,386.7	3,843.1	3,328.2	2,813.2	2,718.5
Scenario 6a	5,257.1	4,833.1	4,126.4	3,390.4	2,718.5	2,718.5	2,718.5
Scenario 6b	5,257.1	4,785.2	3,998.7	3,254.6	2,718.5	2,718.5	2,718.5

Decarbonisation is achieved in **2040**
No further renovations are required during the
period 2041-2050.

Final total energy consumption (ktoe)

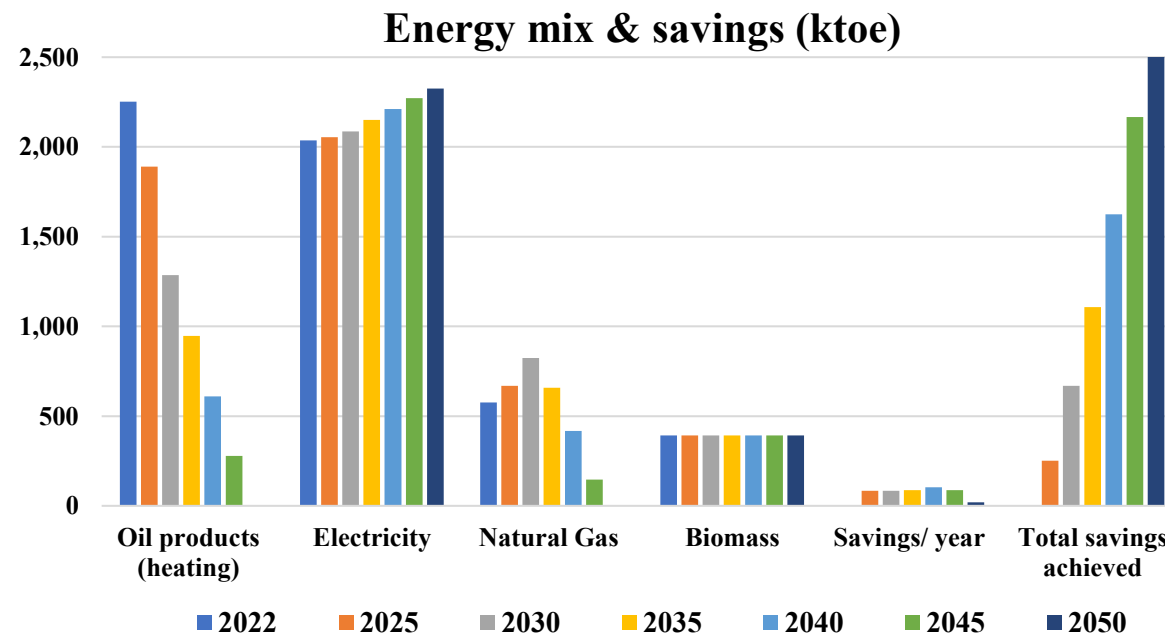


NEW RESULTS (2/14)

Energy mix towards 2050 in the Greek residential sector:

Scenario 5a: 100.000 renovations/year & Investing in new natural gas infrastructure by 2030

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	1,889.7	1,285.0	947.7	610.4	277.9	0.0
Electricity	2,035.6	2,054.8	2,086.7	2,151.0	2,211.6	2,272.3	2,325.5
Appliances and Cooling	1,338.3	1,319.1	1,287.0	1,242.5	1,194.4	1,146.3	1,107.5
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	39.7	103.6	212.4	321.2	429.9	521.9
Natural Gas	576.0	669.1	824.2	658.7	417.9	146.7	0.0
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	83.5	83.5	87.7	103.5	88.2	20.5
Total savings achieved	0.0	250.6	668.2	1,106.8	1,624.2	2,167.2	2,544.0



Decarbonisation is achieved in 2050



NEW RESULTS (3/14)

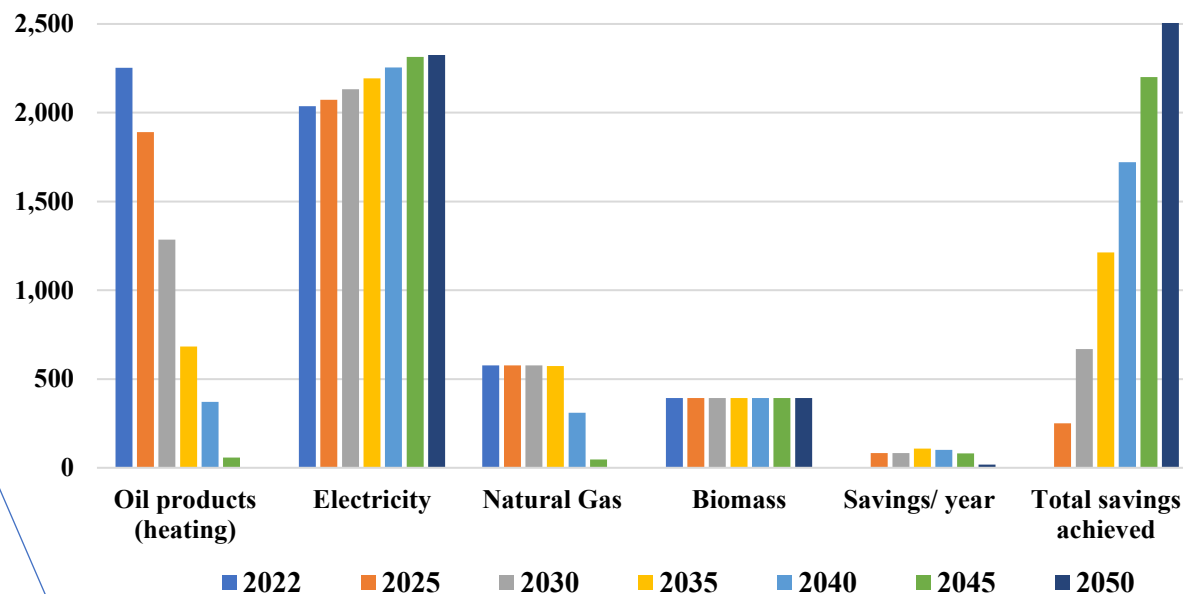
Energy mix towards 2050 in the Greek residential sector:

