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Evaluating the Greek NCEP: Energy-Emissions assessment for the Industry Sector

10th HAEE Energy Transition Symposium
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Decarbonization, climate policy & research outlook

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200 RESEARCHERS | 100 PROJECTS | 120 COUNTRIES | 150 CONFERENCES | 1,000 PUBLICATIONS | 500M MILLION FUNDING

WORLD LARGEST RESEARCH AND INNOVATION TEAM ON SCIENCE-BASED SUSTAINABILITY TRANSITION

Research and Innovation Centers

- ReSEES Research Laboratory - Athens University of Economics and Business
- Stochastic Modeling and Applications Laboratory - Athens University of Economics and Business
- Sustainable Development Unit - Athena Research Center
- Department of Technology, Management, and Economics - Technical University of Denmark

Innovation Acceleration Hubs

- UN Climate Change Global Innovation Hub
- EIT Climate-KIC
- Brigaid Connect
- MENA Maritime Accelerator
- Black Sea Accelerator

Science - Policy Networks

- Sustainable Development Solutions Network (SDSN)
- SDSN Global Climate Hub
- SDSN Europe
- SDSN Greece
- Water Europe
- Nexus cluster

Scientific Associations and Academies

- World Council of Environmental and Resource Economists Associations (WCEREA)
- European Association of Environmental and Resource Economists (EAERE)
- World Academy of Art and Science (WAAS)
- Academia Europaea
- European Academy of Sciences and Arts
- InterAcademy Partnership (IAP)

SDGs - ESG measurment
Sustainable Finance

Sustainable pathways to
Climate Neutrality and Resilience

Sustainable pathways for
Seas and Oceans

Sustainable pathways
Land Use and WFEB Nexus

Innovation Acceleration
Education Upskilling Reskilling

Prof. Phoebe Koundouri Founder and Scientific Chair
phoebekoundouri.org

The Global Climate Hub (GCH)

Q&A

https://doi.org/10.1038/s41893-024-01289-8

The Global Climate Hub

Check for updates

Phoebe Koundouri, Professor of Environmental Economics and Sustainability at Athens University of Economics and Business, talks to *Nature Sustainability* about how the Global Climate Hub can help countries achieve sustainability against the backdrop of interconnected, complex challenges.

What is the Global Climate Hub?

The Global Climate Hub (GCH), an innovative initiative under the United Nations Sustainable Development Solutions Network (SDSN), focuses on the development of science-based solutions and regional, national and sub-national pathways for the transition to a climate-neutral and resilient world. These efforts are co-designed with, for example, central and local government representatives and the respective SDSN national hubs. As the aim is to deliver optimal dynamic mixtures of technological, policy, fiscal and financial measures to help countries reach climate neutrality and resilience, fostering cross-disciplinary collaboration and on governance. Our current economic system is based on unsustainable production and consumption practices responsible for frightening global temperature increases that threaten both natural ecosystems and human well-being; they impact social inequalities, public health and economies worldwide. That is why we need urgent and collaborative action from all segments of society.

systems. The second is the development of a socio-economic narrative for a just and equitable implementation of the science-based pathways. The third is adopting transformative participatory stakeholder approaches to co-design pathways, co-owned across scientists and technology developers, politicians, policymakers, finance and business sectors, non-governmental organizations and civil society. The fourth is developing powerful digital artificial intelligence (AI)-driven infrastructure that supports model and data integration, as well as data harmonization, management and visualization.

The GCH consists of nine separate units – data platforms and digital applications, atmospheric physics and climatology, energy and transport systems modelling, land, water–food–energy–biodiversity and marine systems modelling, climate and health, innovation/acceleration, policy, finance and labour markets for just transition, transformative and participatory approaches, and finally education, training, upskilling and reskilling.

The activities of each unit intersect with, and feed into, an overarching strategy facili-

- The Global Climate Hub (GCH), an innovative initiative under the United Nations Sustainable Development Solutions Network (SDSN)
- It focuses on the development of science-based solutions, and regional, national, and sub-national pathways for the transition to a climate neutral and resilient world.
- The GCH consists of 9 separate Research Units – working in coordination, to achieve a *just and equitable* implementation of science-based sustainable pathways.

COP28 UAE
BRINGING THE WORLD TOGETHER

Learn more about SDSN Global Climate Hub's involvement in COP28

SDSN Global Climate Hub

Climate Data Platforms and Digital Applications

Inter-disiplinary mathematical MODELLING: Resilient Mitigation and Adaptation Pathways

DownScaling Climate Scenarios | Energy & Transport Systems | Land & Marine Systems | Health Systems | Socio-Economic Systems

Trans-disciplinary CO-DESIGN: Resilient Mitigation and Adaptation Pathways

Innovation Incubation Acceleration | Transformative Participatory Approaches | Education Training

Model: Simulated scenarios for Greece

Considering the following scenarios:

(a) the do-nothing scenario (business-as-usual - **BAU**) which assumes that the current trends will continue applying until 2050;

(b) the **NECP** (National Energy Climate Plan) scenario which assumes that the main sectors climate-neutrality policies are jointly implemented. [e.g. cleaner fuels & increased energy efficiency]

Sectors	Main policy instruments simulated for the NCNC scenario
Residential, Industry, Transportation, Services	The **Greek National Energy and Climate Plan (NECP),** as defined by the Greek Ministry of Energy and Environment (2024), assumes certain interventions per sector. These refer to improvements of energy use efficiencies and cleaner energy mixes.

Tool: Cross-sectoral Energy-Emissions Analysis

Energy Demand		
Sectors	Activity Level (AL)	Energy uses (and energy intensity, EI)
Residential	Population (distinguished between urban and rural)	Lighting, cooking, space heating, space cooling, water heating, and other appliances
Industry	Value Added of each industry product, or tons of product	Food and tobacco, textiles and leather, wood products, paper pulp and printing, chemicals and chemical products, rubber and plastic, non-metallic minerals, basic metals, machinery, transport equipment, other manufacturing, mining, cement and steel production
Agricultural energy use	Agricultural products (FABLE Calculator's output)	Energy used for the agricultural and livestock products
Transportation	Passengers and freight in passenger/km or tons/km	Cars, light trucks, motorcycles, buses, trains, domestic airplanes, shipping, freight trucks and trains
Services	Number of public buildings	Tertiary sector services
Energy Supply (fuels' production processes to cover the demand)		
Primary Resources	Solar, crude oil, coal lignite, hydropower, wind, coal, municipal solid waste, biofuels	
Secondary Resources	Diesel, petroleum coke, refinery feedstocks, residual fuel oil, kerosene, CNG, LPG, gasoline, Hydrogen, biogas, oil, heat, electricity, synthetic fuels	
Transformation processes	Transmission and distribution, synthetic fuel production, generation of hydrogen, electricity, heat, oil refining – with the associated losses	
GHG emissions		
Types of pollutants	CO_2, CH_4, N_2O, PM2.5, Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulfur Hexafluoride (SF_6), Black Carbon (BC), Organic Carbon (OC)	

LEAP (Low Emissions Analysis Platform)

•Detailed representation of all sectors' energy uses.

The energy demand (D) has been calculated as the product of an activity level (AL) and an annual energy intensity (EI, energy use per unit of activity), according to LEAP's Final Energy Demand Analysis method

$$D_{sector,scenario} = AL_{sector,scenario} \cdot EI_{sector,scenario}$$

•Detailed representation of all primary feedstock fuels, secondary fuels & their transformation processes to feed the demand.

•The GHG emissions are then estimated automatically, based on the emission coefficients of the IPCC's Fifth Assessment Report (IPCC, 2014) per sector, per use and per fuel type for the demand side, and per process for the supply side.

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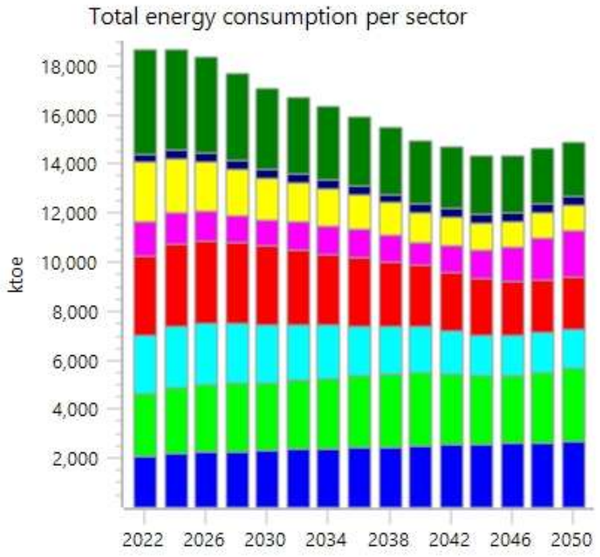
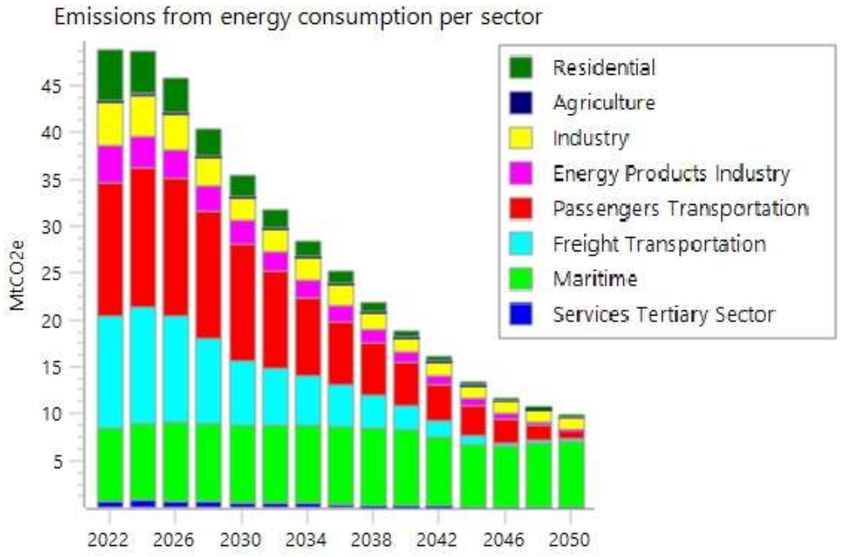
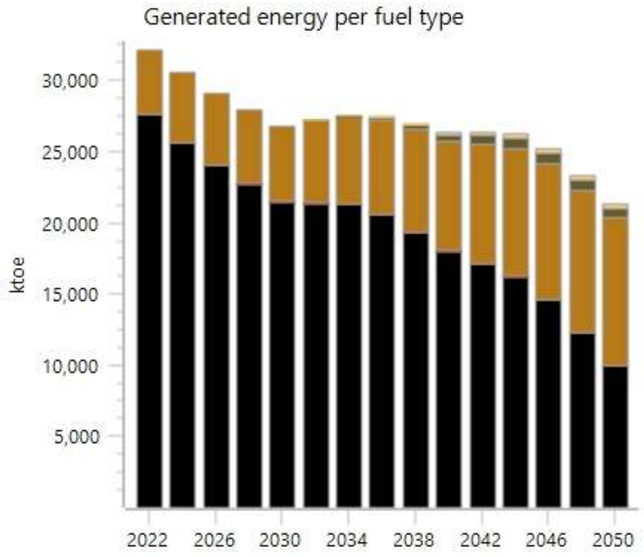
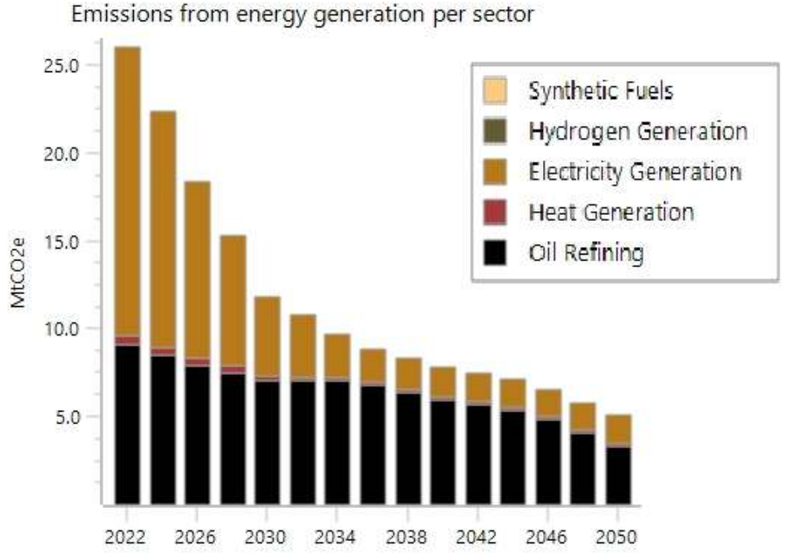
The big picture for Greek Energy System: Cross-sectoral Energy-Emissions Results









- **Energy Consumption & Emissions:** The NCNC scenario reduces total energy demand by 23%, with industry (-58%) and transport (-34%) seeing the largest drops. Residential energy use declines due to population shrinkage & improved efficiencies, while services (+28%) and agriculture (+15%) increase.

