Global Trade Analysis Project

Institute for Economics and Forecasting, Ukrainian National Academy of Sciences

Transition towards High Share of Renewables in Ukraine: Linked Energy System and CGE Model Approach

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Outline

1. Motivation
2. Overview of the Ukrainian energy sector
3. Long-term policies and international obligations
4. Methodological framework
5. Scenarios and results
6. Concluding remarks

1. Motivation

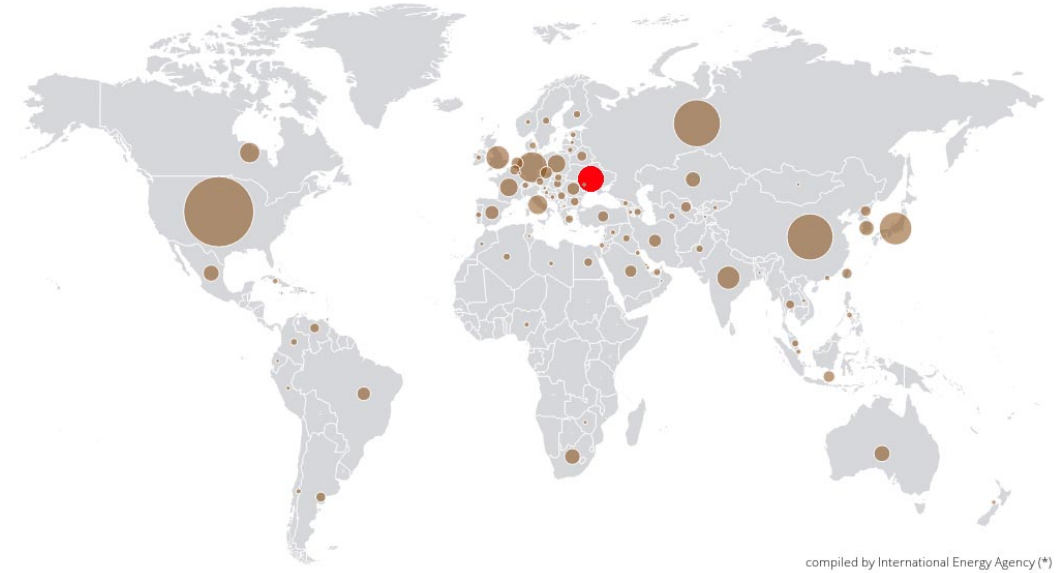
1. Motivation: challenges and opportunities

- **Poor efficiency and high energy intensity :**
  - Energy intensity level in Ukraine is ***three times higher than in OECD*** (IEA, 2018).
- **One of the highest carbon intensities in the world:**
  - Ukraine has 5th highest GDP carbon intensity in the world (WB, 2017b).
- **High level of dependency on energy import and declining national fossil-fuels production:**
  - 35% share of imports in total primary energy supply in 2015 (51% for natural gas; 75% in case of crude oil and oil products) (IEA, 2018);
- **Low share of renewable generation:**
  - 4.2% RES share in GFEC (compare with 20% world average share) (IEA, 2018).
- **Inefficient energy market regulatory framework, poor investment climate, obsolete infrastructure.**

2. Overview of the Ukrainian energy sector

2.1. Ukrainian CO_2 emissions in the global context

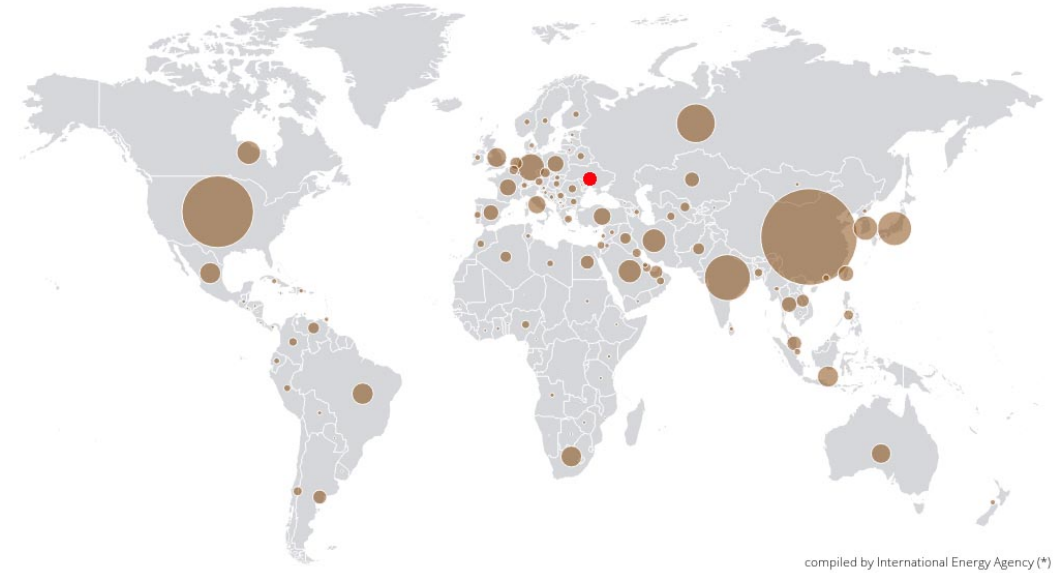
CO2 emissions (MtCO2) (1990)



In 1990 Ukraine was ranked the 6th among the largest emitters of energy-related CO_2

In 2015 Ukraine was the 23rd largest emitter of CO_2 emissions from fuel combustion.

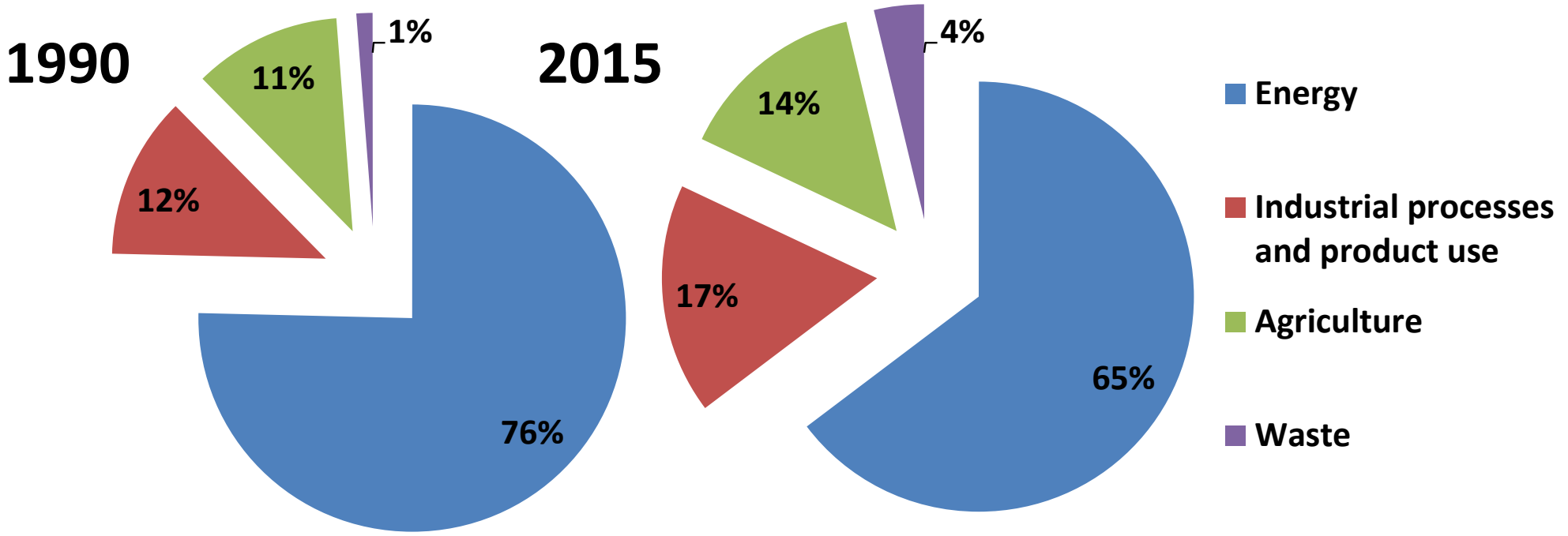
CO2 emissions (MtCO2) (2015)