Scenario 5b: 100.000 renovations/year & Investing in electrification

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	1,889.7	1,285.0	683.5	370.8	58.1	0.0
Electricity	2,035.6	2,072.0	2,132.7	2,193.4	2,254.0	2,314.7	2,325.5
Appliances and Cooling	1,338.3	1,309.4	1,261.3	1,213.3	1,165.2	1,117.1	1,107.5
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	66.5	175.3	284.1	392.8	501.6	521.9
Natural Gas	576.0	576.0	576.0	573.2	310.3	47.4	0.0
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	83.5	83.5	108.8	101.6	81.1	18.8
Total savings achieved	0.0	250.6	668.2	1,212.2	1,720.3	2,201.1	2,544.0



Energy mix & savings (ktoe)



Decarbonisation is achieved in 2050

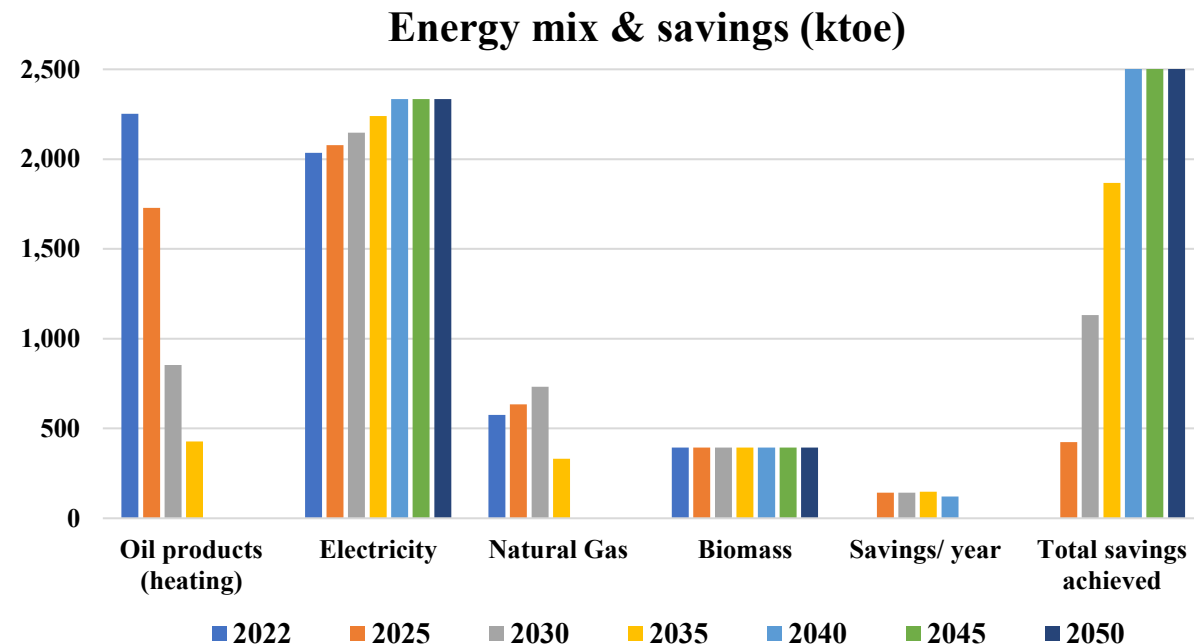


NEW RESULTS (4/14)

Energy mix towards 2050 in the Greek residential sector:

Scenario 6a: 145.000 renovations/year & Investing in new natural gas infrastructure by 2030

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	1,728.0	853.8	426.5	0.0	0.0	0.0
Electricity	2,035.6	2,077.3	2,146.8	2,240.5	2,325.5	2,325.5	2,325.5
Appliances and Cooling	1,338.3	1,302.6	1,243.1	1,179.5	1,107.5	1,107.5	1,107.5
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	78.7	207.7	364.9	521.9	521.9	521.9
Natural Gas	576.0	634.8	732.8	330.4	0.0	0.0	0.0
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	141.3	141.3	147.2	121.3	0.0	0.0
Total savings achieved	0.0	424.0	1,130.7	1,866.7	2,530.1	2,530.1	2,530.1



Decarbonisation is achieved in 2040



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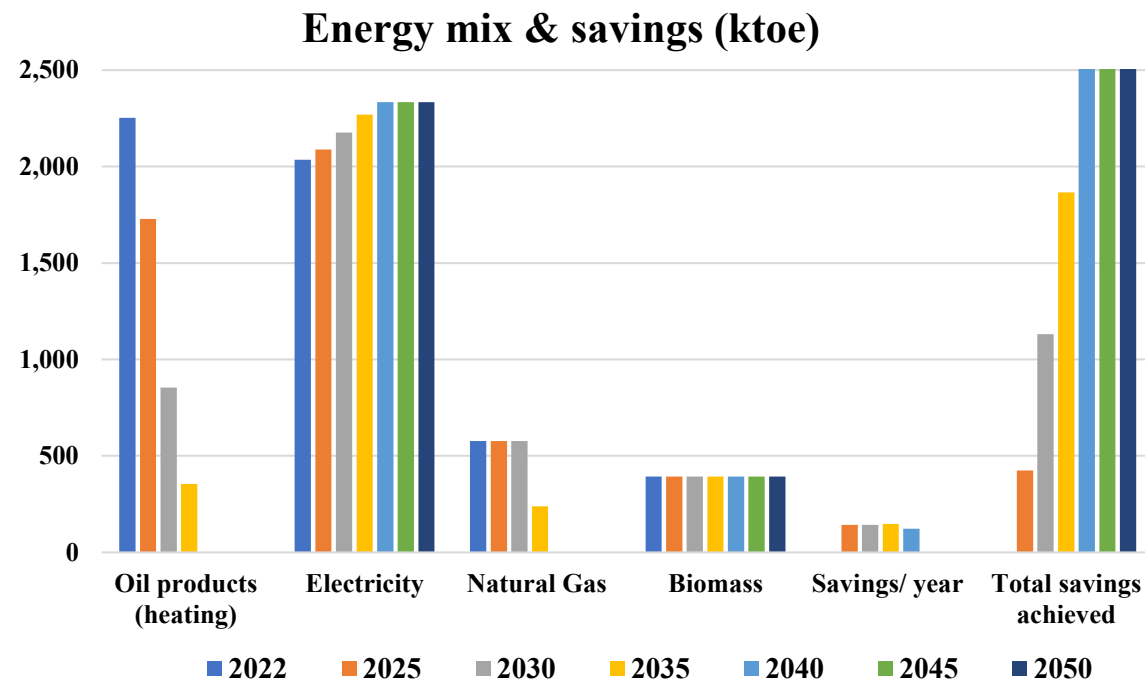


