IEF | State Organization
"Institute for Economics and Forecasting
of the National Academy of Sciences of Ukraine"

Regional energy modeling for post-war recovery in Ukraine

The discussion platform
“SCIENCE FOR RECOVERY AND SUSTAINABLE DEVELOPMENT”

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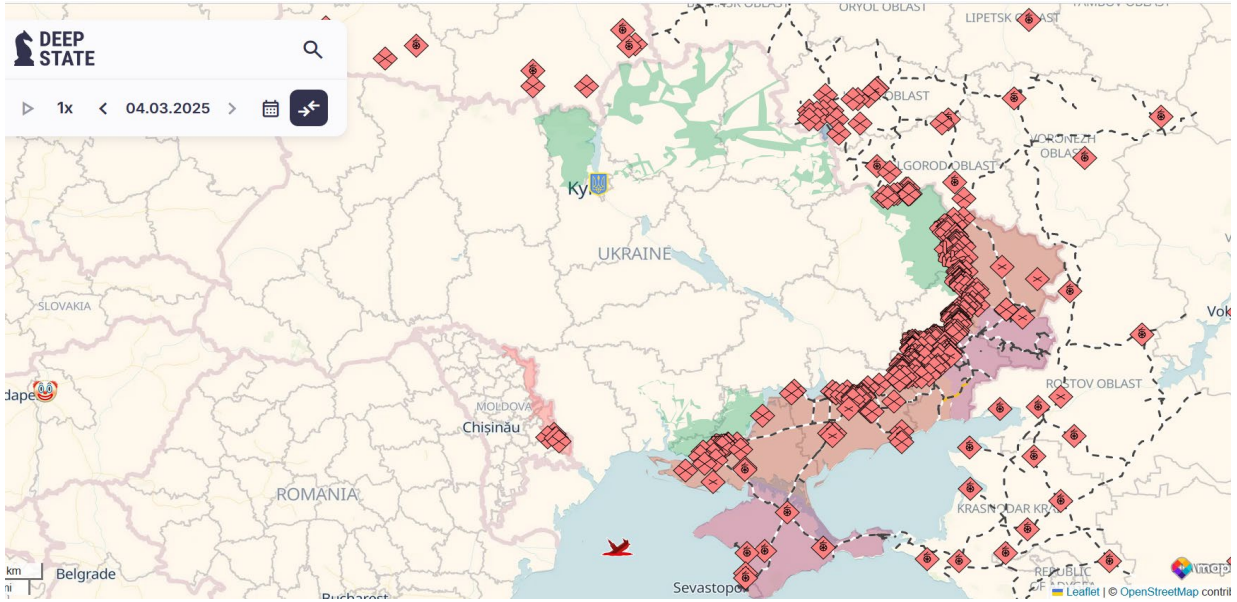
Uncertainty

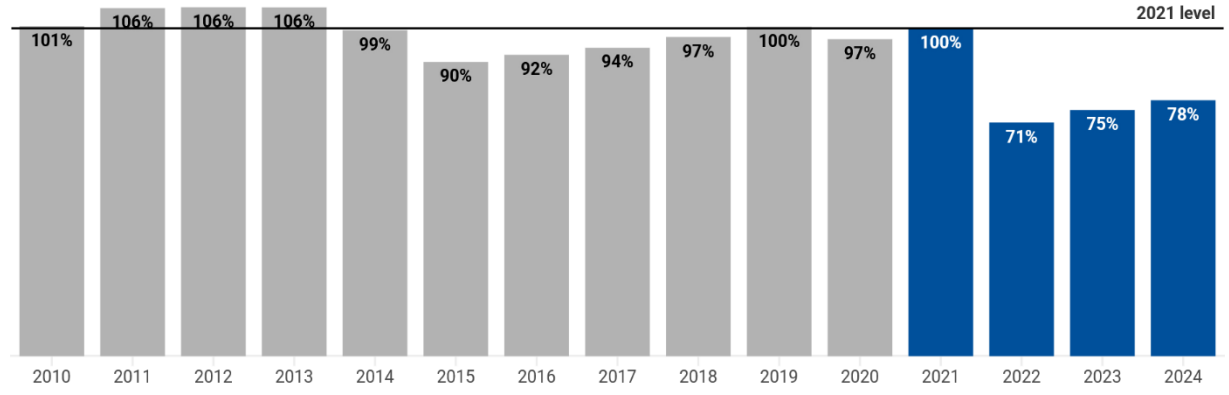
Uncertainty of the state and consequences of the war