**** CO2 Emissions from Fuel Combustion only***

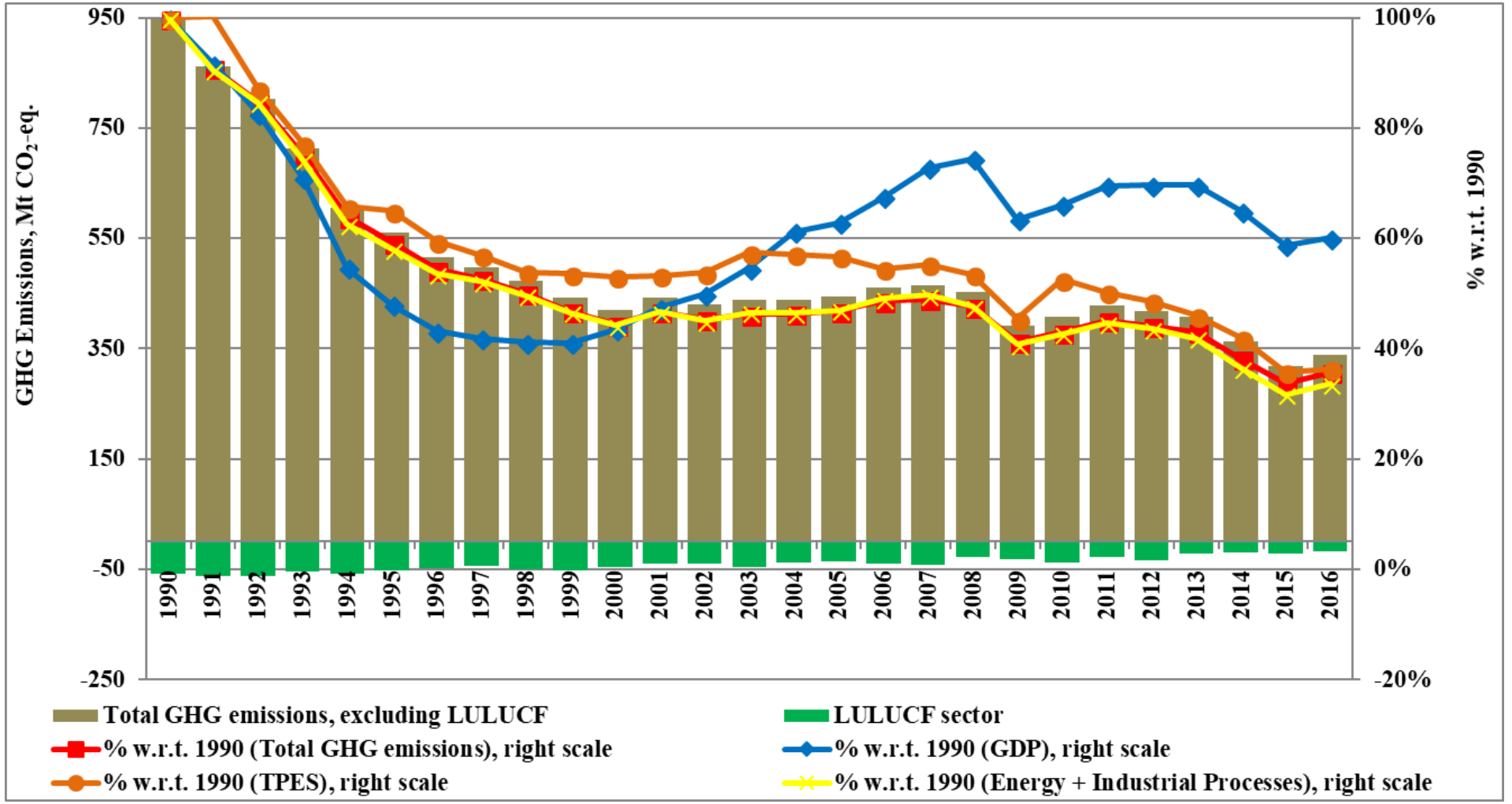
2.2. GHG emissions by sources in Ukraine

GHG emissions in “Energy” sector contributed **65-76%** of total GHG emissions between 1990 and 2015. Including emissions from “Industrial Processes” it constituted **82-90%** of the aggregate GHG emissions. This determined general dynamics of GHG emission in Ukraine.

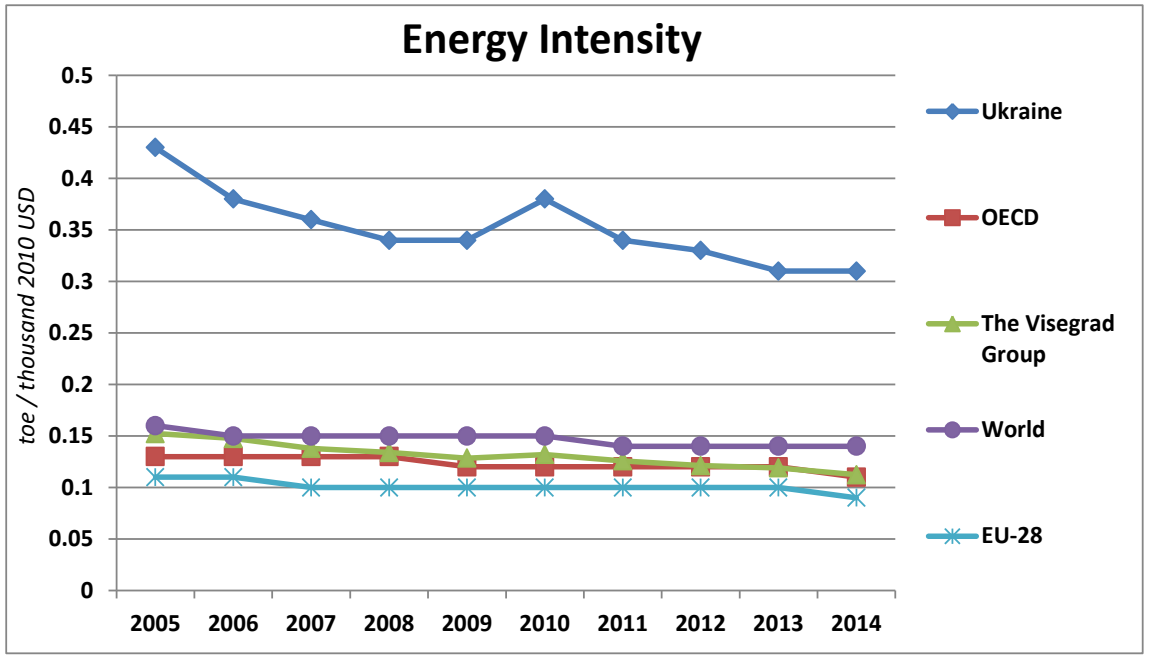


2.3. Key energy and economic indicators

Dynamics of GHG emissions follows the curve of total primary energy supply.
In 1990-2000, dynamics of the GHG emissions was following GDP trends, but in 2001-2008, as a result of structural changes, GDP increase was no longer accompanied by the GHG emissions growth (**decoupling**).