- **Energy Supply Shift:** Oil refining drops 3x, while electricity production rises by 6.5 Mtoe in 2050. Hydrogen and synthetic fuels contribute 1.1 Mtoe and 571 ktoe, reducing reliance on fossil fuels and cutting GHG emissions from 26MtCO_2eq (2022) to 5.2MtCO_2eq (2050).

- **Renewable Expansion:** NCNC projections lead to 77% less natural gas use, complete lignite phase-out, and a 540% increase in wind/solar by 2050. Hydropower grows 120%, accelerating the clean energy transition.

- **GHG Emissions (100-Year GWP) Reduction:** NCNC achieves a 91.7% cut in emissions by 2050, reaching near total decarbonization, while BAU trends upward.

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Methodology: Main Data of current conditions

Main data Sources:

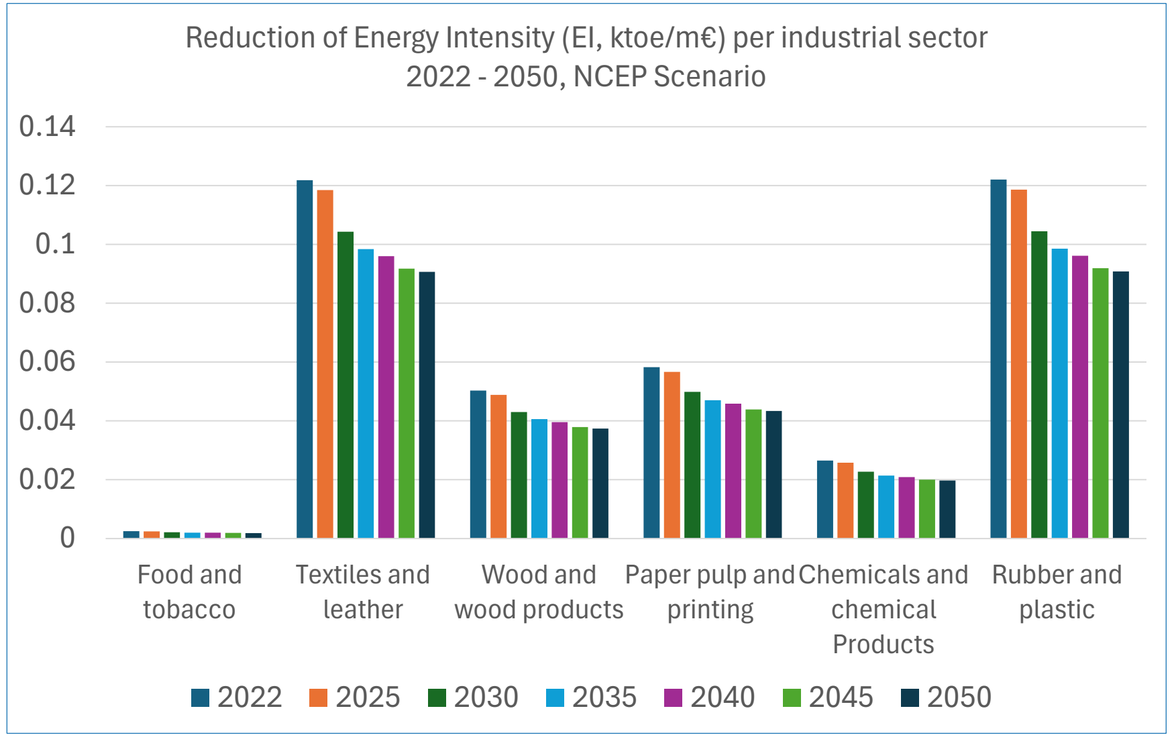
1)https://ec.europa.eu/eurostat/databrowser/view/nrg_d_indq_n__custom_13790290/default/table?lang=en Special filter for energy consumption per fuel and subsector of Industrial consumption

2)https://ec.europa.eu/eurostat/databrowser/view/nrg_bal_c/default/table?lang=en Energy Balance for the entire country

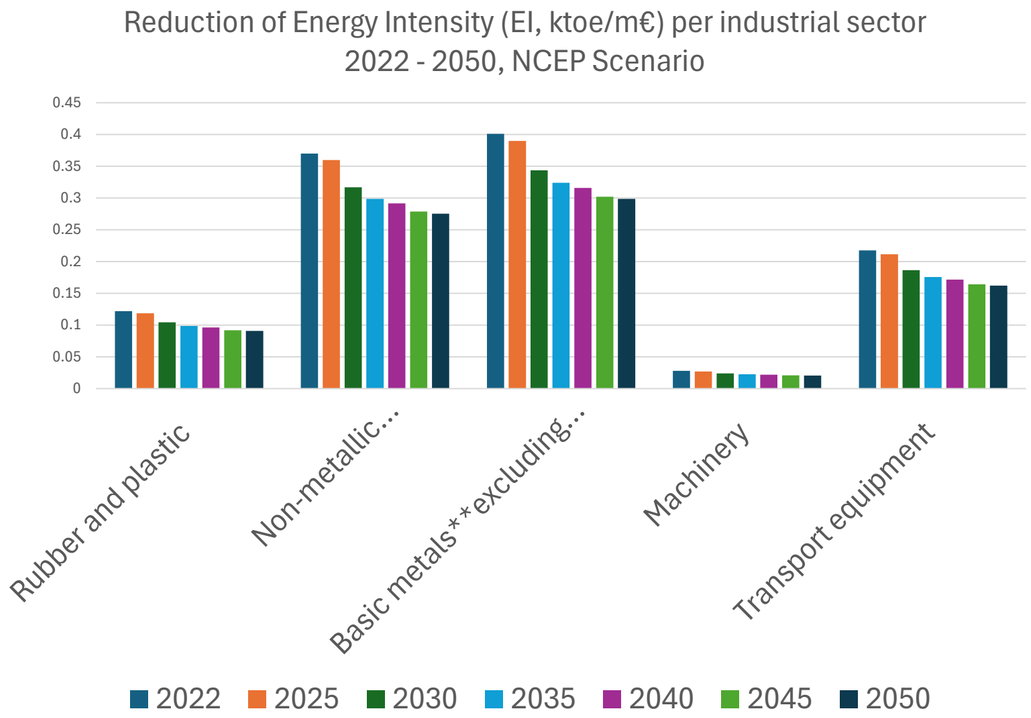
3) https://joint-research-centre.ec.europa.eu/scientific-tools-and-databases-0/potencia-policy-oriented-tool-energy-and-climate-change-impact-assessment/jrc-idees_en Energy Uses in Greek Industrial Sector

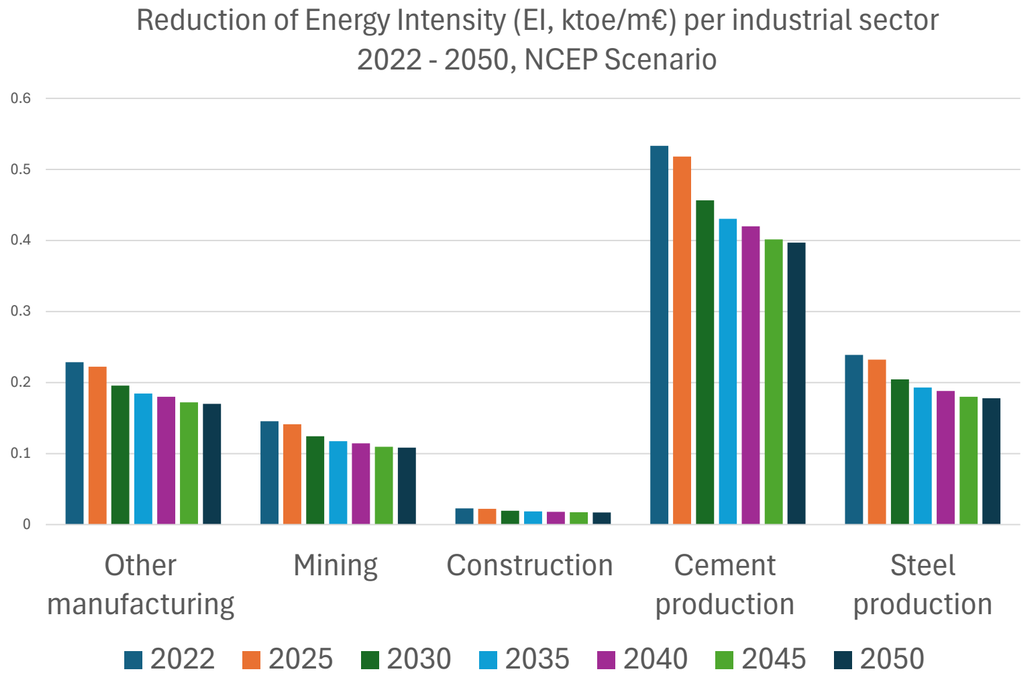
Methodology: Main principles

	Food and tobacco	Textiles and leather	Wood and wood products	Paper pulp and printing	Chemicals and chemical Products
Activity Level VA%	31.38	2.67	0.47	4.06	12.26
Activity Level VA (m€)	9481.00	807.50	142.50	1225.50	3705.00
	Rubber and plastic	**Non-metallic minerals**Excluding cement**ISIC 23 - ISIC 2395**	**Basic metals**excluding steel**	**Machinery**	**Transport equipment**
Activity Level VA%	**3.24**	**4.59**	**6.35**	**11.32**	**1.76**
Activity Level VA (m€)	978.50	1387.00	1919.00	3420.00	532.00
	Other manufacturing	**Mining**	**Construction**	**Cement production**	**Steel production**
Activity Level VA%	**1.73**	**2.17**	**16.73**	**0.78**	**0.50**
Activity Level VA (m€)	522.50	655.50	5054.00	237.02	150.00



Methodology: Main principles, EI reverse estimation





Methodology, An assumption: The overall Activity Level (AL) of industrial sector according OECD Projections

- For alternative scenarios, if the overall Activity Level (AL) of industrial sector is supposed to vary across time period 2022-2050,
- then OECD projections for Europe describe the different shares of the industrial sub-sectors across other economy industries.
- [The Land-Water-Energy Nexus | OECD]