GDP is still more than 20% lower than in 2021

Real GDP, % of 2021

CENTRE FOR ECONOMIC STRATEGY

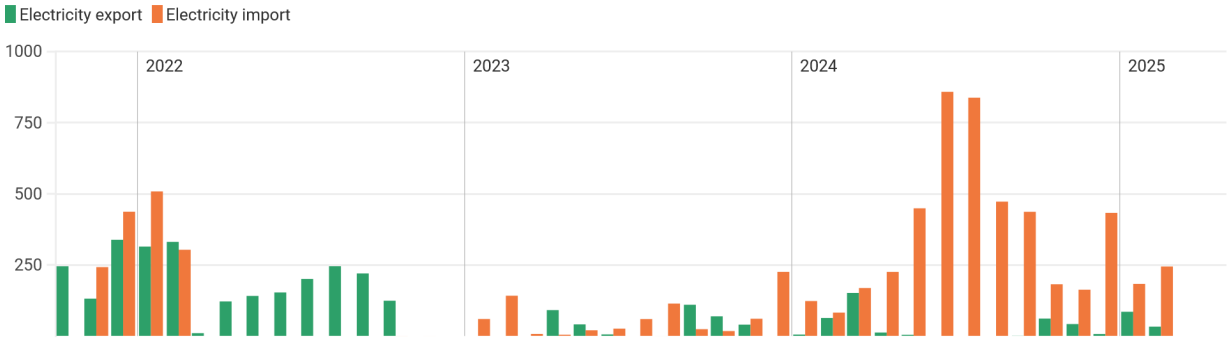


Sources: State Statistics Service, NBU (forecast for Q4 2024) • Supported by PrivatBank
Last updated on: 2025-01-21. Export data as CSV

In February, Ukraine imported seven times more electricity than it exported

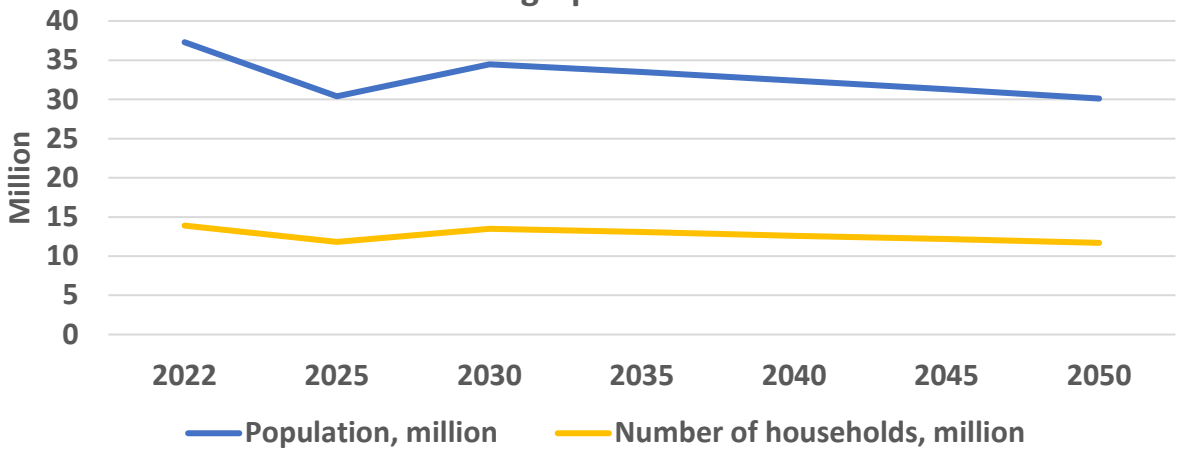
CENTRE FOR ECONOMIC STRATEGY

Monthly volumes of commercial electricity exports and imports, GWh



Source: entso-e • Scheduled Commercial Exchanges from Ukraine, Border-Country, total for all countries bordering Ukraine
Supported by PrivatBank