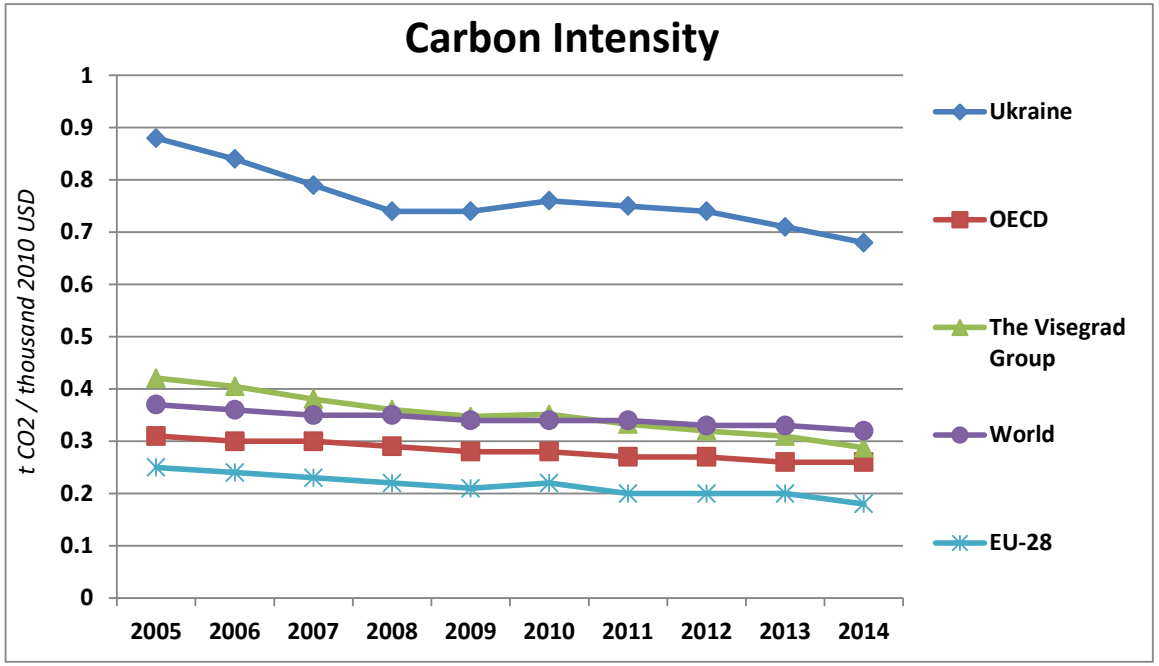


2.4. Energy and carbon intensity of GDP



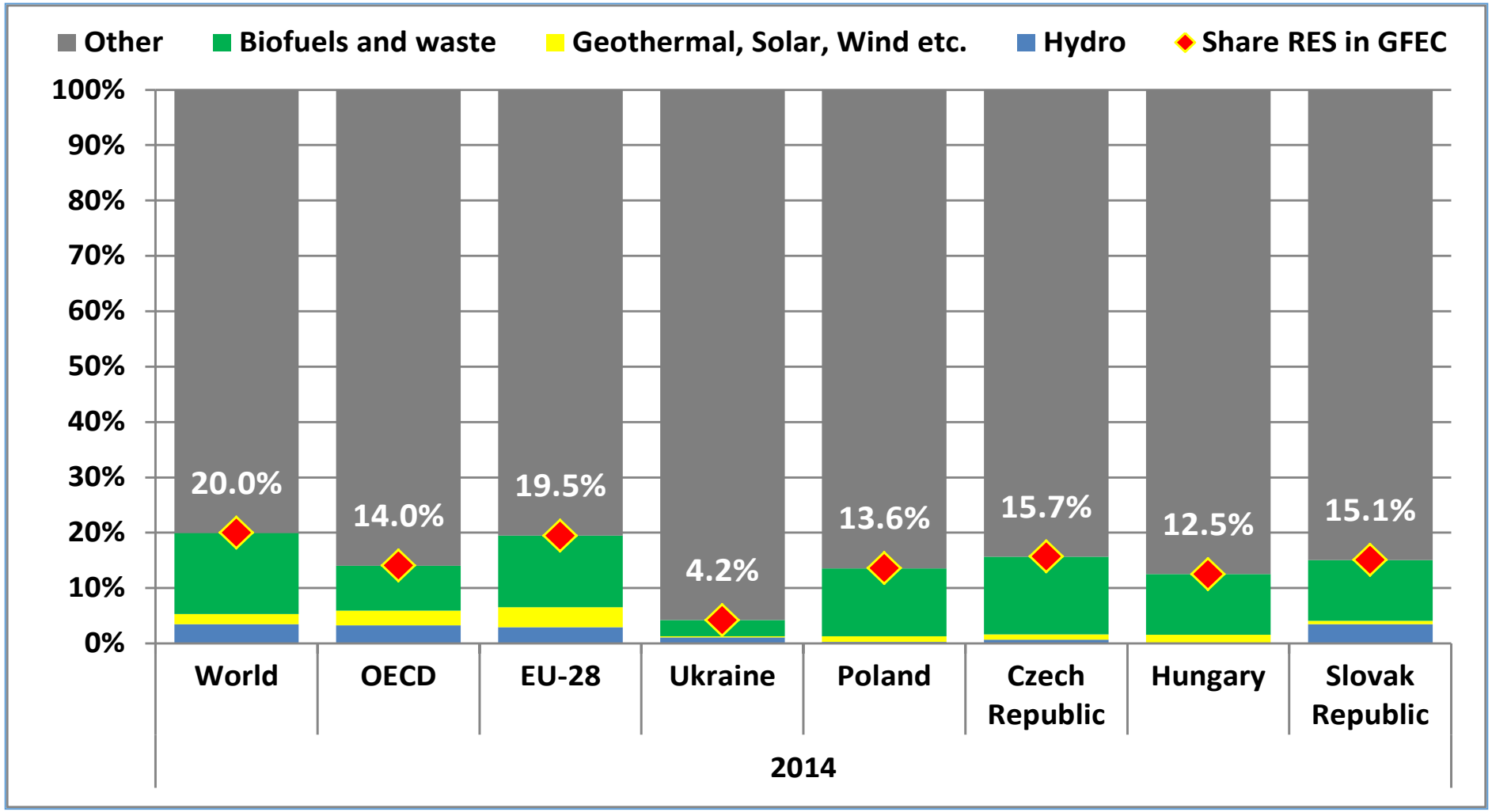
The energy intensity of Ukraine's GDP (2014) was correspondingly 2.6 and 2.4 times higher than in OECD countries and in the countries-members of the Visegrad Group.
Ukrailne's GDP energy intensity was 3.4 times higher than in EU.

The carbon intensity of the Ukraine's GDP (2014) was almost 2.8 times higher than in OECD countries and 2.4 higher than in Visegrad countries.
Ukraine's GDP carbon intensity was 3.8 times higher than the EU-28 2014 average.



2.5. Renewables share in Gross Final Energy Consumption

In terms of Renewables share in GFEC, Ukraine lags behind most developed countries (including the countries-members of Visegrad Group) as well as world average -> ***potenital for environmental policies with double dividends***.



3. Long-term policies and international commitments

3.1. Ukraine in international climate agreements

- ✓ Ukraine is Annex I Party to **United Nation Framework Convention on Climate Change** since 1996.
- ✓ Ukraine is Annex B Party to the **Kyoto Protocol** since 2004 (Second Commitment Period of the Kyoto Protocol is under ratification process).
- ✓ Ukraine is a Party to **Paris Agreement** starting from September 19, 2016 with **Nationally Determined Contribution (NDC)** that presents national goals on climate actions – both mitigation (reduction of GHG emissions) and adaptation to climate change impacts .

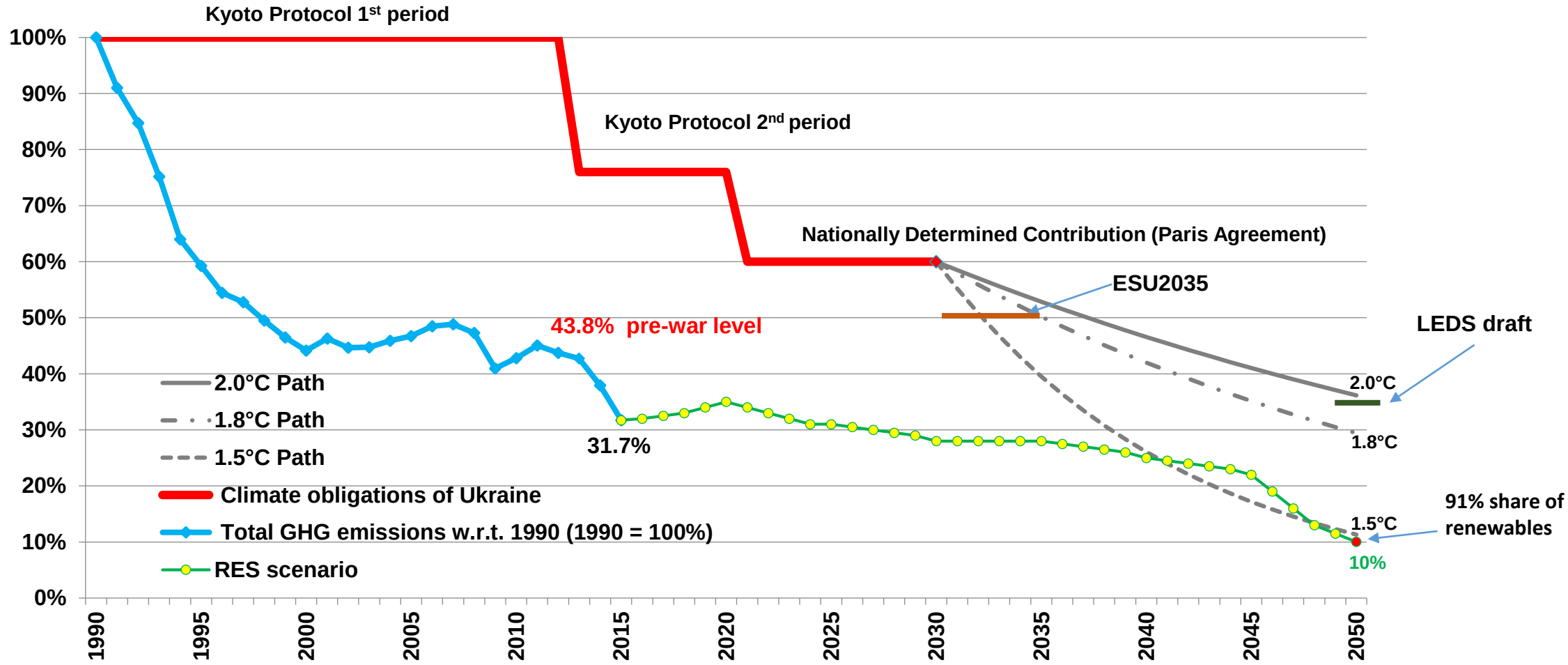
3.2. Energy strategy of Ukraine till 2035: key indicators

In August 2017 Ukrainian Cabinet of Ministers adopted and updated Energy Strategy of Ukraine till 2035 (ESU2035).