The Land-Water-Energy Nexus

Biophysical and Economic Consequences

Report

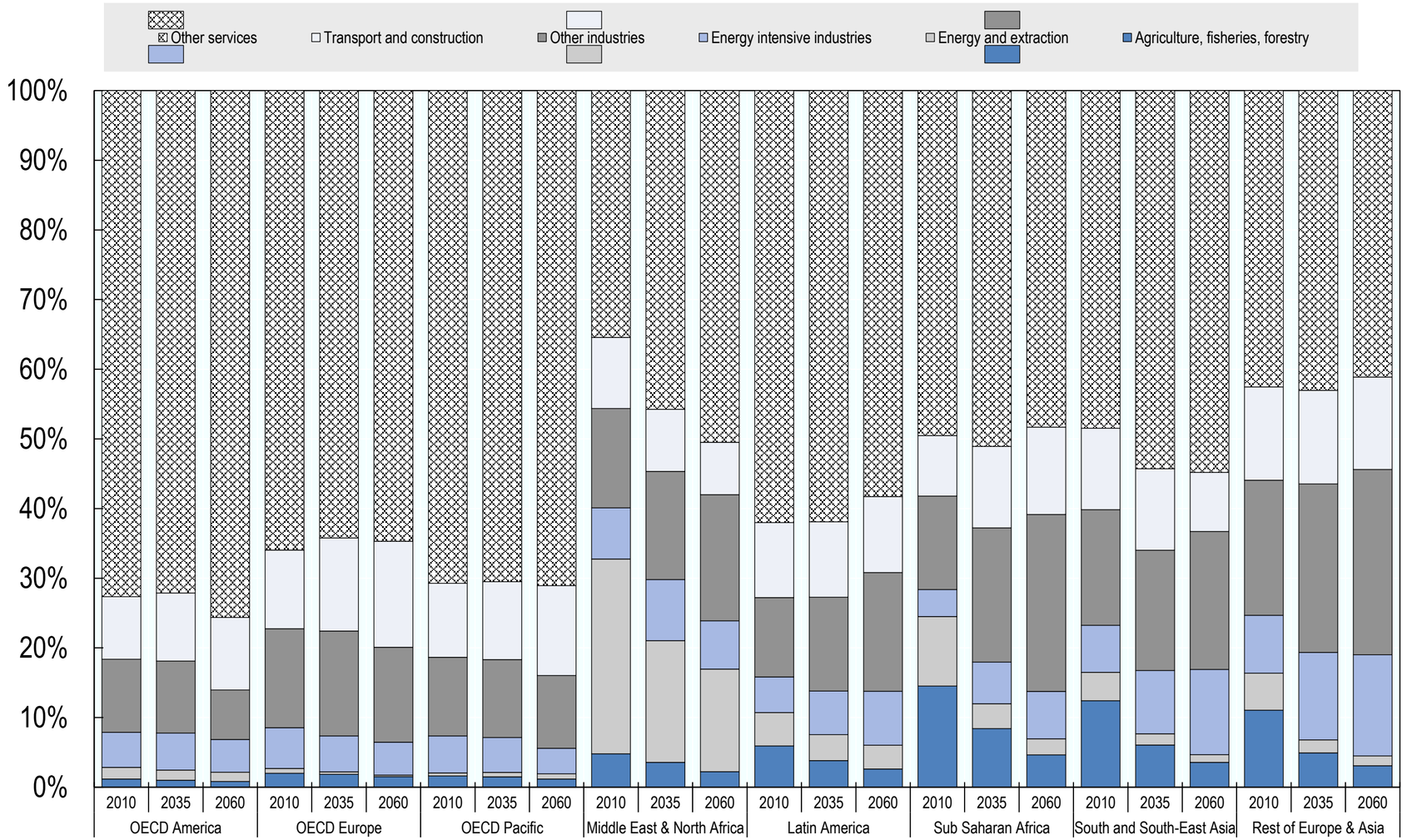
More info

26 September 2017

Changes in share (%) of GDP per economy sector

		Agriculture, fisheries, forestry	Energy and extraction	Energy intensive industries	Other industries	Transport and construction	Other services
OECD America	2010	1.17	1.68	5.01	10.51	8.97	72.66
	2035	1.00	1.47	5.32	10.33	9.76	72.12
	2060	0.82	1.34	4.69	7.11	10.42	75.62
OECD Europe	2010	1.99	0.72	5.83	14.22	11.30	65.95
	2035	1.86	0.35	5.16	15.06	13.37	64.21
	2060	1.51	0.24	4.71	13.62	15.21	64.71

Methodology: The overall Activity Level (AL) of transportation sector according OECD Projections



The Land-Water-Energy Nexus

Biophysical and Economic Consequences

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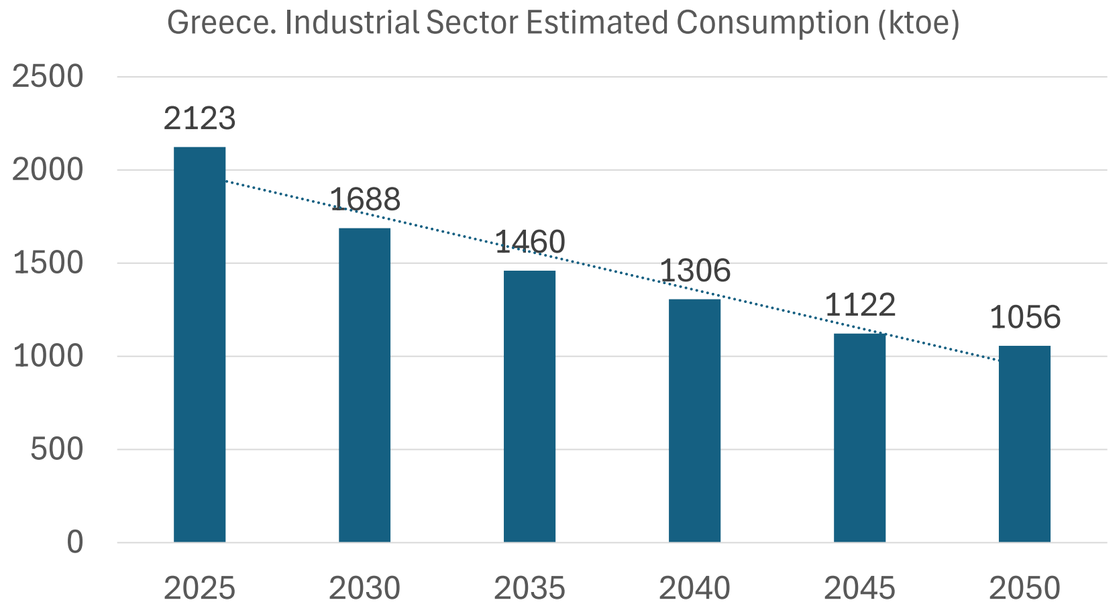
More info

26 September 2017

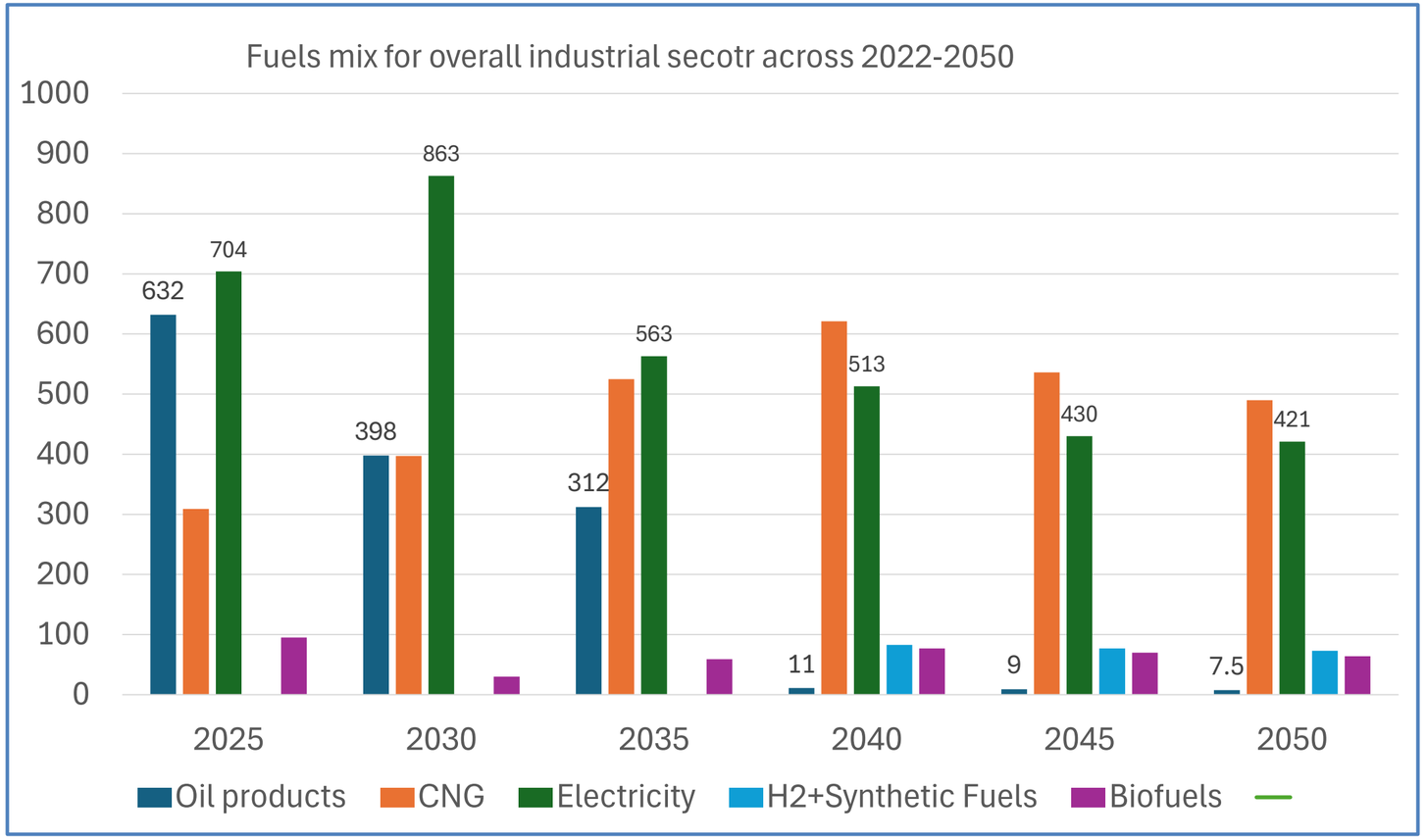
Changes in share (%) of GDP per economy sector

Methodology: Estimated Consumption according to National Climate Neutrality Commitments (NCEP)