Demographic forecast



Source: *Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine, State Statistics Service, Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine*

Ukraine's strategic goals during the war

- Alongside the fight against unprovoked Russian aggression, Ukraine is strengthening its energy and climate policy.
- Climate change is already having a negative impact on Ukraine's economy and energy sector and is not only a short-term or medium-, but a long-term challenge for Ukraine and other countries.
- During the full-scale war, a number of strategic documents were developed and adopted:
  - Climate Law with the goal of achieving climate neutrality by 2050 (October 2024)
  - National Renewable Energy Action Plan 2030 with the target – 27% RES in GFEC (August, 2024)
  - National Energy and Climate Plan (NECP) 2030 (June, 2024)
  - Strategies of state climate policy 2035 (May, 2024)
  - Strategy for thermal modernization (decarbonization) of buildings 2050 (January, 2024)
  - Energy Strategy 2050 the goal of achieving climate neutrality in energy sector (April, 2023)
- Developed draft Long-term Low Emission Development Strategy (LT-LEDS) 2050 (December, 2024)
- Developed draft Second Nationally Determined Contribution of Ukraine under Paris Agreement.
- At the last COPs, it was decided to join global initiatives, in particular, to coal phase-out in electricity generation by 2035, reduce methane emissions by 30% by 2030, triple the share of renewable energy by 2030 and nuclear power capacity by 2050, and much more.

Methodological aspects

Types of Scenarios

Exploratory scenario

- Technical model runs for calibration and parametrization
- Addresses the question “What can happen?”

  For example: *What will happen if we limit electricity imports? How this will affect the price? How this will impact the technology mix in power generation or energy consumption?*

Baseline (Reference) scenario

- Provides a vision of the energy system development under baseline assumptions (business-as-usual, current (frozen) policy, frozen technology mix, most probable etc.)
- Synchronization with macroeconomic and other models, e.g. for parameterization of energy demands and drivers
- Create a basis for comparison with other (Policy) scenarios

Types of Scenarios (2): Policy scenarios

Approach 1: Target or Normative

Optimal pathway to achieve pre-defined or directively established targets, e.g. on energy efficiency, RE development or reduction of GHG emissions

Defining a target in advance requires an analysis of what such a target might look like given the current understanding of future technologies or budget constraints

Approach 2: Measures

Evaluation of the effects of certain policies and measures, such as the introduction of a feed-in tariff or carbon tax

Conceals the risks of losing the ambitiousness of the program document, as it is based on a subjective understanding of the effectiveness and feasibility of the proposed measures

Policy scenario: Target –based approach

Reaching the **TARGET**

Model calculation of the optimal pathway to achieve the target (energy balance, technology solutions)

Identifying a set of policies and measures, sufficient to follow the optimal pathway

Regulation:
Energy efficiency standards; environmental standards and regulations; building codes

Information campaign:
Education, awareness and prevention;
Environmental monitoring and energy audit

Market reforms:
Deregulation and liberalization; elimination of subsidies; new market models and types of regulation

Long-term actions:
Research and development, state and corporate innovation and technology policy

An action plan with detailed quantified intermediate and final goals, measures and timeframes for their implementation, tasks of responsible executives, resource allocation, and KPIs.