	2015	2020	2025	2030	2035
Primary Energy Intensity, toe/thousand 2010 USD GDP PPP	0.29	0.20	0.18	0.15	0.13
Share of RES (including hydro and thermal energy in TPES, %	4%	8%	12%	17%	25%
Share of RES (including big Hydro PP) in Electricity production, %	5%	7%	10%	>13%	>25%
Share of Wind and Solar in Electricity production, %	1%	5.5%	6.7%	>9.7%	>12.8%
Share of Nuclear in Electricity production, %	*54%*	*52%*	*51%*	*50%*	*48%*
The share of Coal PP complies with Directive 2010/75/EC	*<1%*	*<10%*	*<40%*	*85%*	*100%*
CO_2 Emission w.r.t. 1990, %	31.8%	<60%	<60%	<60%	<50%

3.3. Long term energy policies

In November 2017 Ministry of Ecology and Natural Resources of Ukraine released Draft Low Emission Development Strategy (LEDS) with target – ***do not exceed 35% of 1990 GHG emissions level in 2050.***

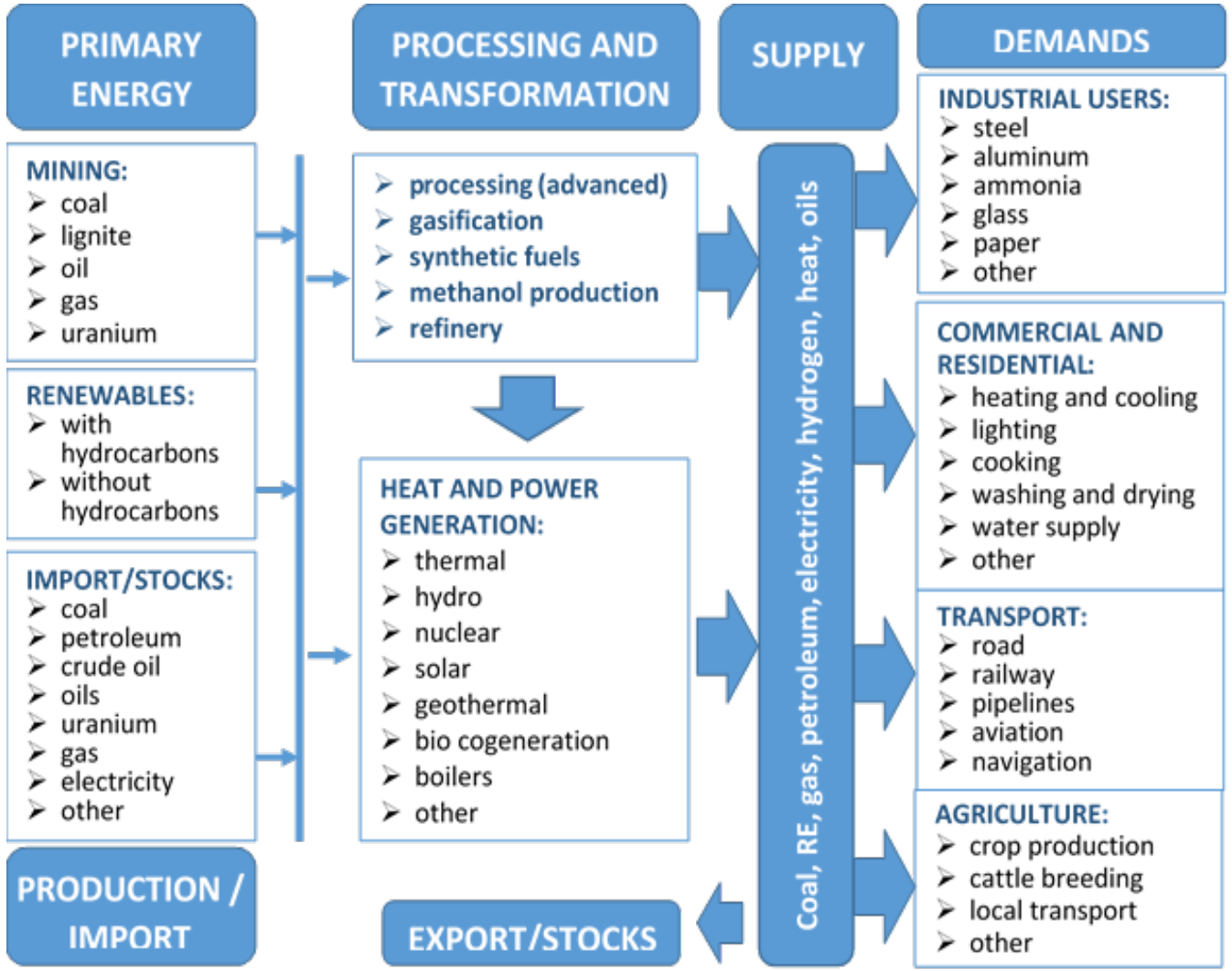


Note: Estimates of the temperature paths for Ukraine are based on the CI (2017) methodology. Ukrainian NDC level is taken as a peak emission in 2030, afterwards annual reduction rates of 3.5% (in case of 1.8°C path) and 8% (for 1.5°C path) are applied to derive corresponding emission levels by 2050.