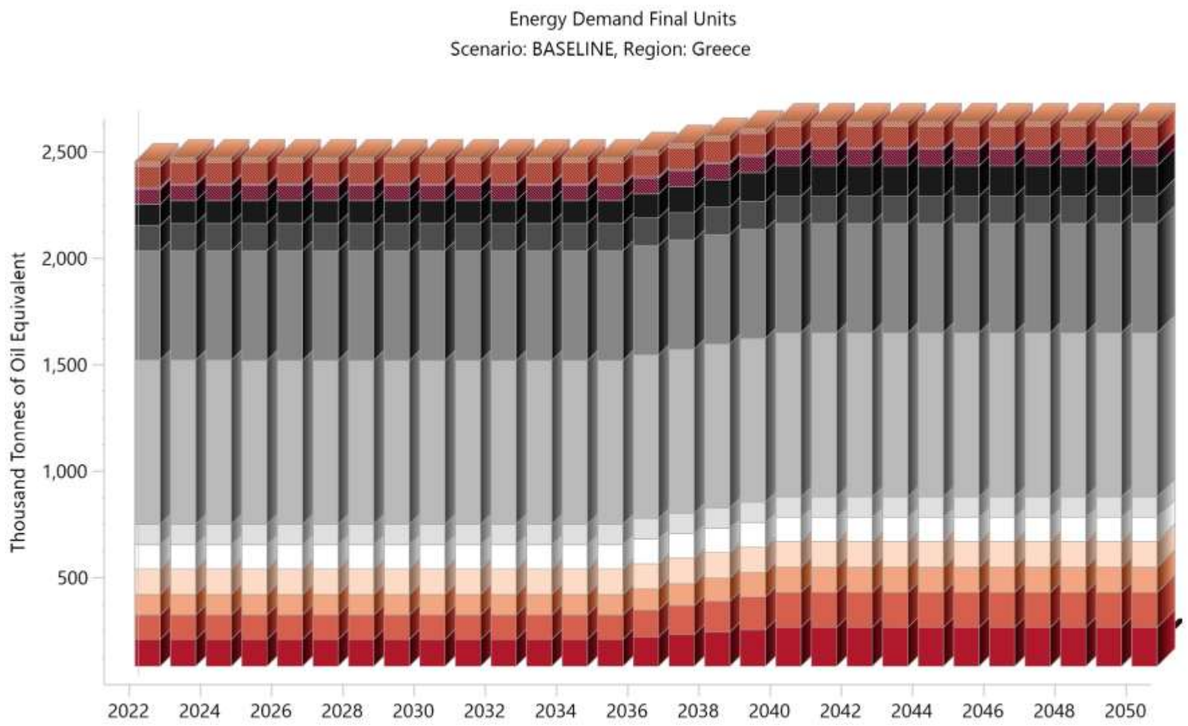


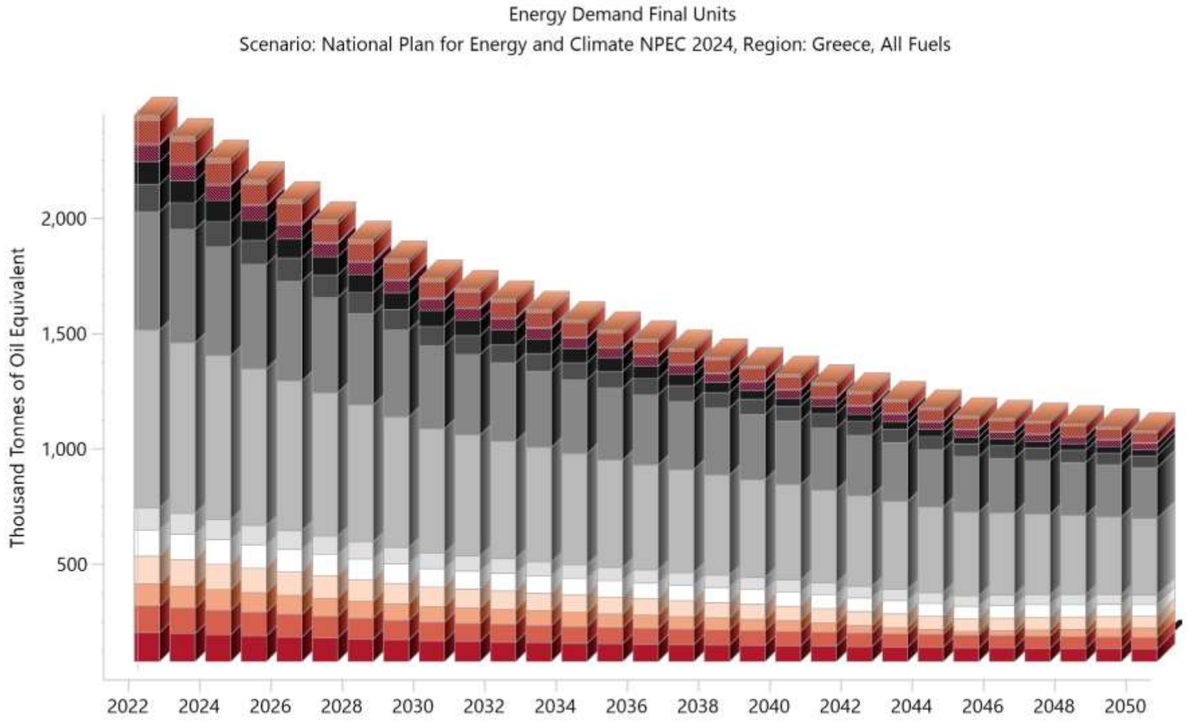
Source: Greek Ministry of Energy & Environment (2024): National Energy & Climate Plan (NECP)