NEW RESULTS (5/14)

Energy mix towards 2050 in the Greek residential sector:

Scenario 6b: 145.000 renovations/year & Investing in electrification

Consumption by fuel (ktoe)	2022	2025	2030	2035	2040	2045	2050
Oil products (heating)	2,252.5	1,728.0	853.8	354.1	0.0	0.0	0.0
Electricity	2,035.6	2,088.2	2,175.9	2,268.6	2,325.5	2,325.5	2,325.5
Appliances and Cooling	1,338.3	1,296.5	1,226.9	1,162.3	1,107.5	1,107.5	1,107.5
Electric Heating System	696.0	696.0	696.0	696.0	696.0	696.0	696.0
Heat Pumps	1.3	95.6	252.9	410.2	521.9	521.9	521.9
Natural Gas	576.0	576.0	576.0	238.9	0.0	0.0	0.0
Biomass	393.0	393.0	393.0	393.0	393.0	393.0	393.0
Savings/ year	0.0	141.3	141.3	147.2	121.3	0.0	0.0
Total savings achieved	0.0	424.0	1,130.7	1,866.7	2,530.1	2,530.1	2,530.1



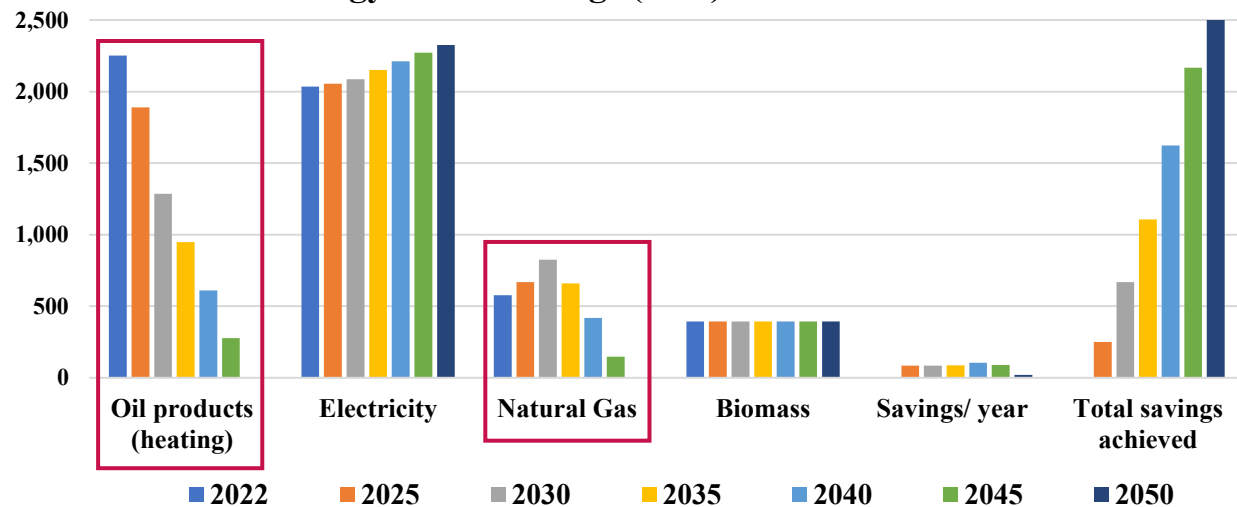
Decarbonisation is achieved in 2040



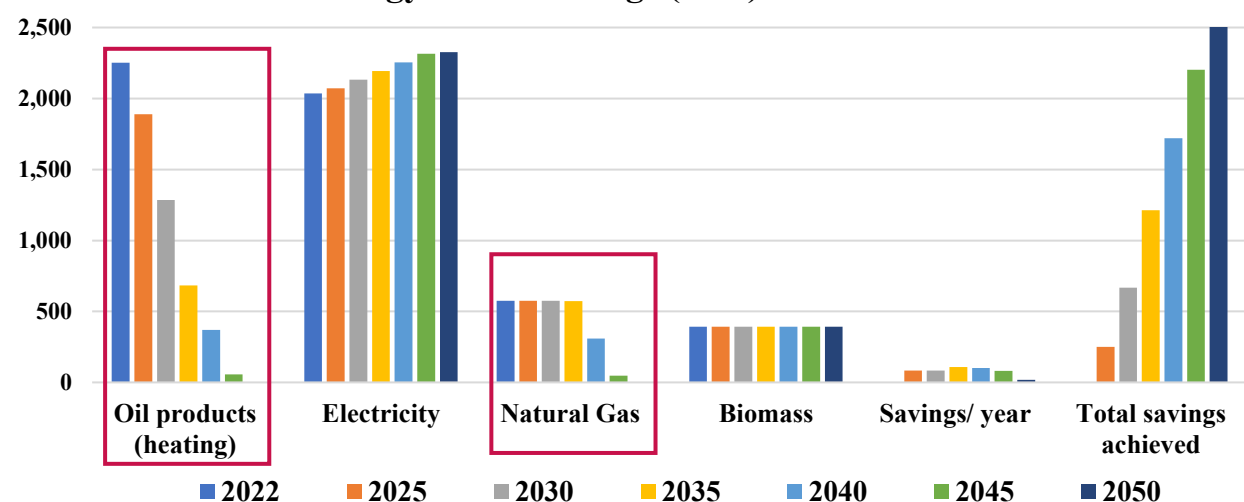
NEW RESULTS (6/14)