4. Methodological framework

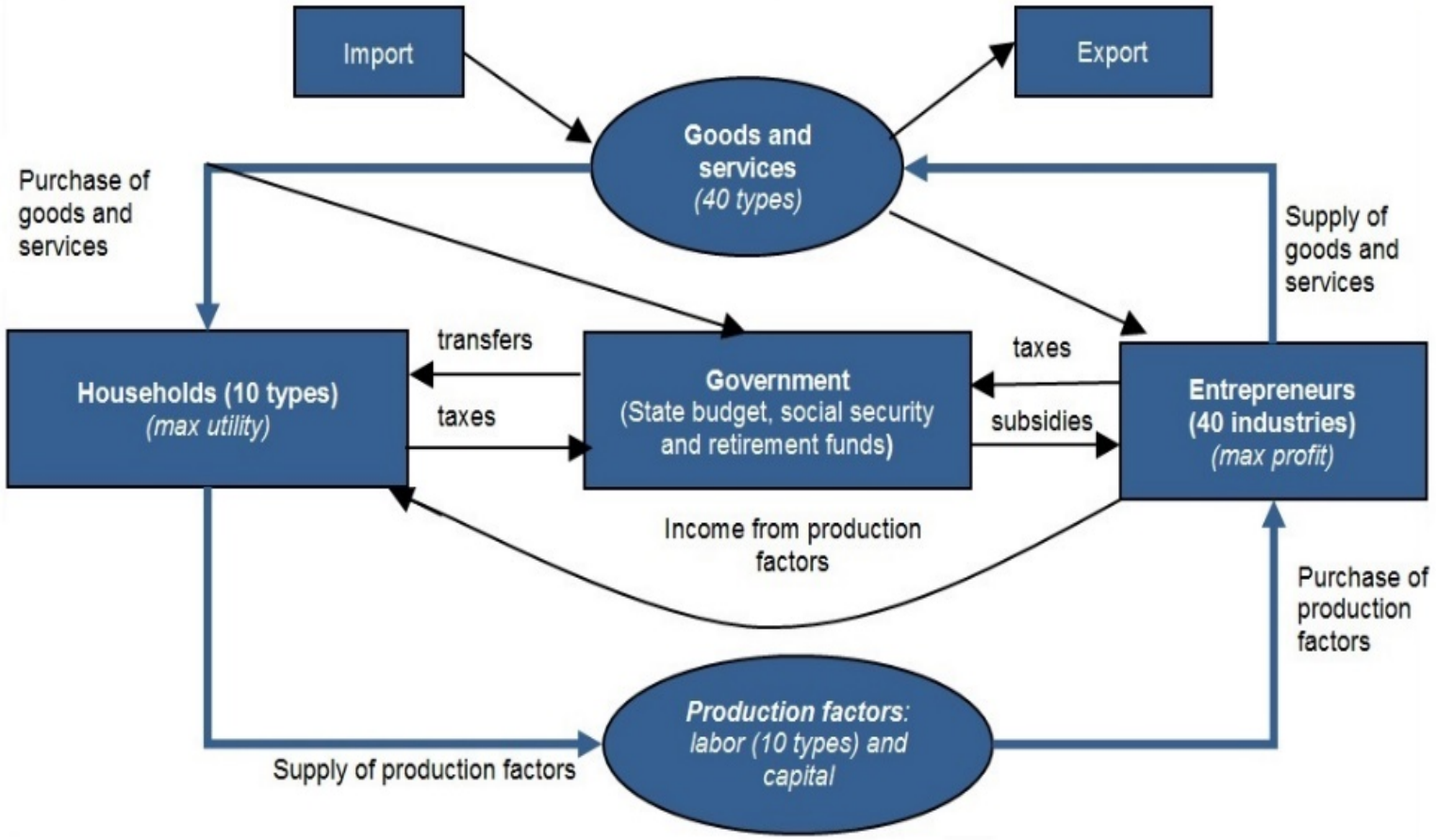
4.1. Energy system TIMES-Ukraine model

Linear quasi-dynamic optimization perfect foreseen energy system model of MATKAL/TIMES family. Provides a technology-rich basis for estimating energy dynamics over a long-term horizon.



4.2. Ukrainian general equilibrium model (UGEM)

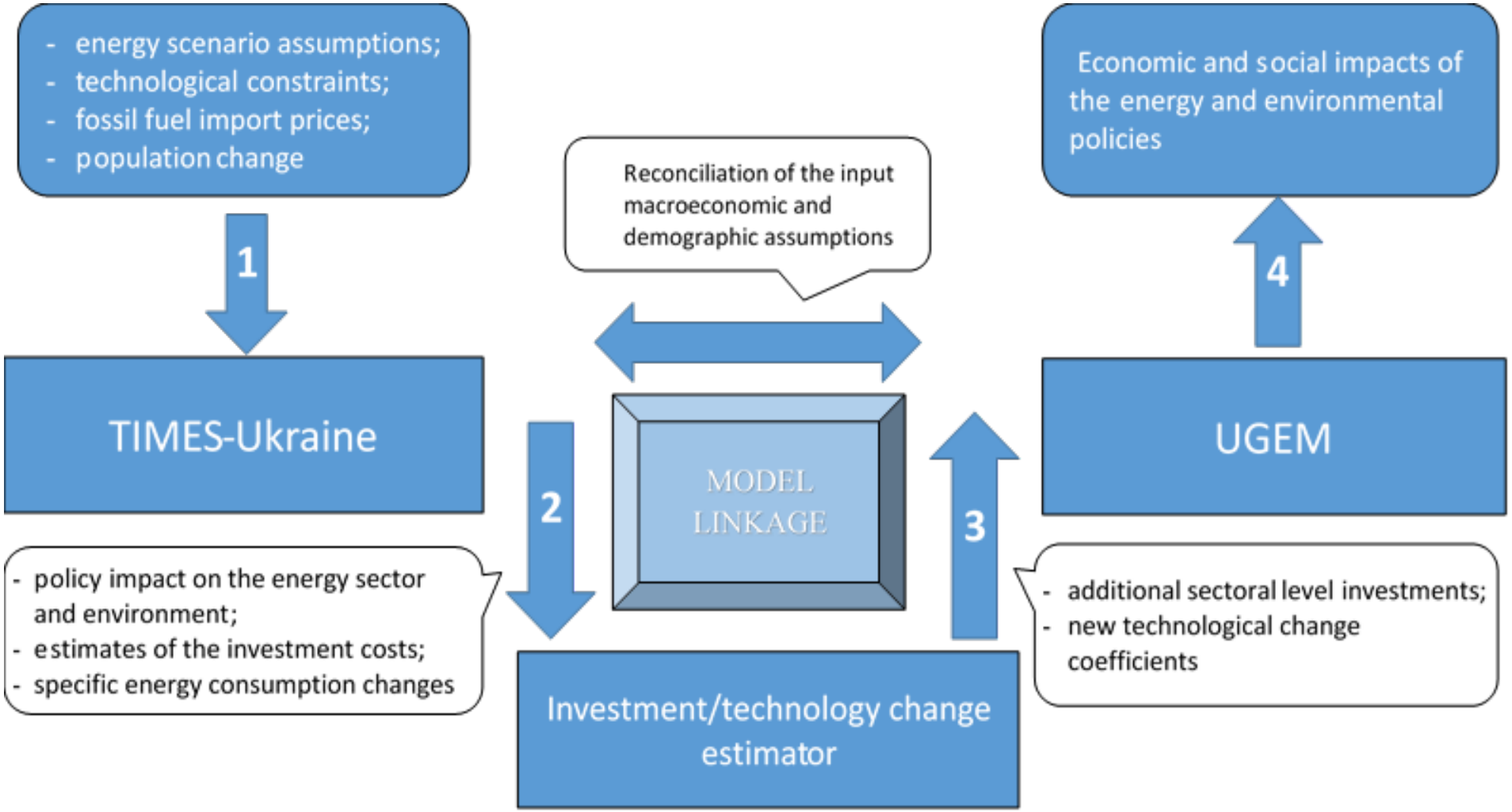
Recursive dynamic computable general equilibrium model with heterogeneous households (10 types) and extended energy sector represented via nested CES production function.
Model is based on the 2015 benchmark year and represents 40 sectors (7 energy subsectors).



Circular flows in the UGEM model

4.3. TIMES-Ukraine and UGEM models linkage

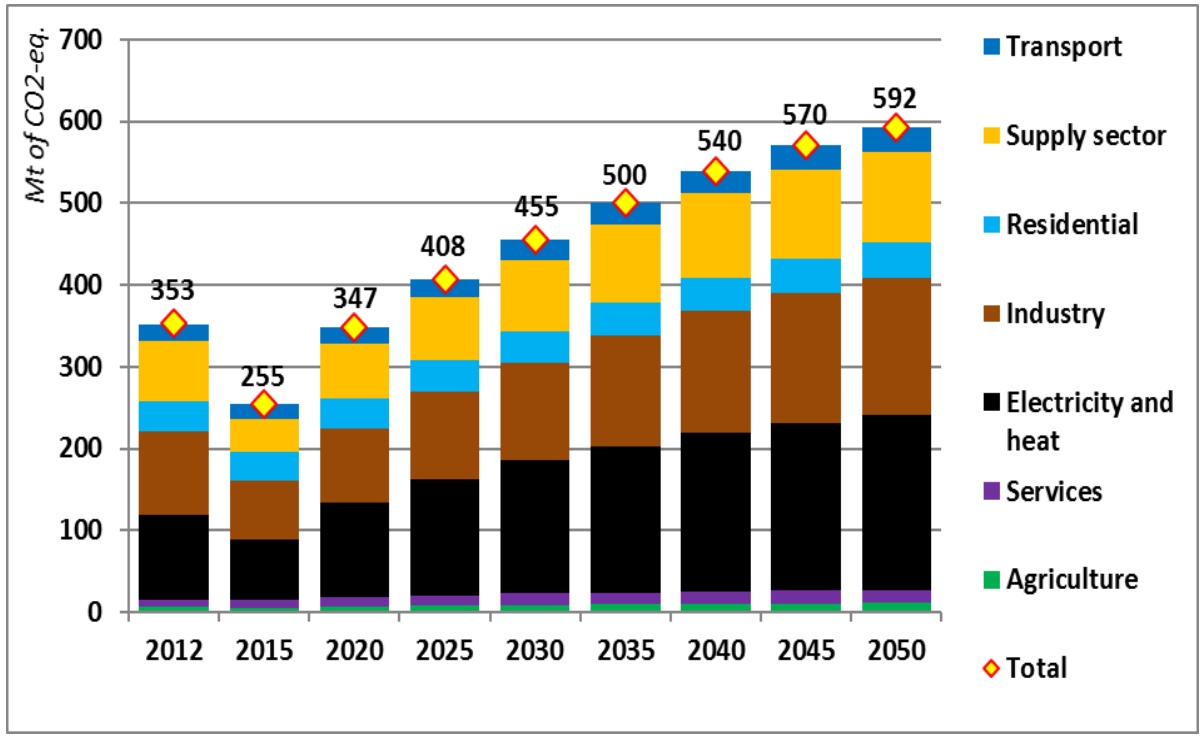
To provide an assessment of LED policies in Ukraine we use a **soft-linkage** of TIMES-Ukraine and UGEM models.