Analysis : Fuel mix across 2022-2050 under NECP. All Industrial Segments

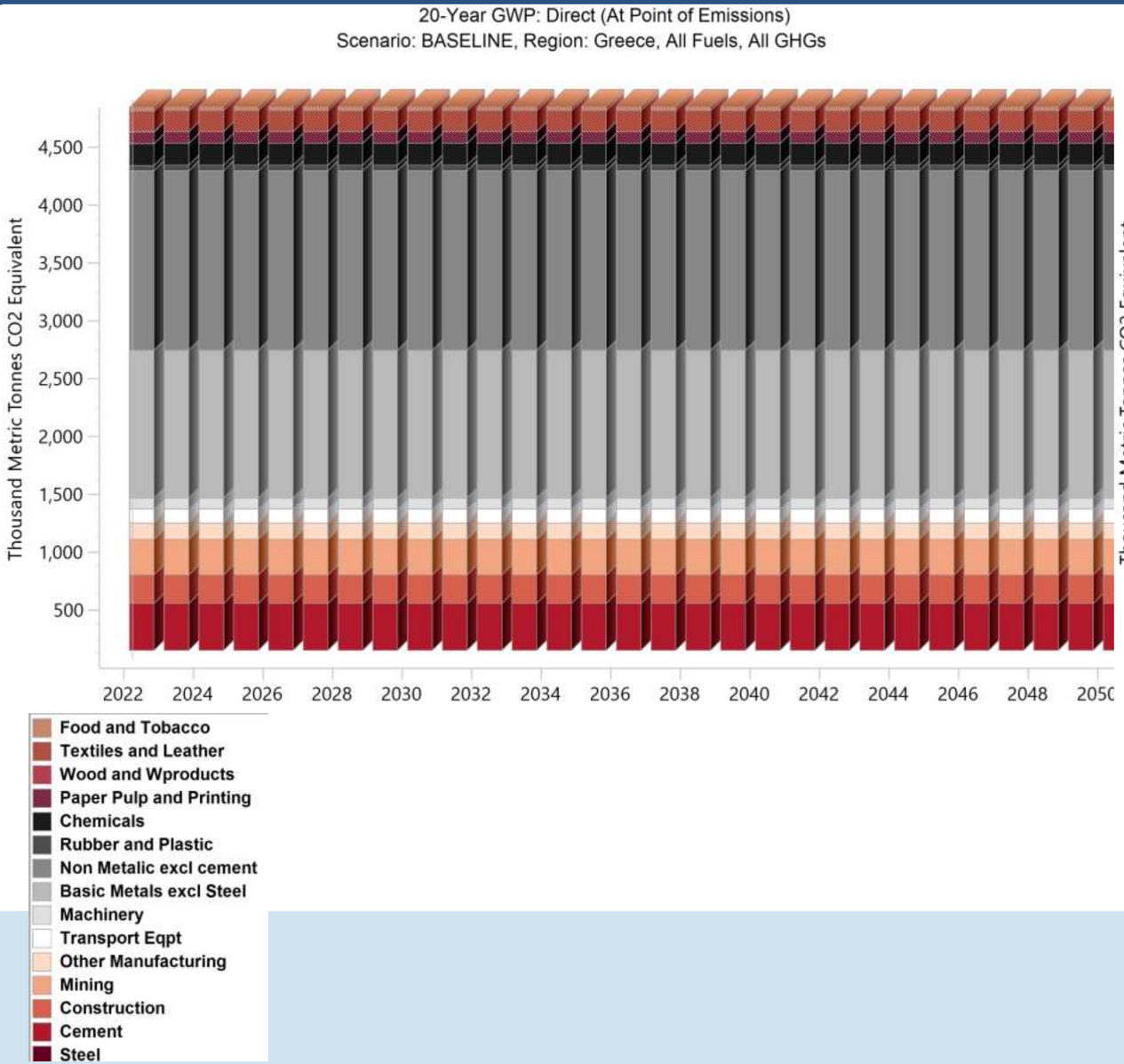


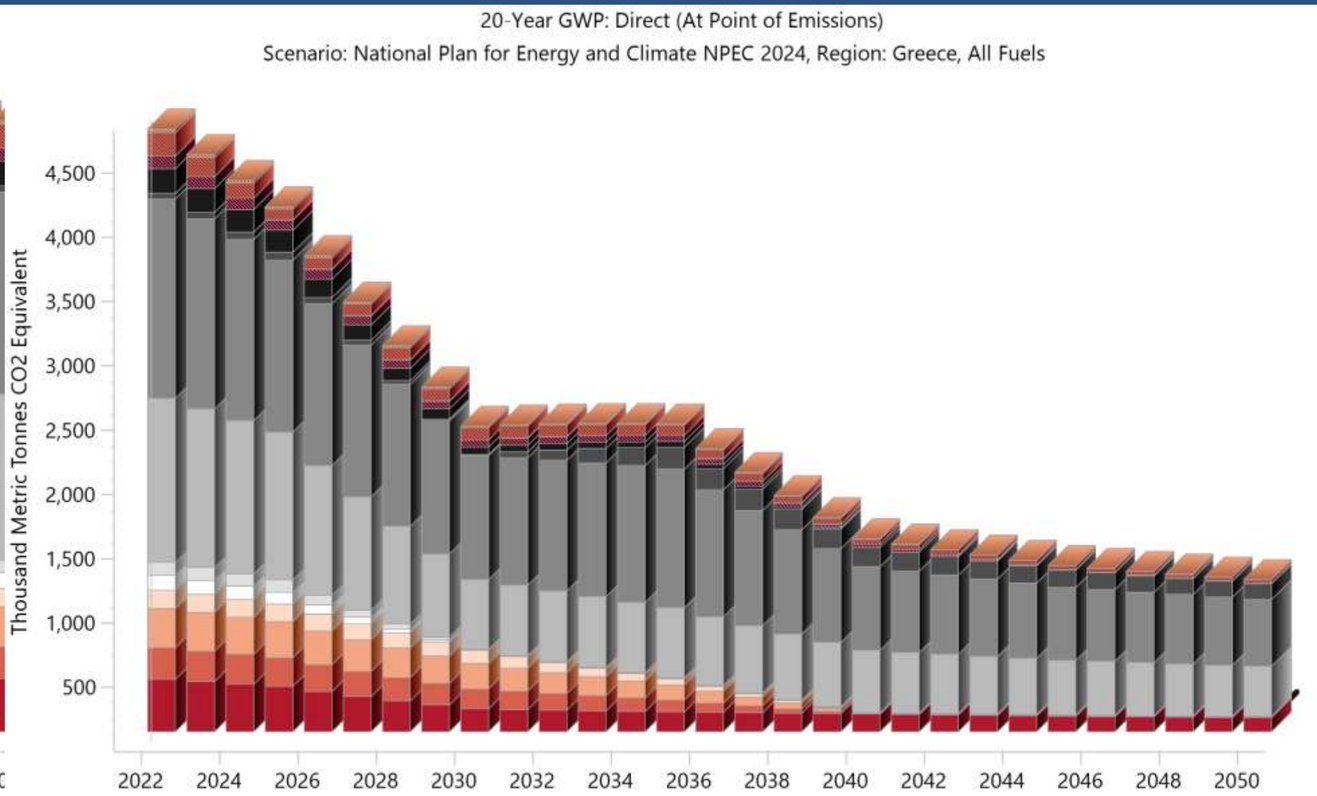
Results: Energy Demand BAU vs NCEP



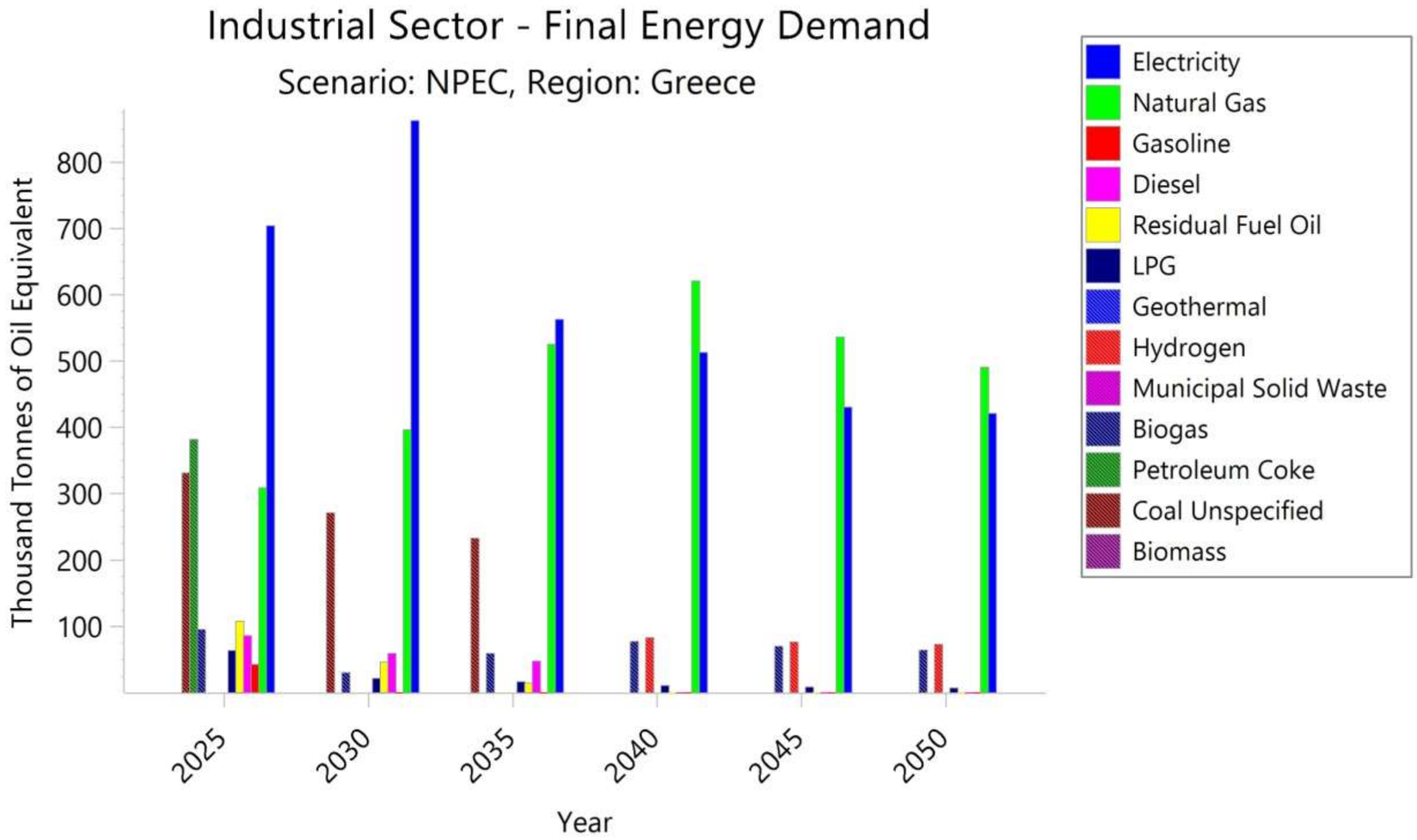


Results: GHG emissions BAU vs NCEP

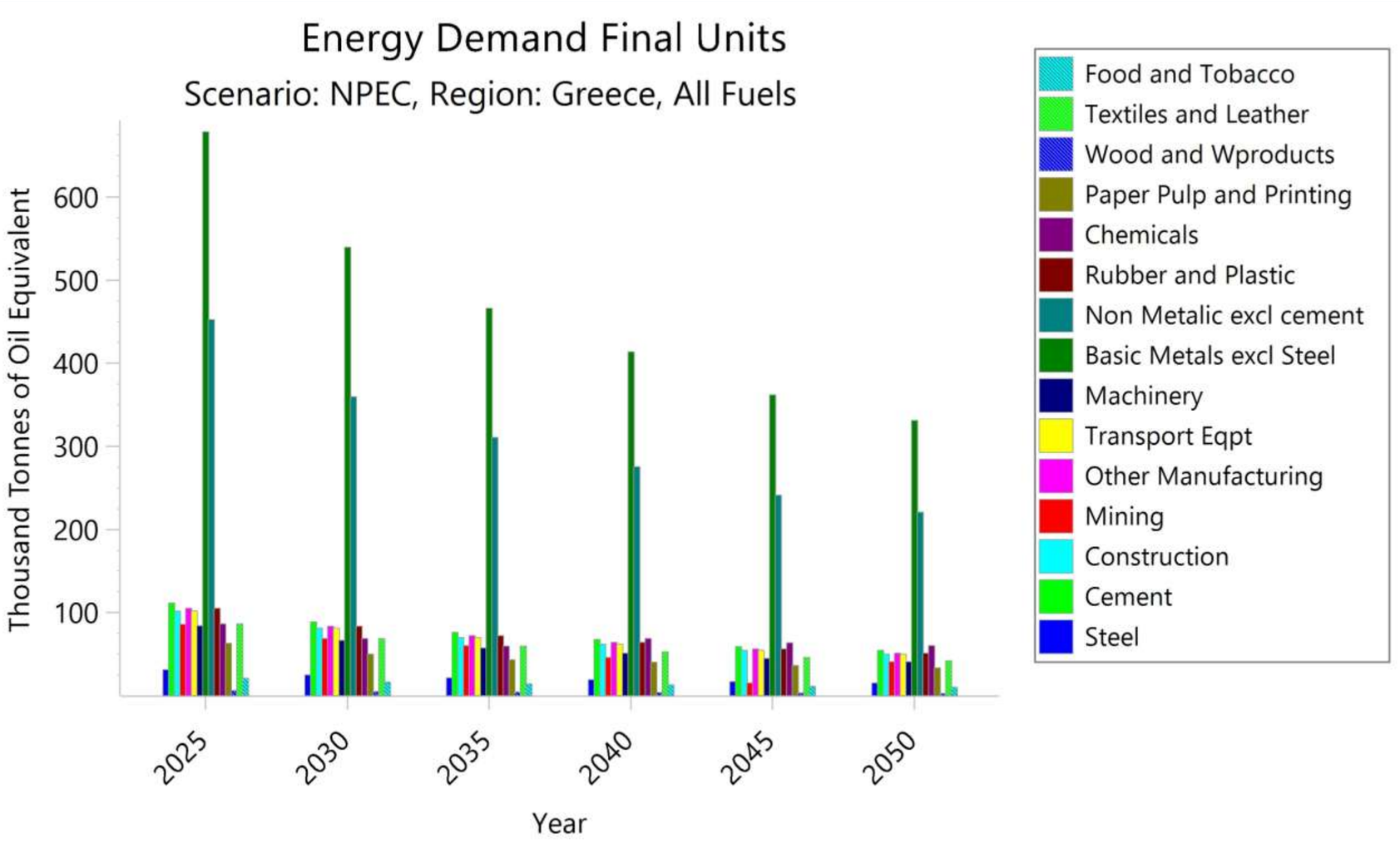




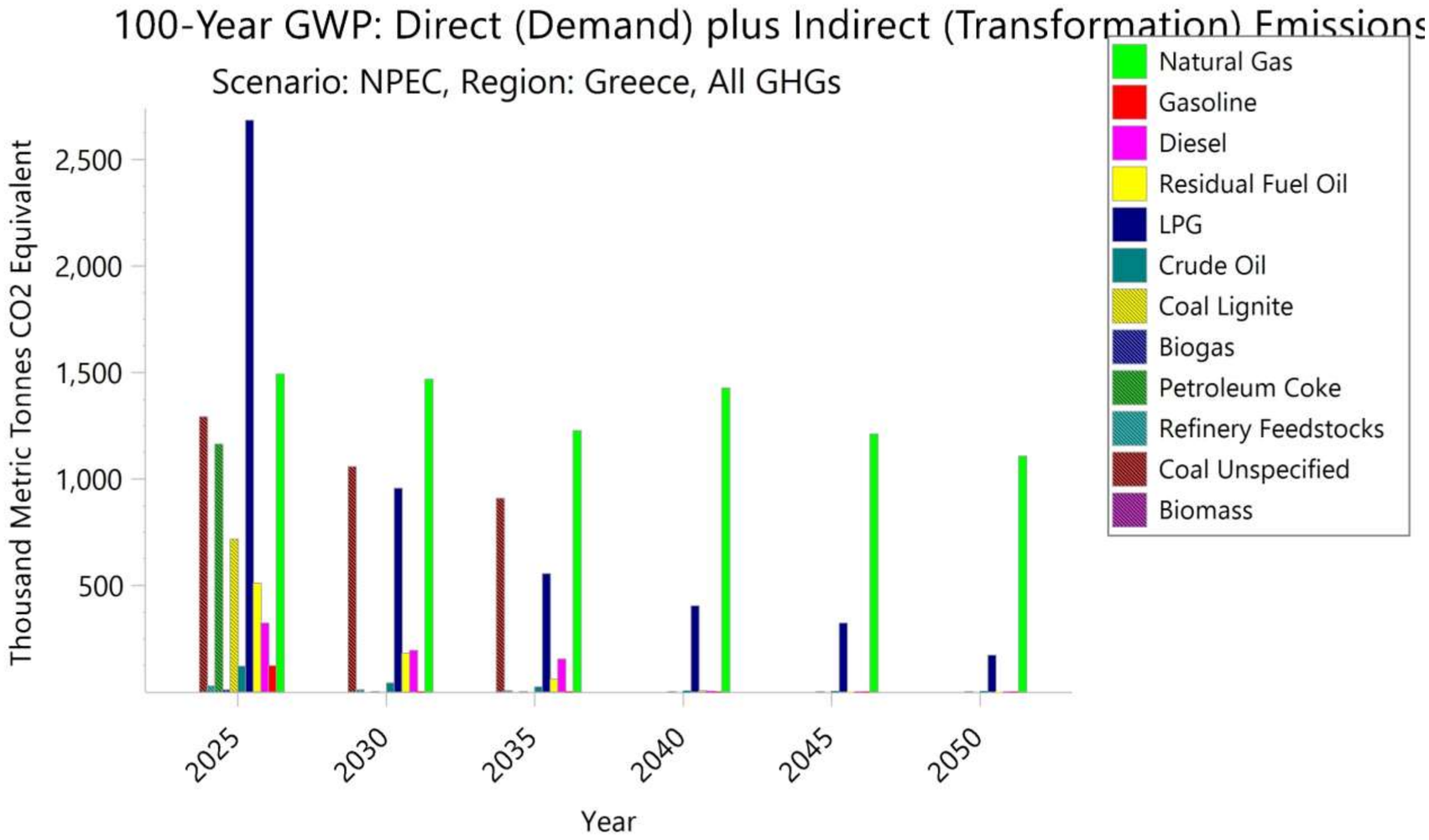
Results: NCEP, Projected Demand per Fuel