Policy scenario: measures-based approach

Assessment of **MEASURES**

Regulation:
Energy efficiency standards; environmental standards and regulations; building codes
Set parameters of new techs

Information campaign:
Education, awareness and prevention;
Environmental monitoring and energy audit
Incorporated to the model by assumptions

Market reforms:
Deregulation and liberalization; elimination of subsidies; new market models and types of regulation
Incorporated by assumptions

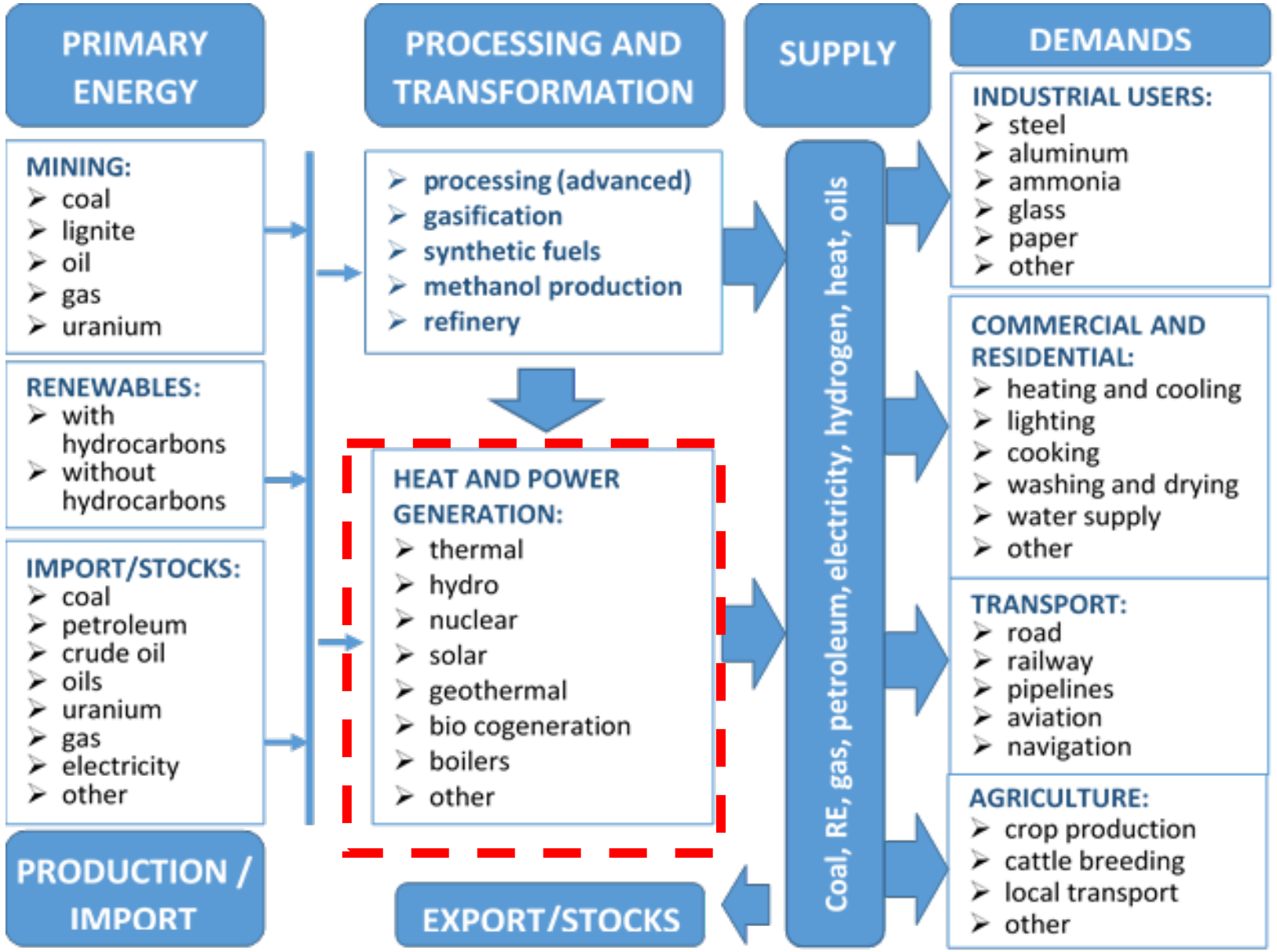
Long-term actions:
Research and development, state and corporate innovation and technology policy
Availability of new techs

Model assessment of the impact of measures on the development of the energy system and the environmental effect

Comparison of results with the desired future state of the energy sector

An action plan with detailed quantified intermediate and final goals, measures and timeframes for their implementation, tasks of responsible executives, resource allocation, and KPIs.