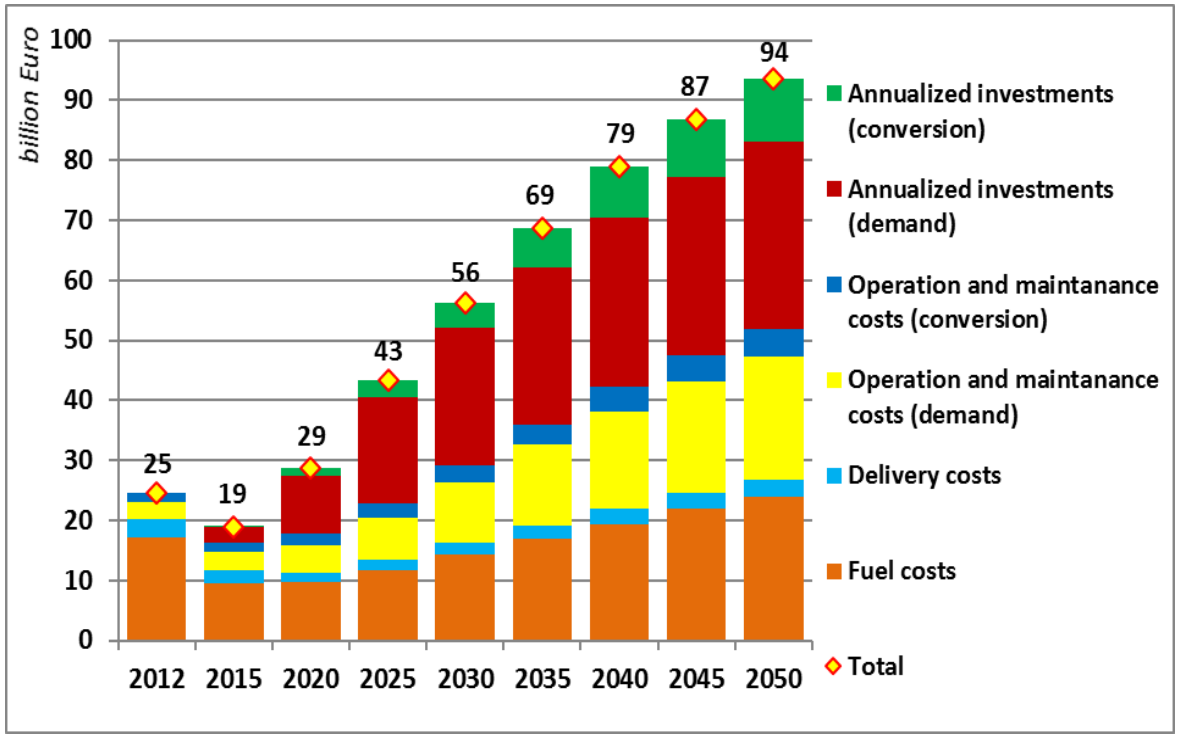
5. Scenarios and results

5.1. Business as usual (BaU) scenario

- 4% annual average 2016-2050 GDP growth rate.
- -0.4% annual average population change.
- No fundamental changes in the energy system.
- Gradual replacement of technologies.



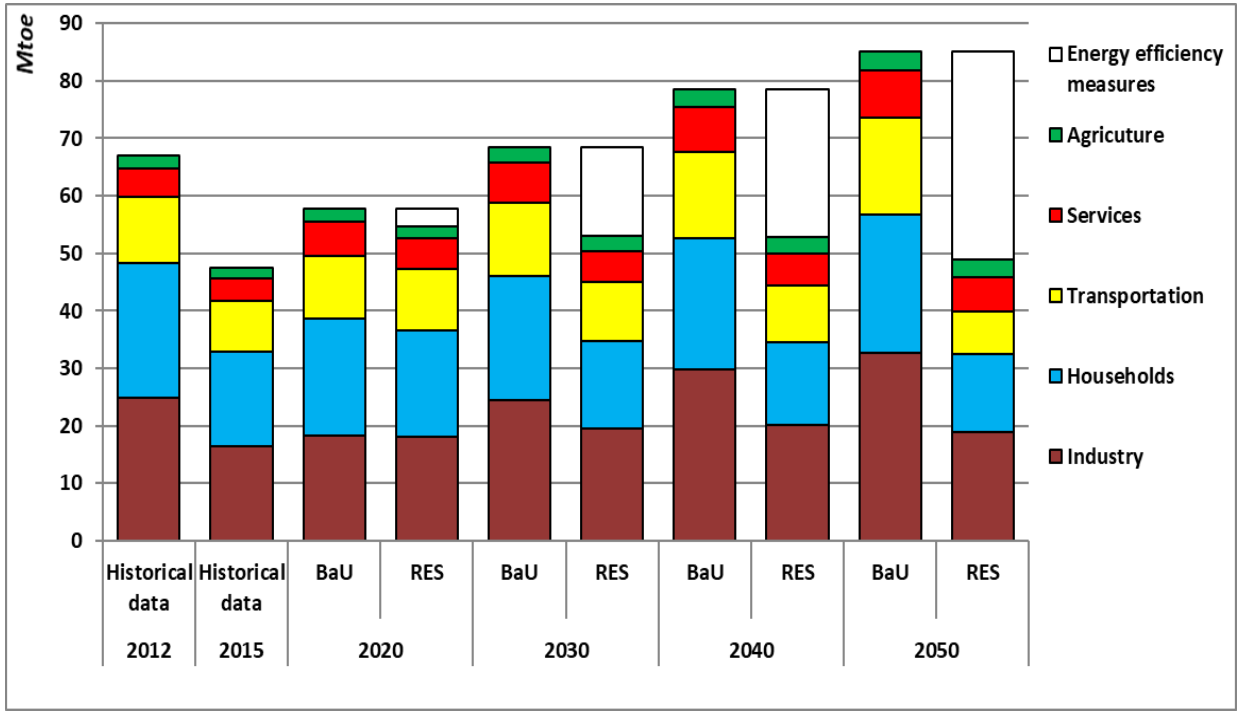
Forecast of the GHG emissions in Ukraine according to the BaU scenario, Mt CO_2-eq



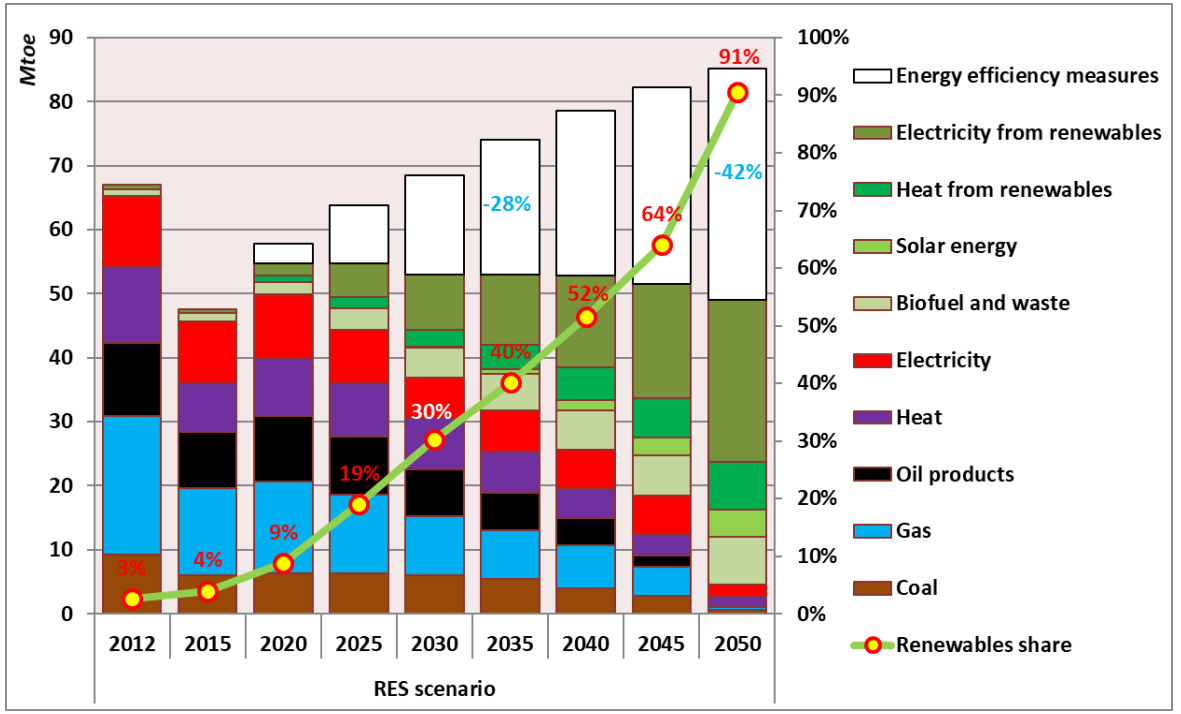
Energy system costs under the BaU scenario, bn 2012 EUR

5.2. Renewable energy scenario (RES)

- Key target – 91% share of renewables in final energy consumption in 2050.
- Consistent with 1.5°C global temperature increase by 2050.
- Energy and environmental effects – energy system costs minimization.