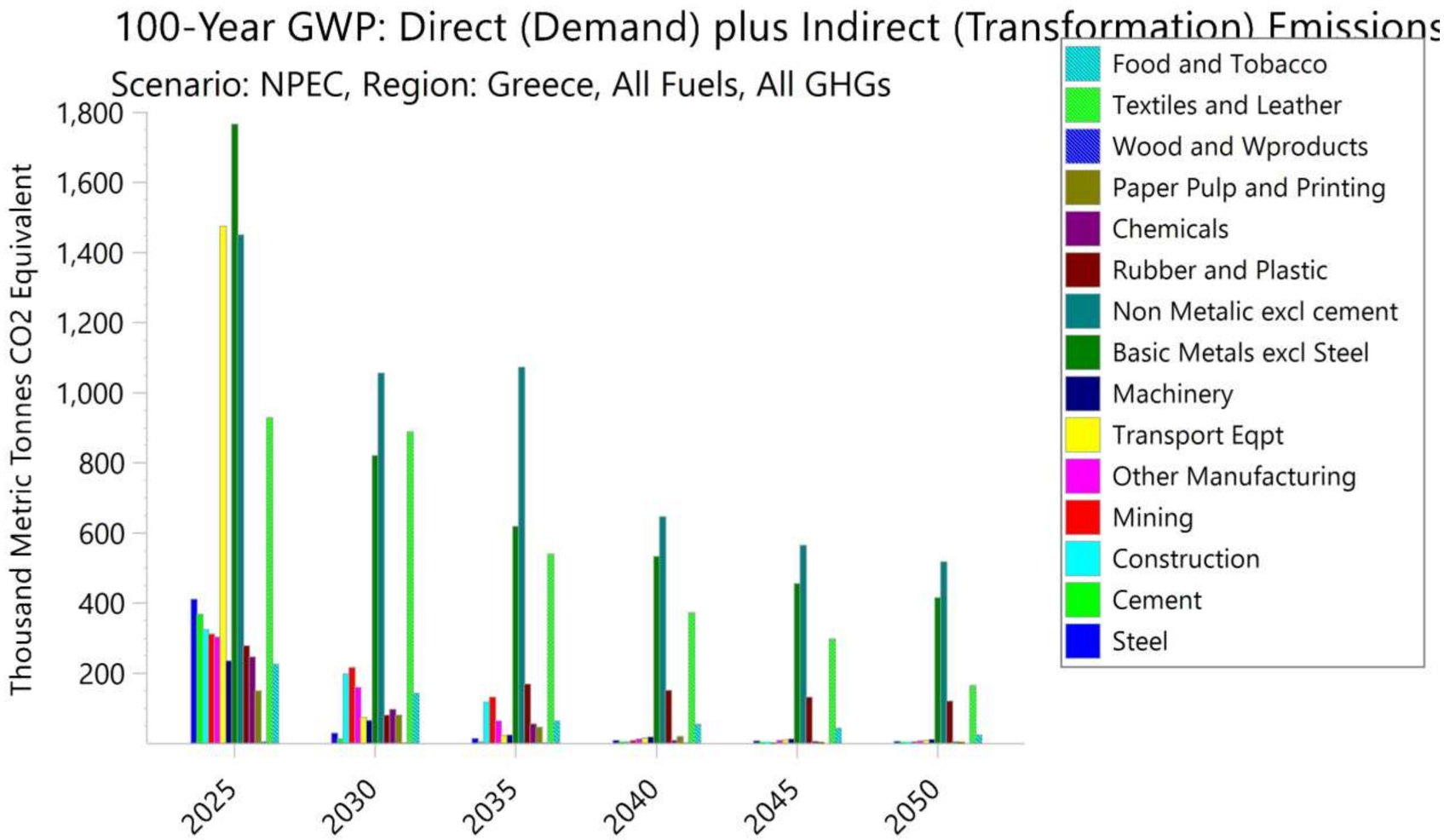
Results: NCEP, Projected Demand per sub-sector



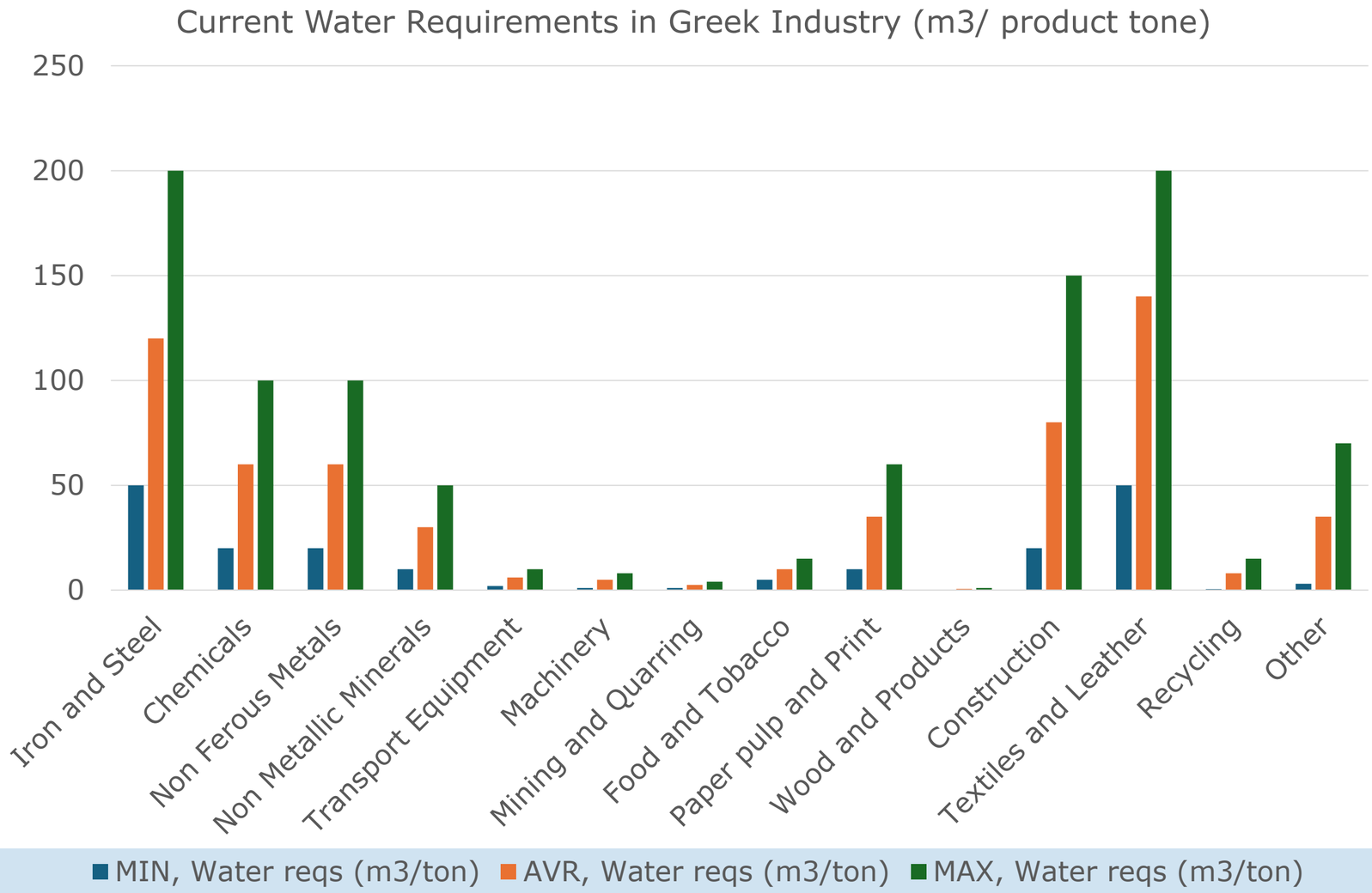
Results: NCEP, Projected GHG Emissions per Fuel



Results: NCEP, Projected GHG emissions per sub-sector



Results: Water Requirements per Industry



Results: Sustainability Considerations for Water use in Industry

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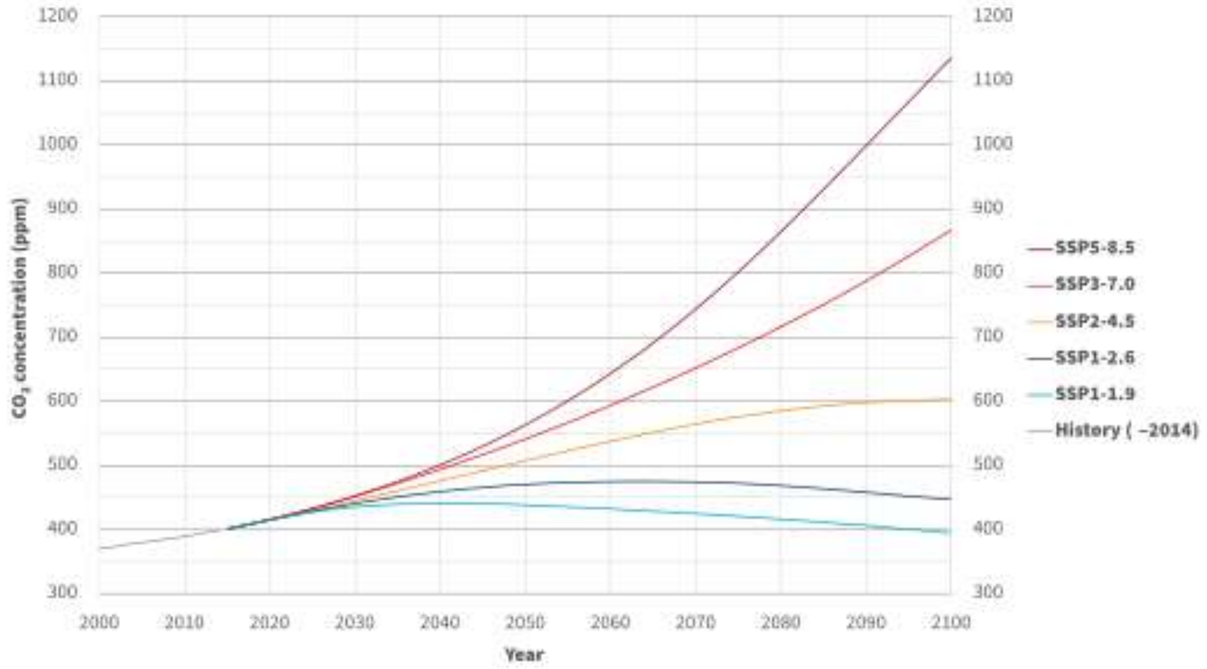
Sustainability Considerations

- Water Recycling and Reuse: Key in almost all industries, particularly where water scarcity is a pressing issue.
- Efficiency Improvements: Upgrading equipment and processes to use less water or use it more efficiently.
- Wastewater Treatment: Employing advanced treatment technologies to meet environmental discharge standards and potential reuse.
- Regulatory Compliance: Adhering to local and European Union regulations regarding water use and quality, which are often stringent and aimed at promoting sustainability.
- Stakeholder Engagement: Collaborating with local communities, governments, and environmental organizations to develop water use practices that benefit all parties.

Alternative Scenarios: The Share Socio-economic Pathways SSP's and their correspondent perspectives for GHG emissions

Shared Socioeconomic Pathways (**SSPs**) are climate change scenarios of projected socioeconomic global changes up to 2100 as defined in the IPCC Sixth Assessment Report on climate change in 2021.[2] They are used to derive greenhouse gas emissions scenarios with different climate policies.[3][4][5] The SSPs provide narratives describing alternative socio-economic developments.



SSP1: Sustainability (Taking the Green Road)

SSP2: Middle of the road (sustainable but Moderate scenario)

SSP3: strong competition between Regions (A Rocky Road)

SSP4: Inequality (A Road Divided)

SSP5: Fossil-Fueled Development (Taking the Highway)

Alternative Scenarios: The Share Socio-economic Pathways SSP's and their correspondent perspectives for GPD Growth

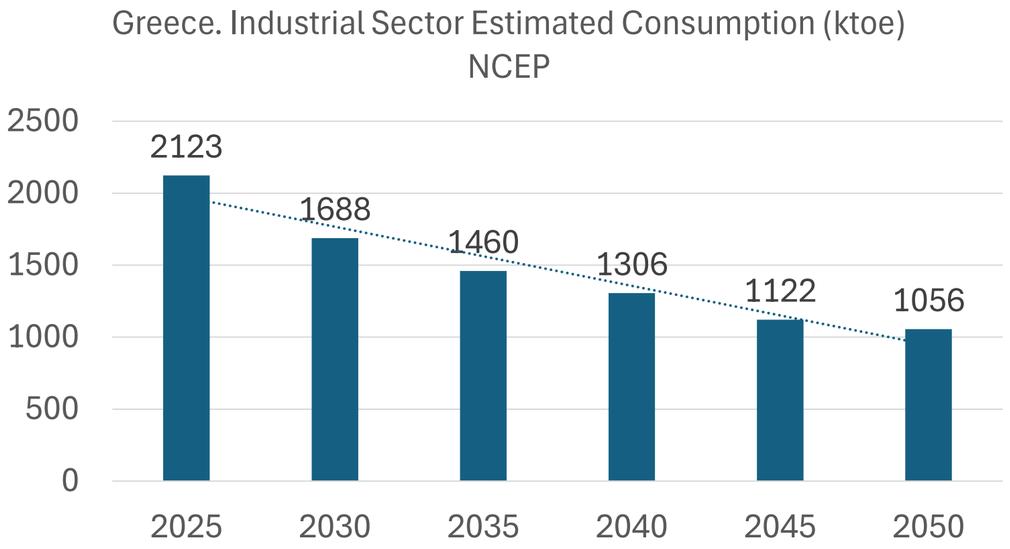
Changes in growth rate of total GDP of Greece, across 2022-2050 period, according to IIASA-OECD sources