Energy mix towards 2050 in the Greek residential sector – Cross-scenario comparison:

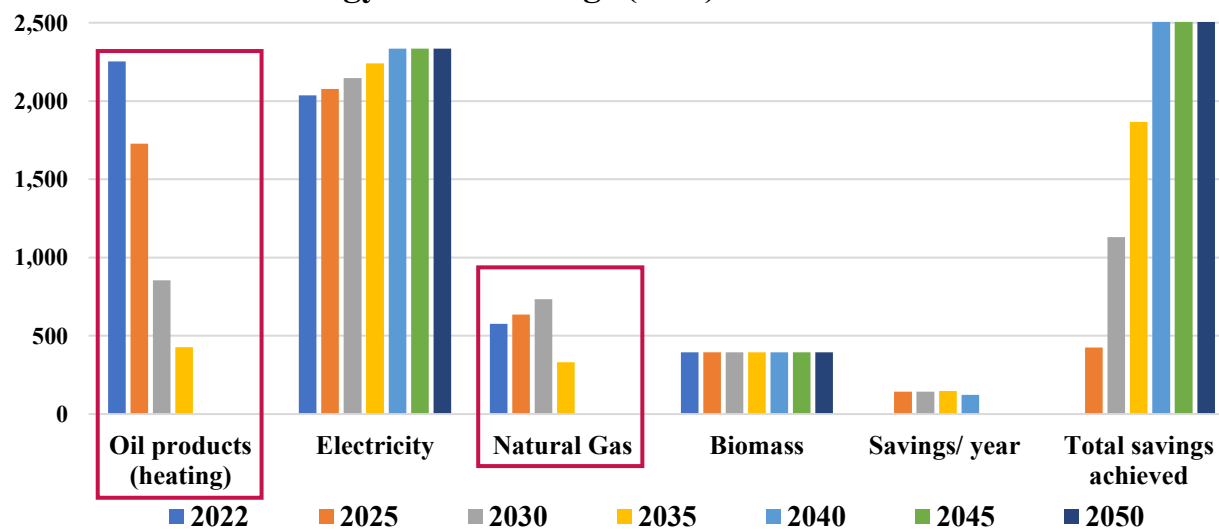
Energy mix & savings (ktoe) – Scenario 5a



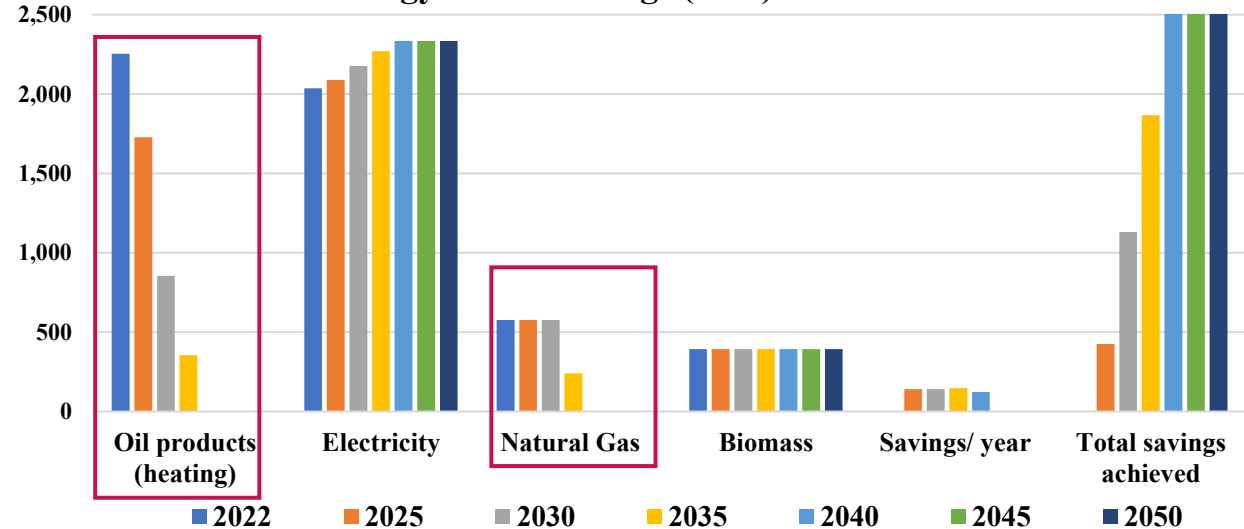
Energy mix & savings (ktoe) – Scenario 5b