Structure of TIMES-Ukraine Model



The **TIMES-Ukraine (energy system wide) model** describes all energy (gas, oil, coal, electricity, heat, etc.) flows in the country or all economic sectors related to extraction, production, transformation, final consumption of energy resources, etc.

The power system model (for example, PLEXOS, used by Ukrenergo) describes in detail only the power sector (electricity production) with a predetermined demand for electricity in the country.

Models by their nature are not competitors, but can only complement each other.

History of TIMES-Ukraine Model

2004 IEF NASU launched studies on energy modelling

2006 Beginning of the TIMES-Ukraine model development under the NASU project

2009 Cooperation with the leading international institutions and first practical use TIMES-Ukraine model in international projects (USAID/Hellenic Aid project "Energy security and the development of markets in Europe and Eurasia: analysis of the national priorities", supported by IRG (Gary Goldstein) and CRES (George Giannakidis).

2010 First practical use TIMES-Ukraine model for preparing the national strategic document (General Plan of Coal Sector Development in Ukraine through 2020, TACIS project, Human Dynamics).

2011 Developed Information-analytical system (based on TIMES-Ukraine model) for strategic panning and forecasting energy balance.

2012 TIMES-Ukraine model is part of interregional integrated energy model for the Energy Community countries (EC-TIMES).

2012 Joined to the project with International Institute for Applied Systems Analysis (IIASA, Austria).

2013 Development of dynamic computable general equilibrium model (UGEM) and its further use in combination with TIMES-Ukraine model.

2014 Applied grid technologies for parallel computations in TIMES-Ukraine model (in Cooperation with the Cybernetics Institute of NASU)

2015 Beginning of the collaboration with the Danish Energy Agency and Danish Technical University.

2015 TIMES-Ukraine used for the preparation of the first NEEAP and INDC.

2017 TIMES-Ukraine used for the preparation of the LEDS.

2018-2020 TIMES-Ukraine used for the preparation of the second NEEAP and updated NDC.

2022 TIMES-Ukraine used for the preparation of the 2050 Buildings Retrofit Strategy of Ukraine

2023 IEF NASU launched energy modelling activities in the framework of the Net Zero World initiative

2023 TIMES-Ukraine used for the preparation of the National Energy and Climate Plan.

2024 TIMES-Ukraine used for the preparation of the LT-LEDS Strategy.

2025 TIMES-Ukraine used for the preparation of the Second NDC of Ukraine under Paris Agreement.

GLOBAL ENERGY AND CLIMATE SCENARIOS

The Intergovernmental Panel on Climate Change (IPCC)