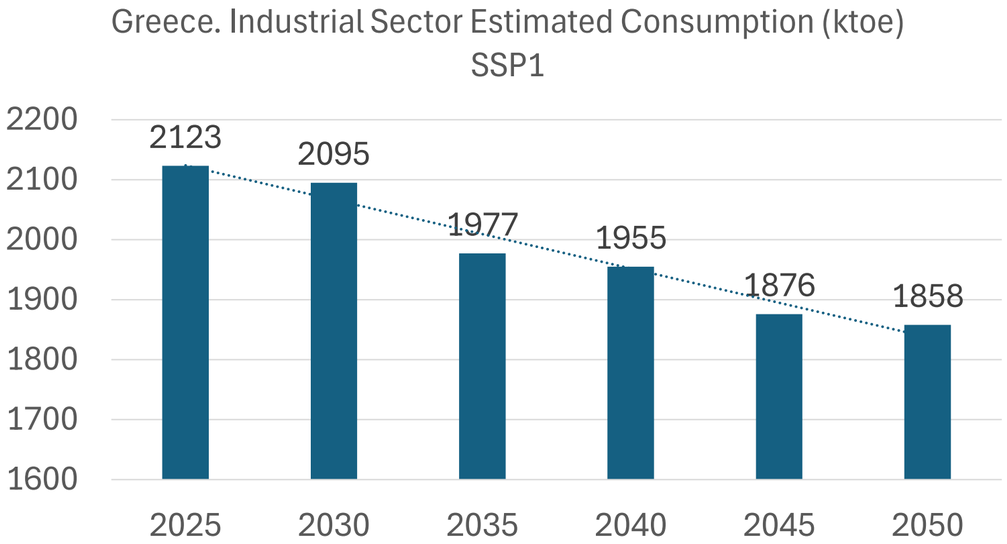
	billion USD_2017/yr	Growth Rate of Greek GDP across time					
Socio-economic scenarios	2022	2025	2030	2035	2040	2045	2050
SSP1	305.6	1.1023	1.1083	1.0909	1.0997	1.0927	1.0793
SSP2	305.6	1.1023	1.1067	1.0796	1.0823	1.0753	1.0676
SSP5	305.6	1.1023	1.1113	1.1135	1.1394	1.1389	1.1237

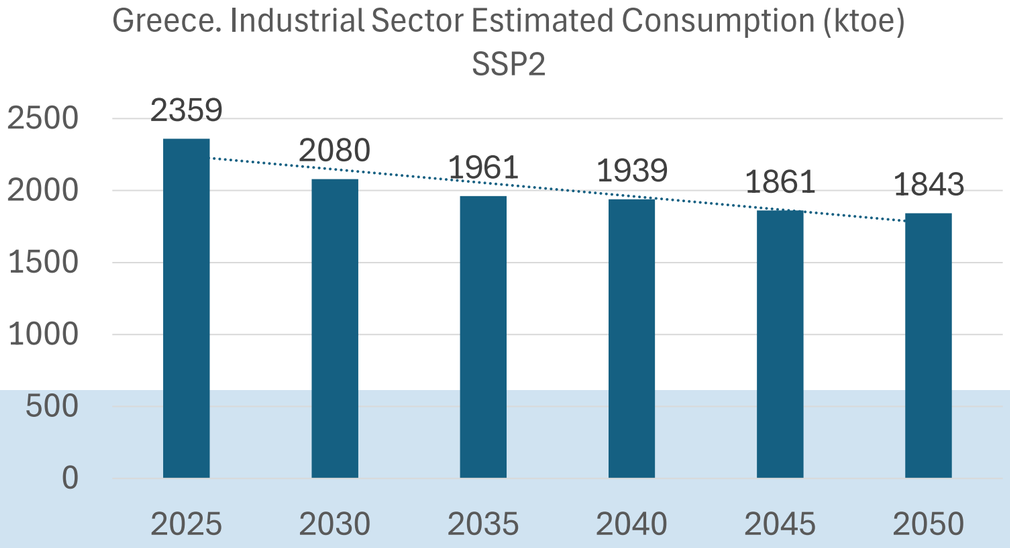
https://data.ece.iiasa.ac.at/ssp/#/about

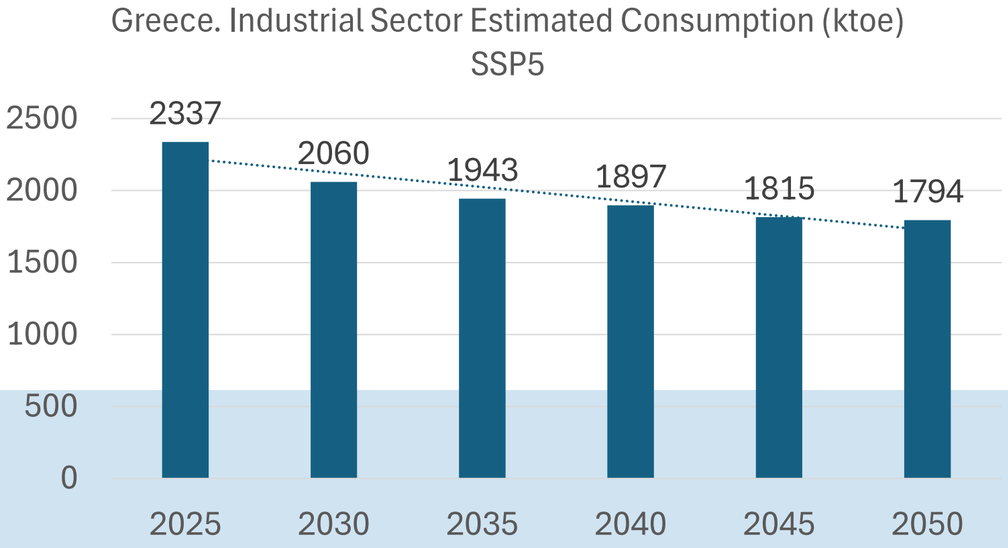
Release 3.1 - July 2024
GDP projections by the OECD
GDP and Population projections by IIASA and WU