Energy mix & savings (ktoe) – Scenario 6a



Energy mix & savings (ktoe) – Scenario 6b



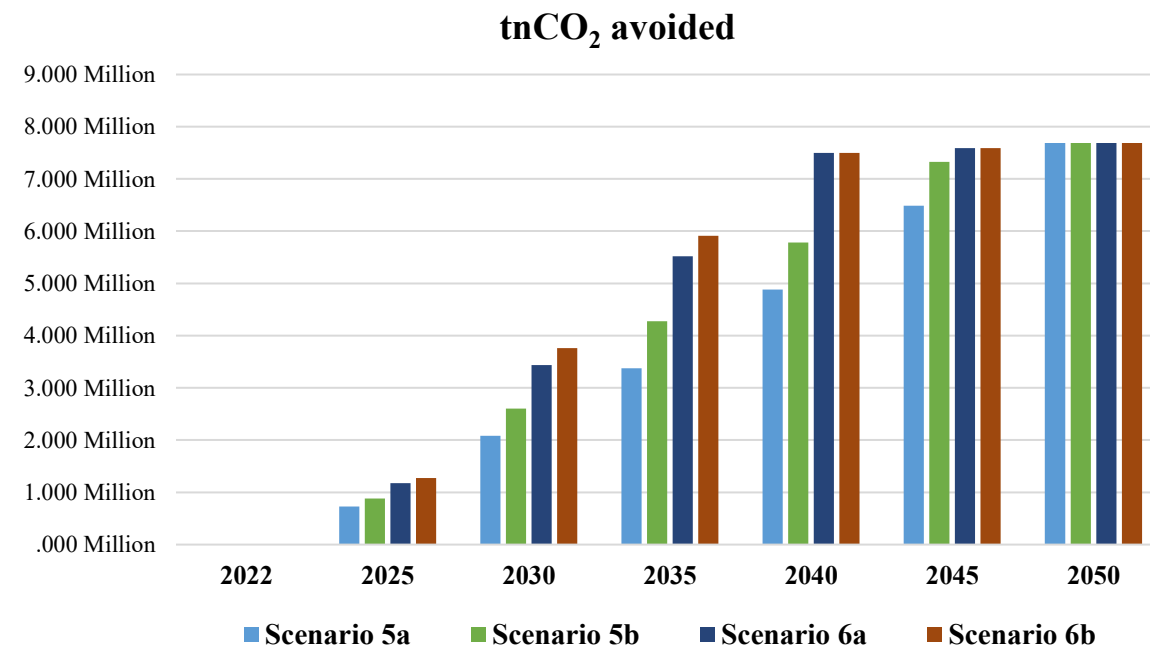
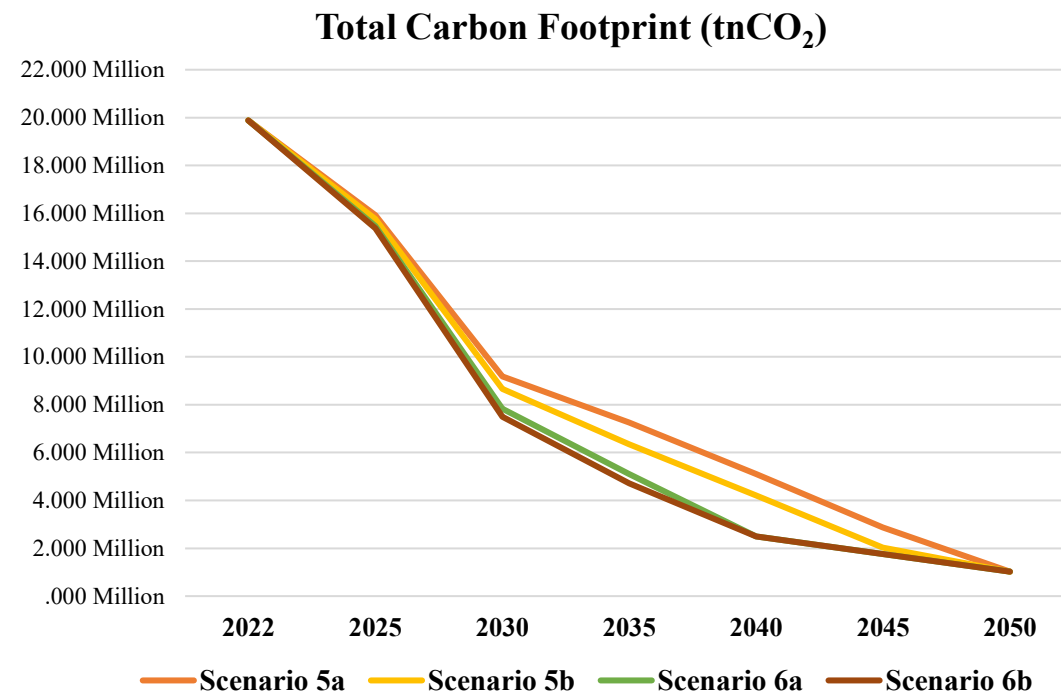
NEW RESULTS (7/14)

Environmental Footprint

	2022	2025	2030	2035	2040	2045	2050
Total tnCO ₂							
Scenario 5a	19.88M.	15.92M.	9.18M.	7.25M.	5.11M.	2.86M.	1.03M.
Scenario 5b	19.88M.	15.77M.	8.66M.	6.35M.	4.21M.	2.03M.	1.03M.
Scenario 6a	19.88M.	15.47M.	7.83M.	5.11M.	2.49M.	1.76M.	1.03M.
Scenario 6b	19.88M.	15.38M.	7.50M.	4.72M.	2.49M.	1.76M.	1.03M.
tnCO ₂ without renovations	19.88M.	16.65M.	11.27M.	10.63M.	9.99M.	9.35M.	8.71M.

tnCO ₂ avoided	2022	2025	2030	2035	2040	2045	2050
Scenario 5a	.00M.	1.45M.	9.09M.	23.37M.	44.75M.	74.02M.	110.44 M.
Scenario 5b	.00M.	1.73M.	11.17M.	29.20M.	55.10M.	88.74M.	126.95 M.
Scenario 6a	.00M.	2.33M.	14.84M.	38.20M.	71.89M.	109.79M.	148.03 M.
Scenario 6b	.00M.	2.51M.	16.15M.	41.39M.	76.73M.	114.62M.	152.86 M.

Investing in **electrification** rather than in **natural gas** leads to **more tnCO₂** avoided.



NEW RESULTS (8/14)

What about costs though?



Energy costs for Households (€/MWh)

	2022	2030	2040	2050
Oil (Diesel heating oil)	140.9	190.4	209.0	227.5
Electricity	210.4	200.9	189.0	177.0
Natural gas	142.8	167.8	184.5	201.1
Biomass	61.2	61.2	61.2	61.2

April 2022 data

Source: [Hellenic Association for Energy Economics](#) following the evolution trend provided by Greece's "Long Term Strategy towards 2050" & the PRIMES model.

Technological costs (€)

	2022	2030	2040	2050
Natural Gas boiler	5,000	4,904	4,713.4	4,713.4
Heat Pump	12,000	7,680	4,086.7	4,086.7
Envelope and windows upgrade (€)	5,000	5,000	5,000	5,000

Sources:

- https://ec.europa.eu/energy/sites/ener/files/documents/2018_06_27_technology_pathways_-_finalreportmain2.pdf
- <https://renewableheatinghub.co.uk/european-heat-pump-association-interview-thomas-nowak>

Building sector's ETS cost evolution (€/tn)

(2023-2025)	0
2025	30
2026-2030	50
2031-2050	100

Estimation of cost evolution based on the evolution of EU's established ETS system:

<https://tradingeconomics.com/commodity/carbon>



The SENTINEL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837089.