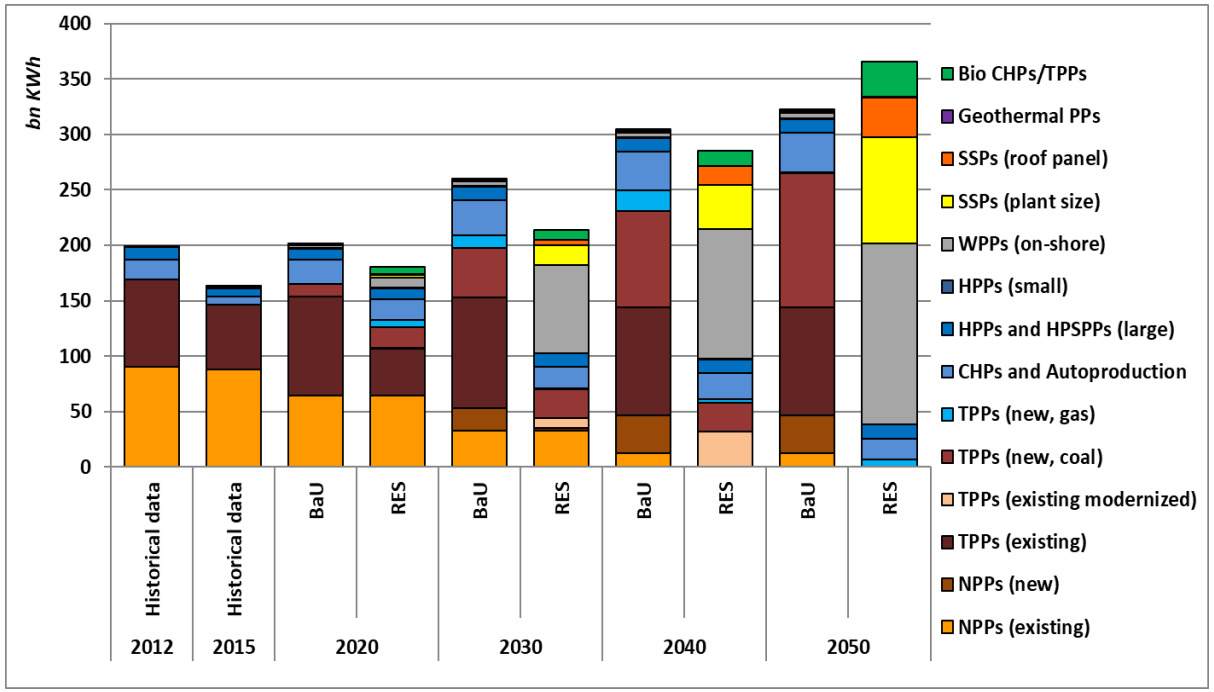


Final energy consumption by users, Mtoe

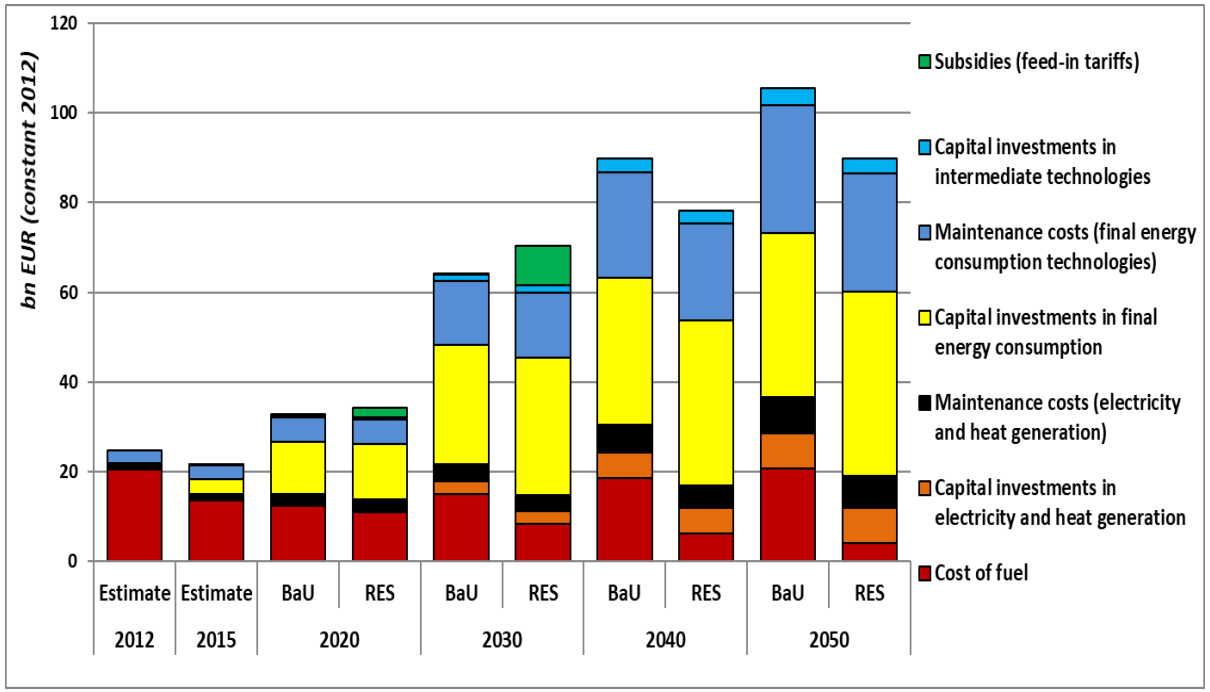


Final energy consumption by sources, Mtoe

5.3. Generation mix and costs of the RES scenario



Electricity generation mix under the BaU and RES scenarios, bn KWh

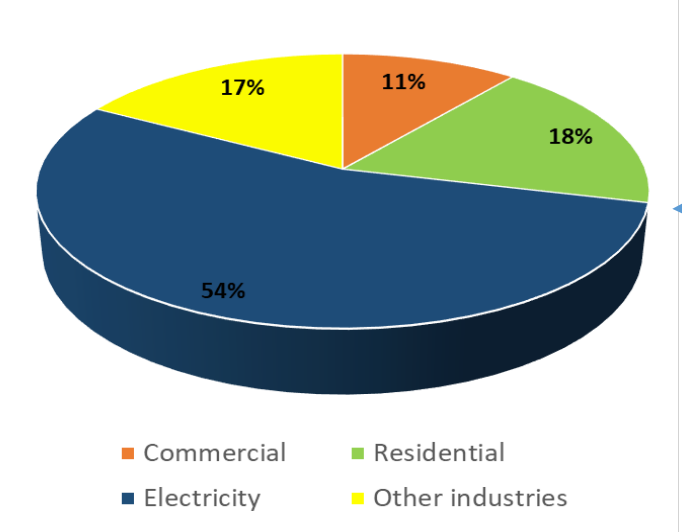


Annual energy system costs under the BaU and RES scenarios, bn 2012 EUR

Note: CHPs – combined heat and power plants; TPPs – thermal power plants; SPPs – solar power plants; WPPs – wind power plants; HPPs – hydro power plants; HPSPPs – hydro pumped storage power plants; NPPs – nuclear power plants.