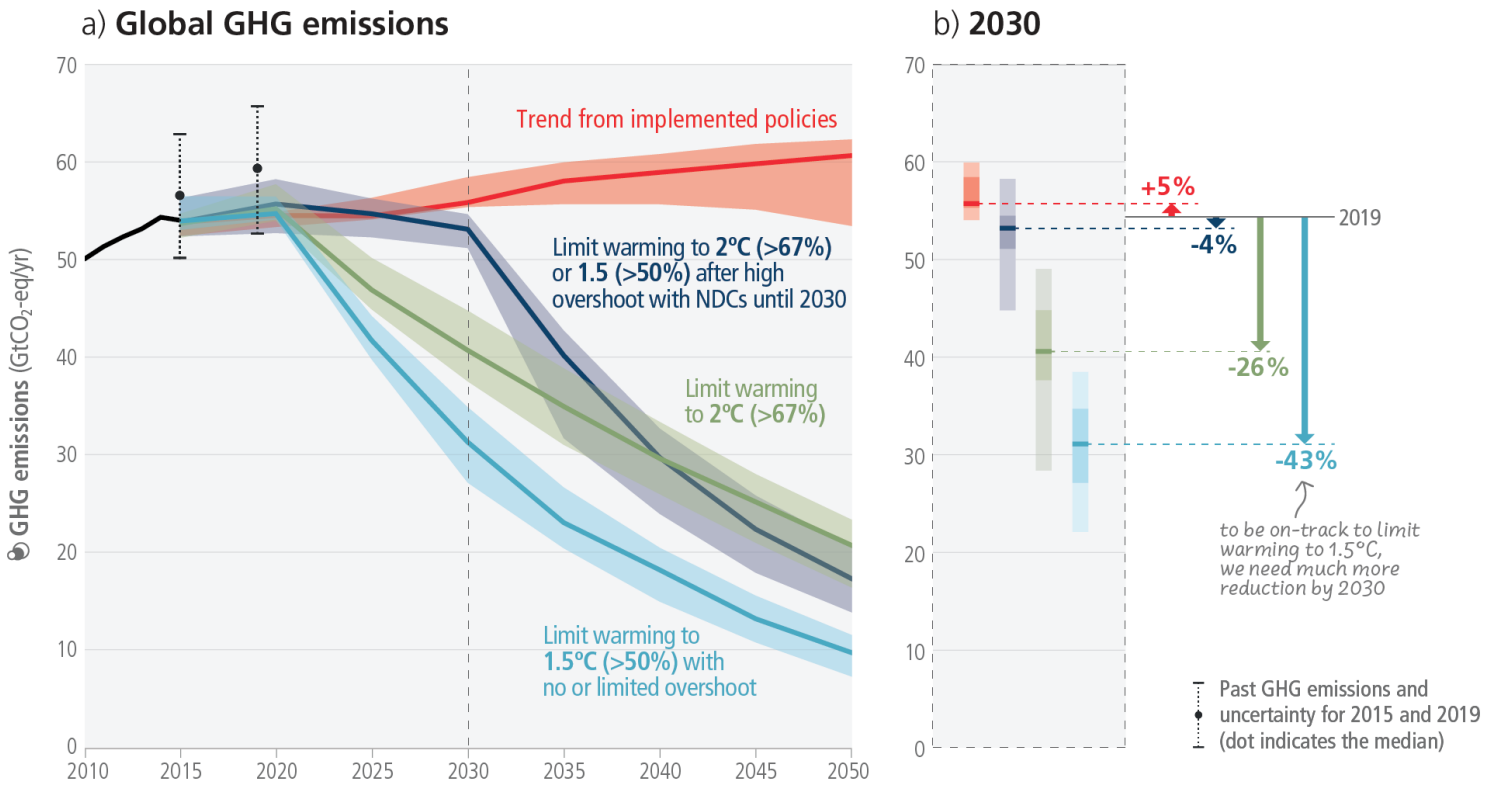
https://www.ipcc.ch/

The Intergovernmental Panel on Climate Change (IPCC)

https://www.ipcc.ch/

IPCC: AR6 Synthesis Report 2023

Projected global GHG emissions from NDCs announced prior to COP26 would make it *likely* that warming will exceed 1.5°C and also make it harder after 2030 to limit warming to below 2°C