NEW RESULTS (9/14)

Fuel & Electricity cost savings due to renovations...

Fuel & Electricity costs without renovations (€)

	2022	2025	2030	2035	2040	2045	2050
	9,909M.	10,373M.	11,148M.	11,306M.	11,464M.	11,622M.	11,780M.

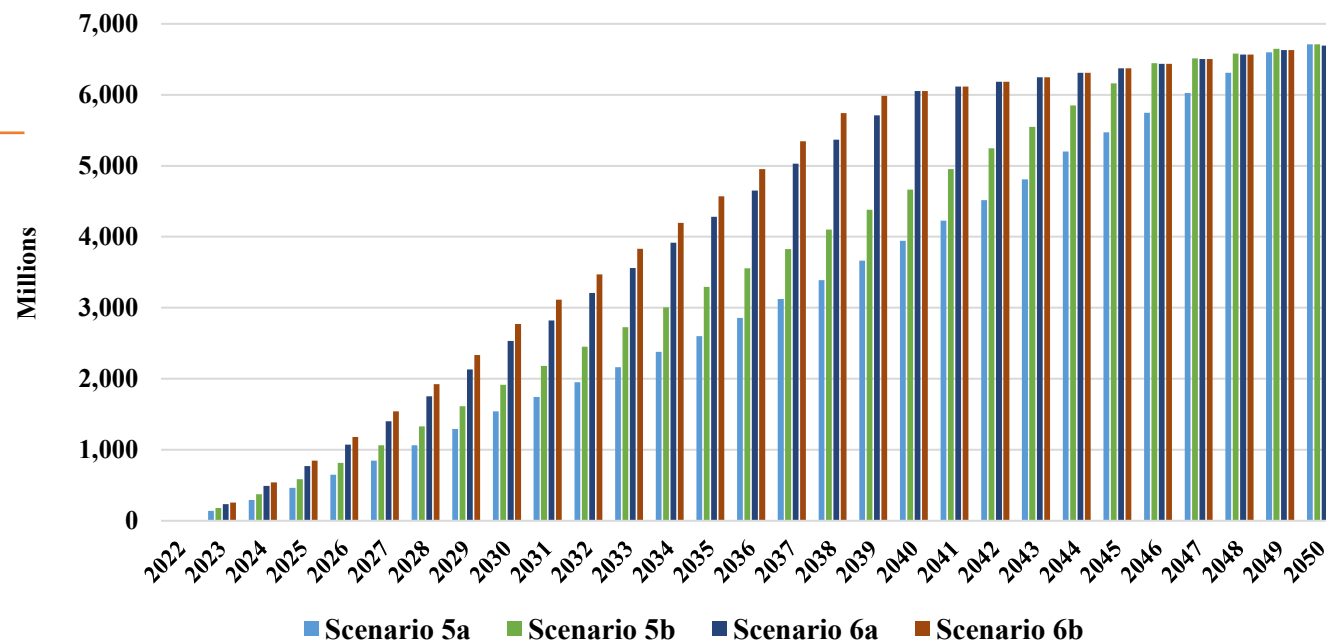
Fuel & Electricity costs with renovations (€)

	2022	2025	2030	2035	2040	2045	2050
Scenario 5a	9,91M.	9,91M.	9,61M.	8,71M.	7,52M.	6,15M.	5,07M.
Scenario 5b	9,91M.	9,79M.	9,23M.	8,01M.	6,80M.	5,46M.	5,07M.
Scenario 6a	9,91M.	9,61M.	8,62M.	7,03M.	5,41M.	5,25M.	5,07M.
Scenario 6b	9,91M.	9,53M.	8,38M.	6,73M.	5,41M.	5,25M.	5,07M.

Total fuel & electricity cost savings (€)

Scenario 5a	89,709.35M.
Scenario 5b	102,707.08M.
Scenario 6a	119,039.39M.
Scenario 6b	122,708.50M.

Fuel & Electricity cost savings (€)