Comparison in Hypothetical Scenarios: Industrial Demand

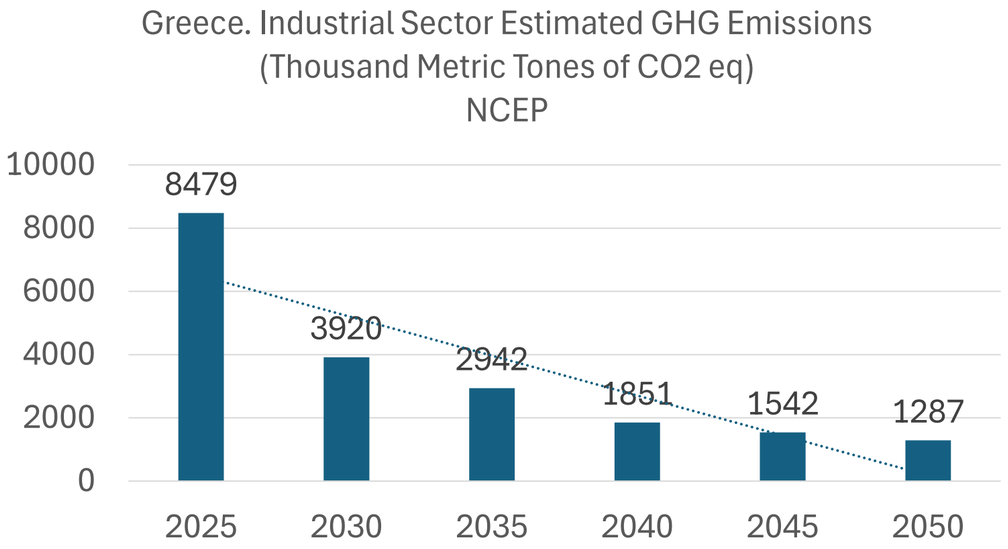


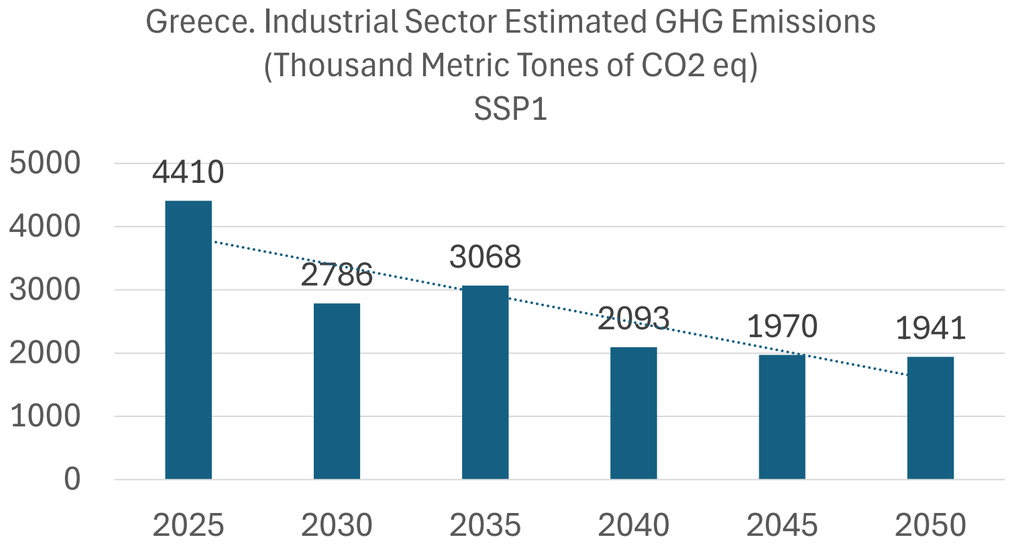


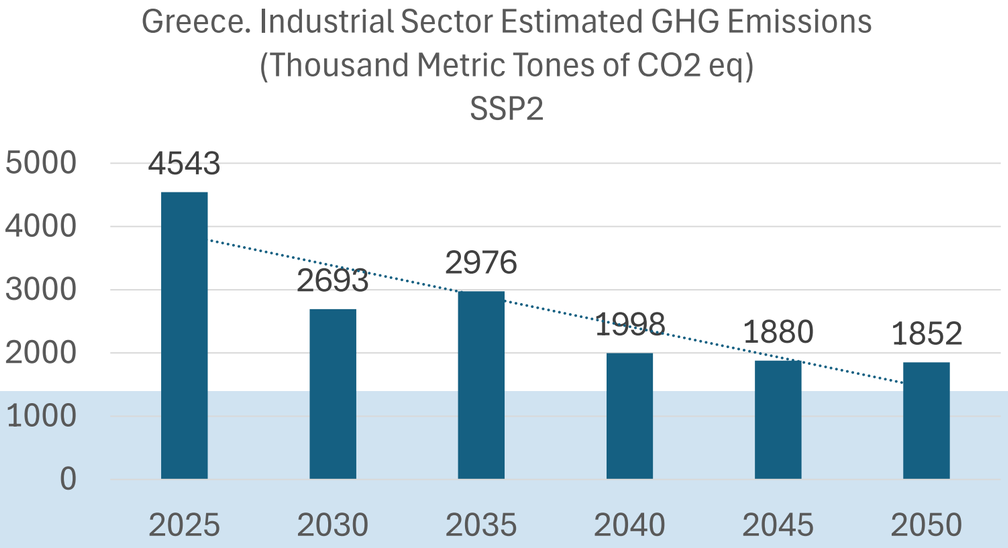


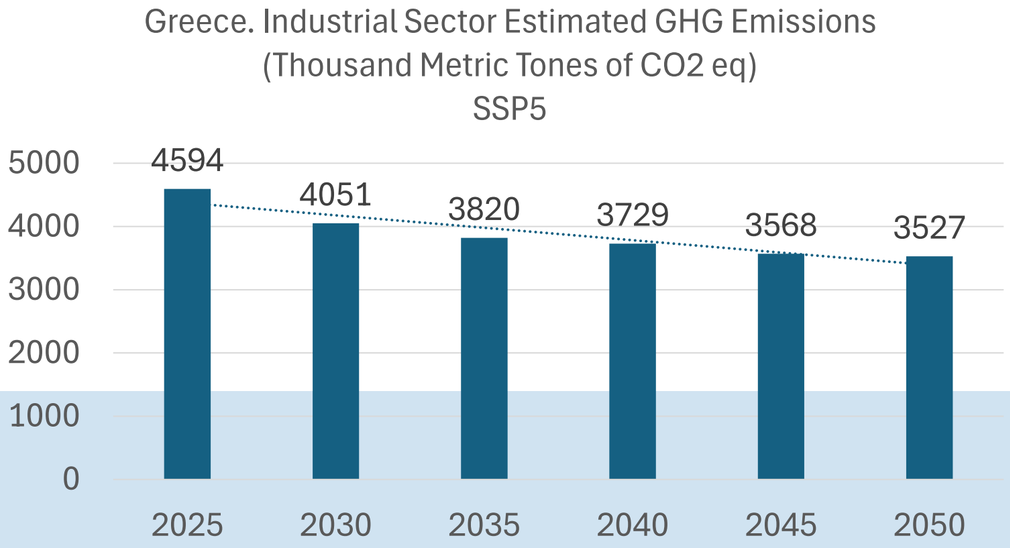


Comparison in Hypothetical Scenarios: Industrial Emissions

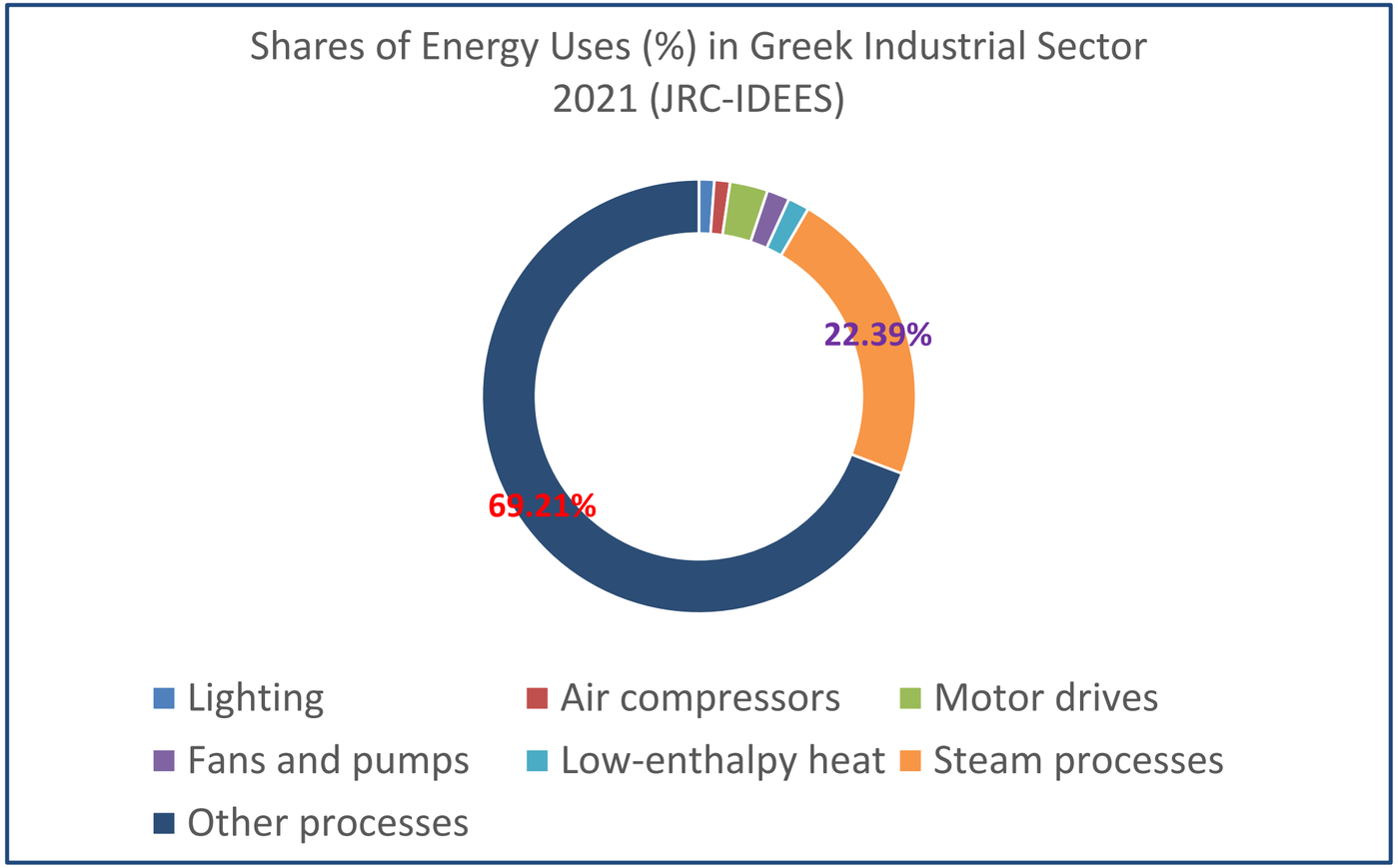








Methodology: Main Data of current conditions



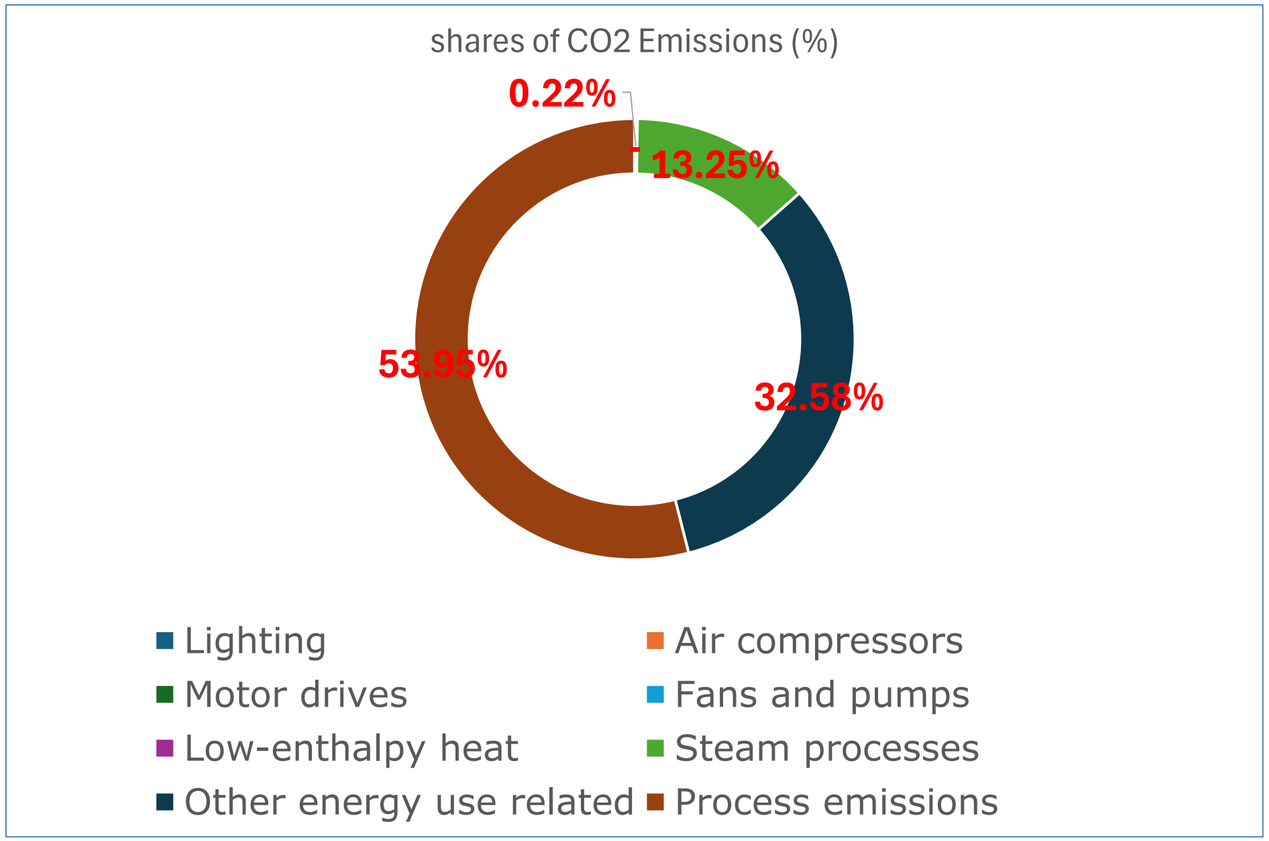
All industrial sectors	100.00 %
Lighting	1.14%
Air compressors	1.17%
Motor drives	2.82%
Fans and pumps	1.68%
Low-enthalpy heat	1.58%
Steam processes	22.39%
Other processes	69.21%

Final energy consumption
In Industrial Sector, 2021:
2565,4 ktoe

Methodology: Main Data of current conditions

Detailed split of CO2 emissions (kt of CO2)	
	2021
All industrial sectors	**9,398.7**
Low-enthalpy heat	20.8
Steam processes	1,245.2
Other energy use related	3,061.7
Process emissions	5,071.1
Iron and Steel	283.3
Non-Ferrous Metals	341.5
Chemical and Petrochemical	679.4
Non-Metallic Minerals	3,620.6
Solvent use and other process	146.2

Steam Processes cover 13% of CO2 emissions
Other energy uses (depended on each sector) cover 32.5%
Process Emissions cover almost 54% of CO2 Emissions



Conclusions

- NECP performs projections for a significant Energy Intensity reduction, therefore Energy Demand reduction and at the same time a drastic reduction in GHG emission, thanks to the generous fuel mix shift, it assumes. So, if compared with the –Do Nothing – Scenario, a remarkable sustainability progress is going to happen in Greek Industrial sector.
- In the NECP scenario the overall industrial energy consumption is 42% reduced (compared to the BAU)
- The GHG emissions of the NECP scenario in 2050, are performing a reduction of about 75%, compared to the BAU.
- It is interesting to compare NECP, with hypothetical scenarios, based on Shared Socio-Economic Pathways, the SSPs.
- These scenarios assume an increased GDP growth, therefore they seem to give an increased Activity Level (AL), so if we apply the same measures, similarly to ESEK, then the Energy Consumption will be a little bit higher than ESEK, but it keeps the same rule of gradual reduction during the upcoming period, 2025-2050, thanks to the Energy Intensity interventions in all cases.
- But with regards to GHG emissions, SSP5 will perform much more emissions, compared to the other scenarios, because not important fuel mix shift (from fossil to renewables) is going to happen.

Next Steps

- It is very essential to define, estimate and calculate which are the main drivers of the future transition, the drivers of change in fuel future preference per use, or the drivers of reduction of Energy Intensity (energy savings interventions).
- Whenever Processes emissions cannot be reduced by fuel mix changes, then these emissions should be implemented throughout LCA and Circularity Principles, to improve material efficiency.
- For water efficiency improvements, there are some technology innovations, that might support the efficient water use practices. These innovation can apply to:
    1) Advanced Membrane Technologies (e.g., reverse osmosis, nano-filtration) for treating and recycling process waters.
    2) Internet of Things (IoT) and AI-driven systems for real-time water quality and quantity monitoring, allowing for predictive maintenance and better water management.
    3) Adopting the appropriate LCA and Circularity principles

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Main data Sources:

1)https://ec.europa.eu/eurostat/databrowser/view/nrg_d_indq_n__custom_13790290/default/table?lang=en Special filter for energy consumption per fuel and subsector of Industrial consumption

2)https://ec.europa.eu/eurostat/databrowser/view/nrg_bal_c/default/table?lang=en Energy Balance for the entire country

3) https://joint-research-centre.ec.europa.eu/scientific-tools-and-databases-0/potencia-policy-oriented-tool-energy-and-climate-change-impact-assessment/jrc-idees_en Energy Uses in Greek Industrial Sector

4) https://www.eea.europa.eu/publications/industrial-waste-water-treatment-pressures

THANK YOU

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