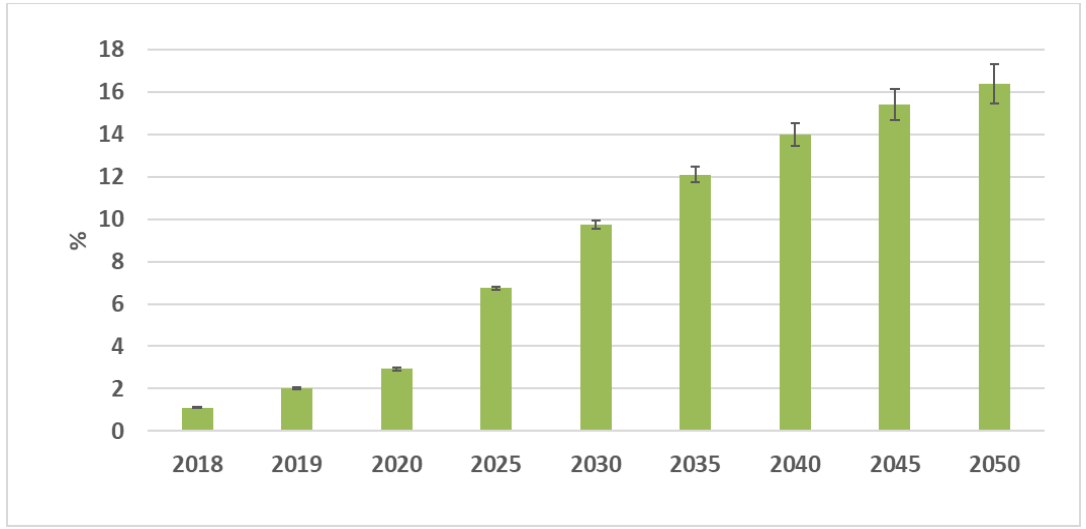
5.4. RES scenario: economic impacts

- Pass data on additional investments and efficiency improvements from TIMES-Ukraine to UGEM.
- Assume no additional external investments; all costs are covered by energy consumers/users.
- Estimate economic impacts under systematic sensitivity analysis approach.

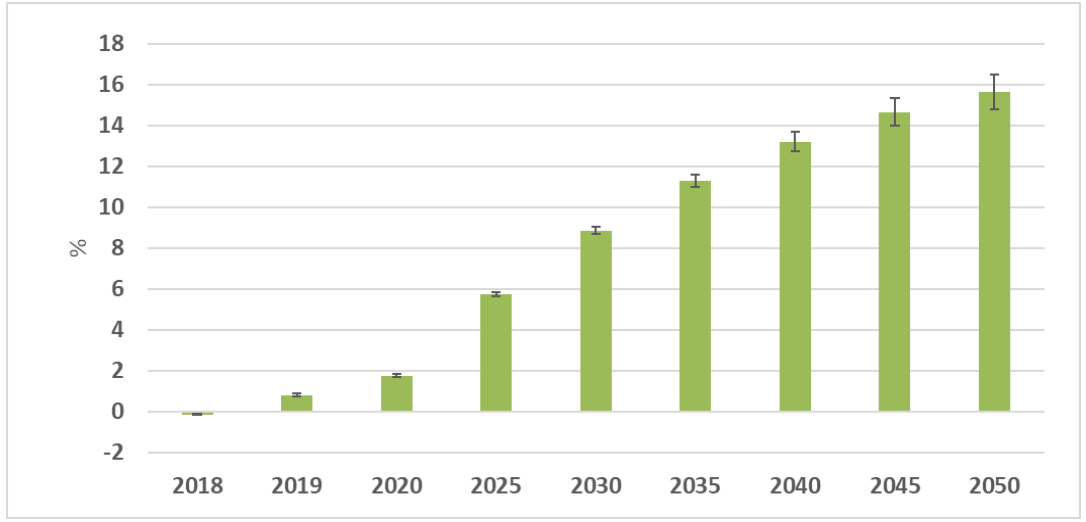


Aggregate 120 bn EUR between 2017-2050

Distribution of the additional investments by sources in RES scenario (w.r.t. BaU, %)



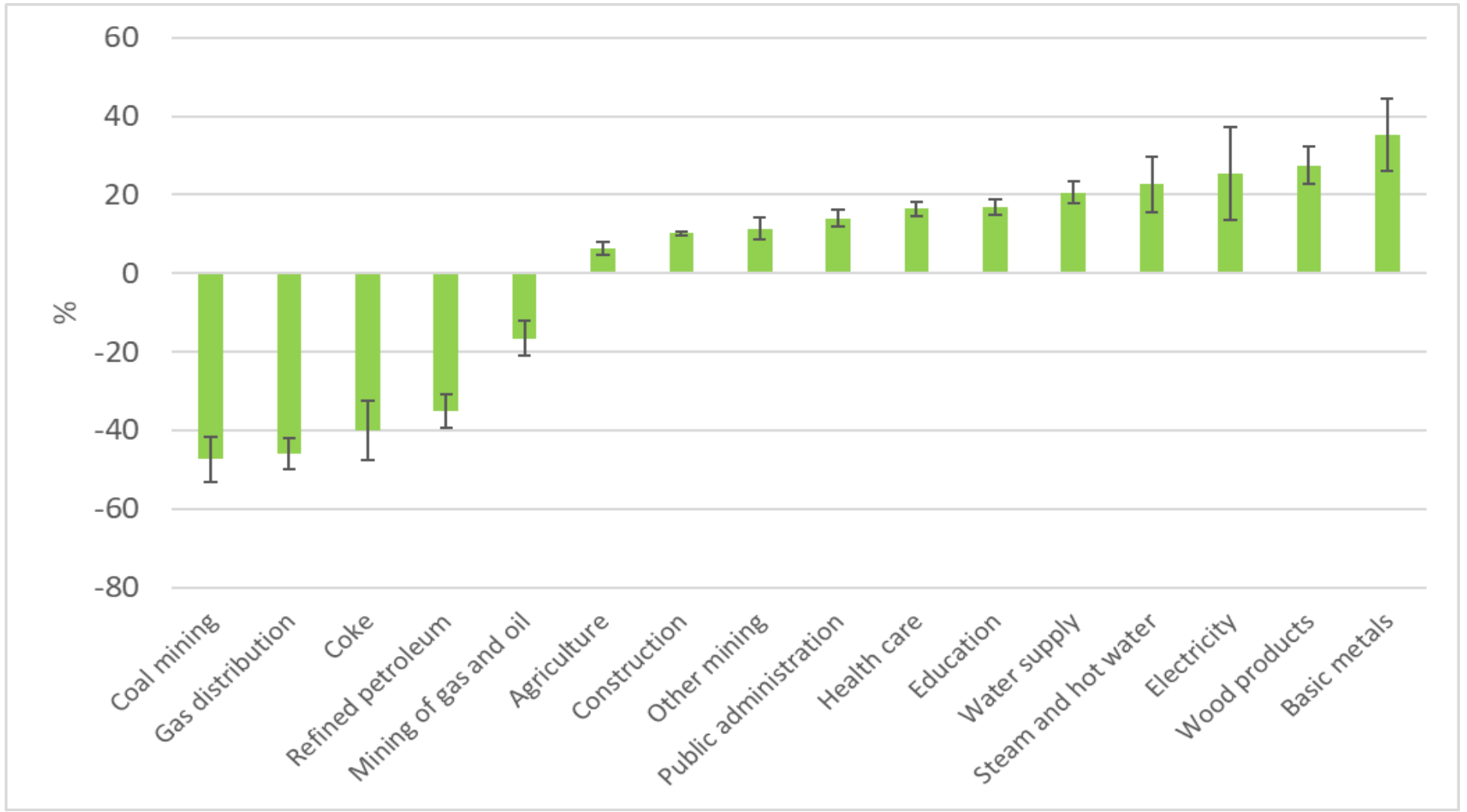
Impacts of the RES scenario implementation on GDP (w.r.t. BaU, %)



Impacts of the RES scenario implementation on households real income (w.r.t. BaU, %)

Note: Error bars indicate 95% confidence intervals for substitution and transformation elasticity changes under the systematic sensitivity analysis approach.

5.5. Sectoral impacts of the RES scenario



Changes in the sectoral output under RES scenario in 2050 (w.r.t. BaU, %)

6. Concluding remarks

- High energy and emission intensities, great potential to explore ***"double dividends"***.
- TIMES-Ukraine<->UGEM models soft linkage to explore ***deep decarbonization*** scenario (91% share of RES by 2050, consistent with 1.5^{o}C global warming target).
- Substantial energy transformation and ***positive macroeconomic effects*** (negative impact on mining sectors)**.**
- Need for significant ***market and institutional transformations***; ***additional incentives*** should be created (further tariff reform, green credits, etc).
- Move to the ***iterative model linkage***.

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Questions/Comments?

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