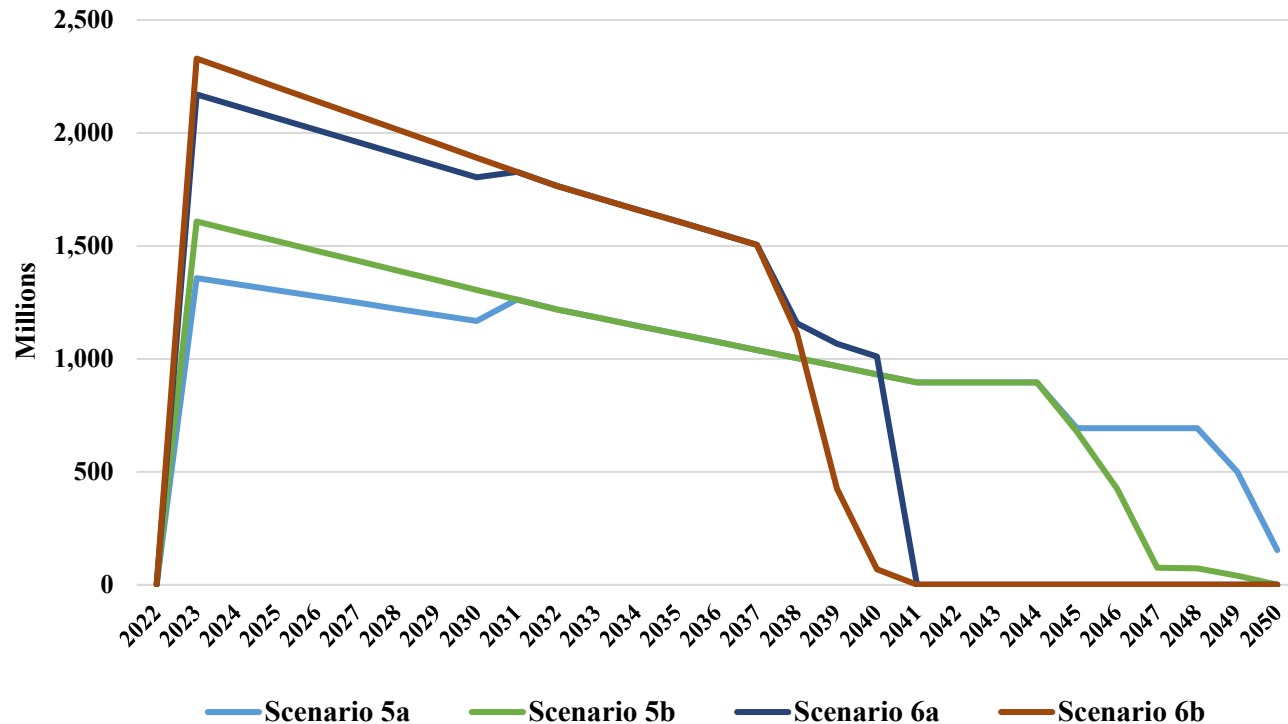


- ✓ Investing in **electrification** rather than in natural gas leads to **less** total fuel costs.
- ✓ Decarbonisation **by 2040** leads to **more** fuel cost savings.

NEW RESULTS (10/14)

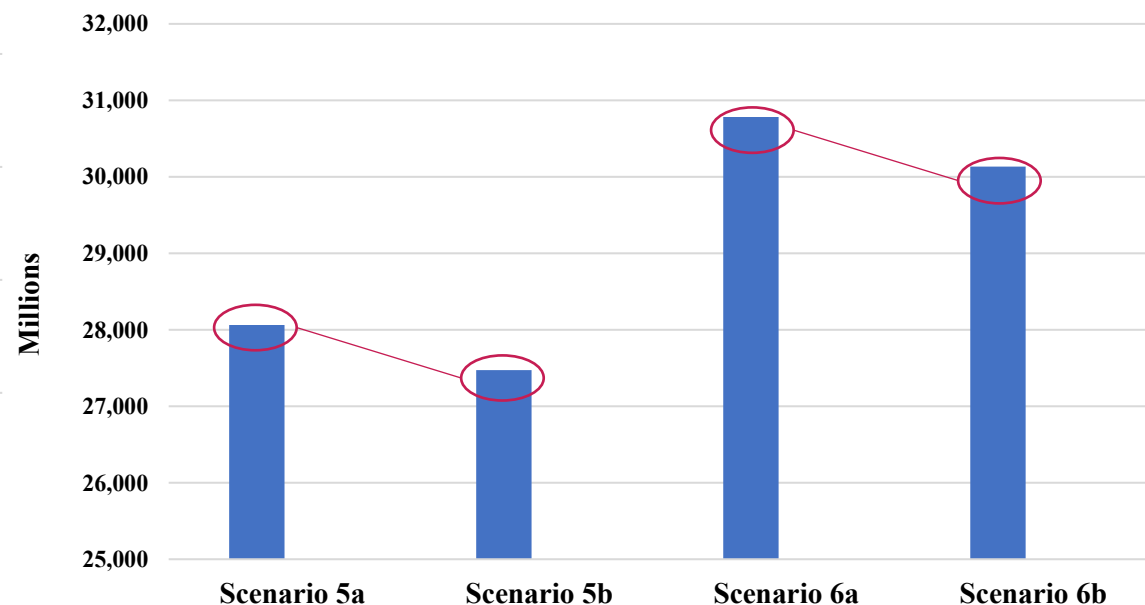
Renovation costs...

Annual cost of renovations (€)



Investing in electrification leads to **lower** renovation costs.

Total renovation costs (€)



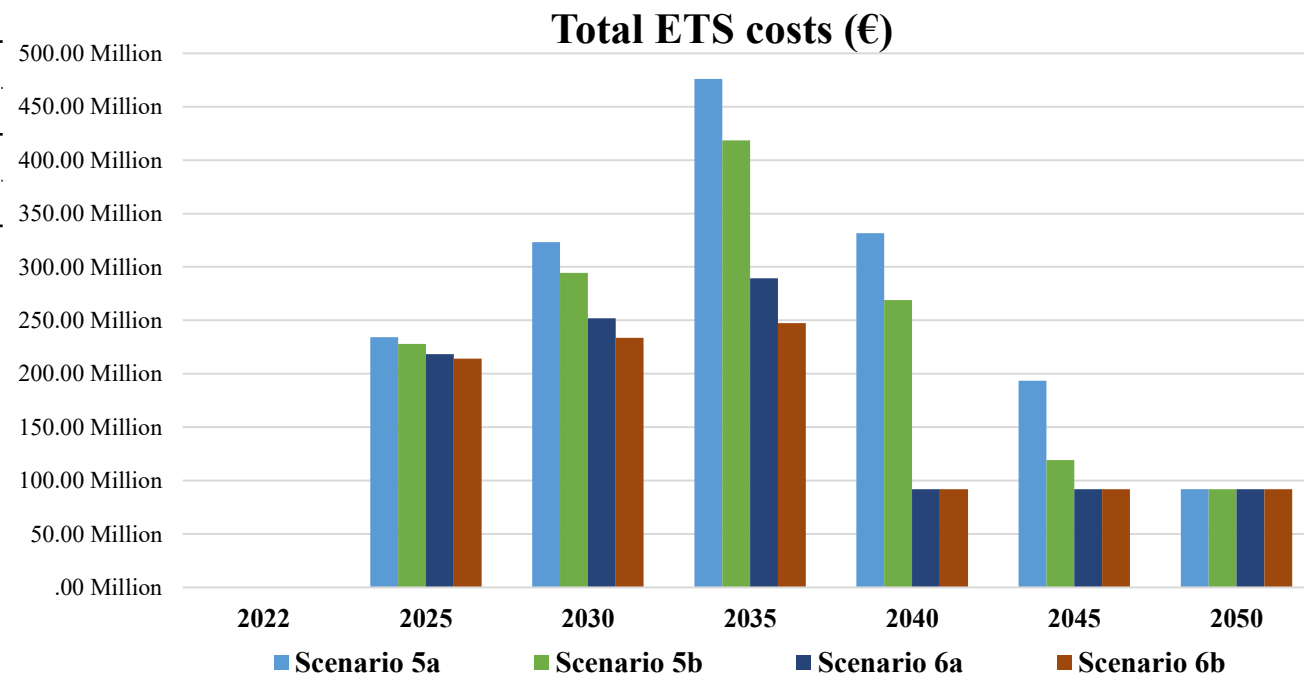
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NEW RESULTS (11/14)

And if we also consider ETS-relevant costs for an ETS price of 30-100 €/tnCO₂ (1/2)...

	2022	2025	2030	2035	2040	2045	2050
Scenario 5a							
Total ETS cost (€)	.00M.	234.30M.	323.30M.	476.02M.	331.47M.	193.52M.	91.86M.
Scenario 5b							
Total ETS cost (€)	.00M.	227.79M.	294.36M.	418.37M.	268.84M.	119.30M.	91.86M.
Scenario 6a							
Total ETS cost (€)	.00M.	218.22M.	251.82M.	289.24M.	91.86M.	91.86M.	91.86M.
Scenario 6b							
Total ETS cost (€)	.00M.	214.10M.	233.53M.	247.46M.	91.86M.	91.86M.	91.86M.



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NEW RESULTS (12/14)

And if we also consider ETS-relevant costs for an ETS price of 30-100 €/tnCO₂ (2/2)...

Extra ETS charges will most probably be undertaken by households...

	2022	2025	2030	2035	2040	2045	2050	Total
ETS cost without renovations (€)	.00 M.	258.49M.	430.82M.	861.65M.	861.65M.	861.65M.	861.65M.	
Potential extra charges in bill/household without renovations (€)	0	60	100	200	200	200	200	4,549
Scenario 5a								
Money saved due to renovations (€)	.00M.	24.19M.	107.52M.	385.62M.	530.17M.	668.13M.	769.79M.	
Potential extra charges in bill/household with renovations (€)	0	54	75	110	77	45	21	1,971
Scenario 5b								
Money saved due to renovations (€)	.00M.	30.70M.	136.47M.	443.27M.	592.81M.	742.34M.	769.79M.	
Potential extra charges in bill/household with renovations (€)	0	53	68	97	62	28	21	1,691
Scenario 6a								
Money saved due to renovations (€)	.00M.	40.28M.	179.01M.	572.40M.	769.79M.	769.79M.	769.79M.	
Potential extra charges in bill/household with renovations (€)	0	51	58	67	21	21	21	1,245
Scenario 6b								
Money saved due to renovations (€)	.00M.	44.39M.	197.29M.	614.19M.	769.79M.	769.79M.	769.79M.	
Potential extra charges in bill/household with renovations (€)	0	50	54	57	21	21	21	1,132

Electrification leads to **lower ETS charges** per household

Decarbonisation by 2040 leads to **lower ETS charges** per household



NEW RESULTS (13/14)

Cross-scenario comparison - Household level

	2022	2025	2030	2035	2040	2045	2050	Total
Potential extra charge on bill/household and fuel costs per household without renovations (ETS 30-100) (€)	2,295	2,462	2,681	2,817	2,854	2,891	2,927	79,654
Scenario 5a								
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	2,295	2,651	2,570	2,392	2,041	1,632	1,230	62,893
Scenario 5b								
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	2,295	2,621	2,476	2,210	1,853	1,436	1,227	59,437
Scenario 6a								
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	2,304	2,753	2,471	2,067	1,508	1,236	1,199	55,913
Scenario 6b								
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	2,295	2,734	2,412	1,989	1,434	1,236	1,199	54,792

Electrification leads to **lower total charges** per household

Decarbonisation by 2040 leads to **lower total charges** per household



NEW RESULTS (14/14)

Cross-scenario comparison - National level

	2022	2025	2030	2035	2040	2045	2050	Total	Money Saved (€)
Potential extra charge on bill/household and fuel costs per household without renovations (ETS 30-100) (€)	9,91M.	10,63M.	11,58M.	12,17M.	12,32M.	12,48M.	12,64M.	343,99M.	-
Scenario 5a									
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	9,91M.	11,45M.	11,10M.	10,33M.	8,81M.	7,05M.	5,31M.	271,60M.	72,38M.
Scenario 5b									
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	9,91M.	11,32M.	10,69M.	9,54M.	8,00M.	6,20M.	5,30M.	256,68M.	87,31M.
Scenario 6a									
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	9,91M.	11,89M.	10,67M.	8,92M.	6,51M.	5,34M.	5,18M.	241,46M.	102,53M.
Scenario 6b									
Potential extra charge on bill/household and fuel costs per household with renovations (ETS 30-100) (€)	9,91 M.	11,81M.	10,42M.	8,59M.	6,19M.	5,34M.	5,18M.	236,62M.	107,37M.

Electrification leads to more money savings

Decarbonisation by 2040 leads to more money savings



CONCLUSIONS & POLICY IMPLICATIONS



- ❖ By following the **NECP renovation rates** (60,000 homes/year, **~1.5%**) **decarbonisation** of the residential sector by 2050 in Greece **cannot be achieved**.
- ❖ When investing in **electrification**, the **earlier** the phase out of **natural gas**, the **higher** the final consumption, as well as the fuel, the renovation, and the ETS costs.
- ❖ To achieve decarbonisation in the Greek residential sector by:
2050: **100,000** renovations/year are required (**~2.5%**).
2040: **145,000** renovations/year are required (**~3.5%**).
- ❖ To achieve **decarbonisation**, investing in **electrification** leads to **lower** ETS, fuel, and renovation costs, and, thus, **lower total costs** at both the household and the national level, in comparison to **investing in natural gas as transition fuel**.
- ❖ Achieving **decarbonisation** by **2040** leads to **lower** ETS, fuel, and **total costs** at both the household and the national level, compared to **achieving decarbonisation by 2050**.



FOR MORE INFORMATION...

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UNIVERSITY OF PIRAEUS
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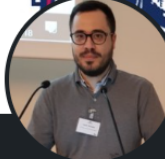

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TECHNOECONOMICS OF ENERGY SYSTEMS LAB



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Thank you!