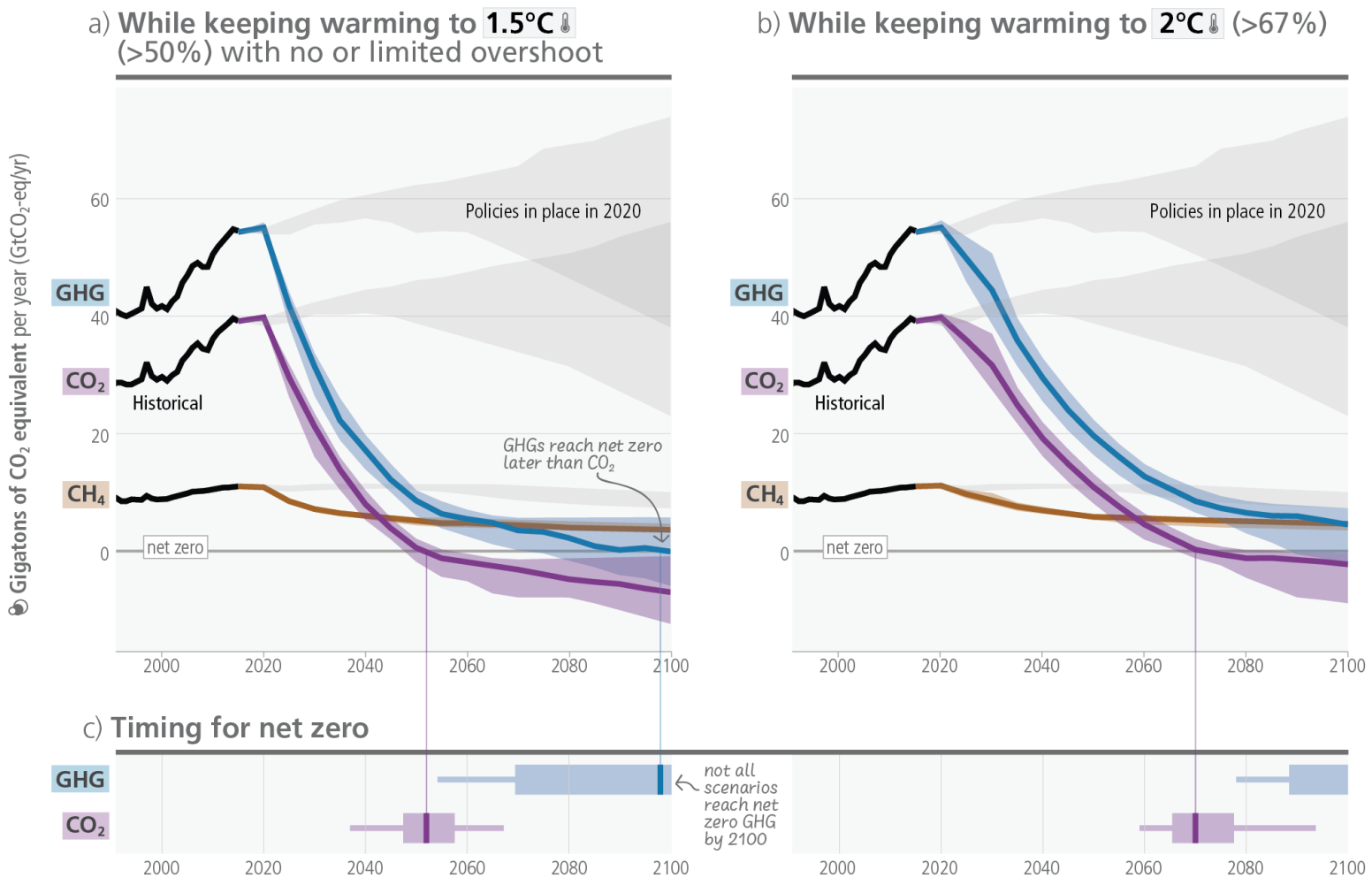


Panel a shows global GHG emissions over 2015–2050 for four types of assessed modelled global pathways:

- Pathways with projected near-term GHG emissions in line with policies implemented until the end of 2020 and extended with comparable ambition levels beyond 2030 (29 scenarios across categories C5–C7);
- Pathways with GHG emissions until 2030 associated with the implementation of NDCs announced prior to COP26, followed by accelerated emissions reductions likely to limit warming to 2°C or to return warming to 1.5°C with a probability of 50% or greater after high overshoot.
- Pathways that limit warming to 2°C (>67%) with immediate action after 2020.
- Pathways limiting warming to 1.5°C with no or limited overshoot.

Global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot reach net zero CO_2 emissions around 2050

Total **greenhouse gases (GHG)** reach net zero later



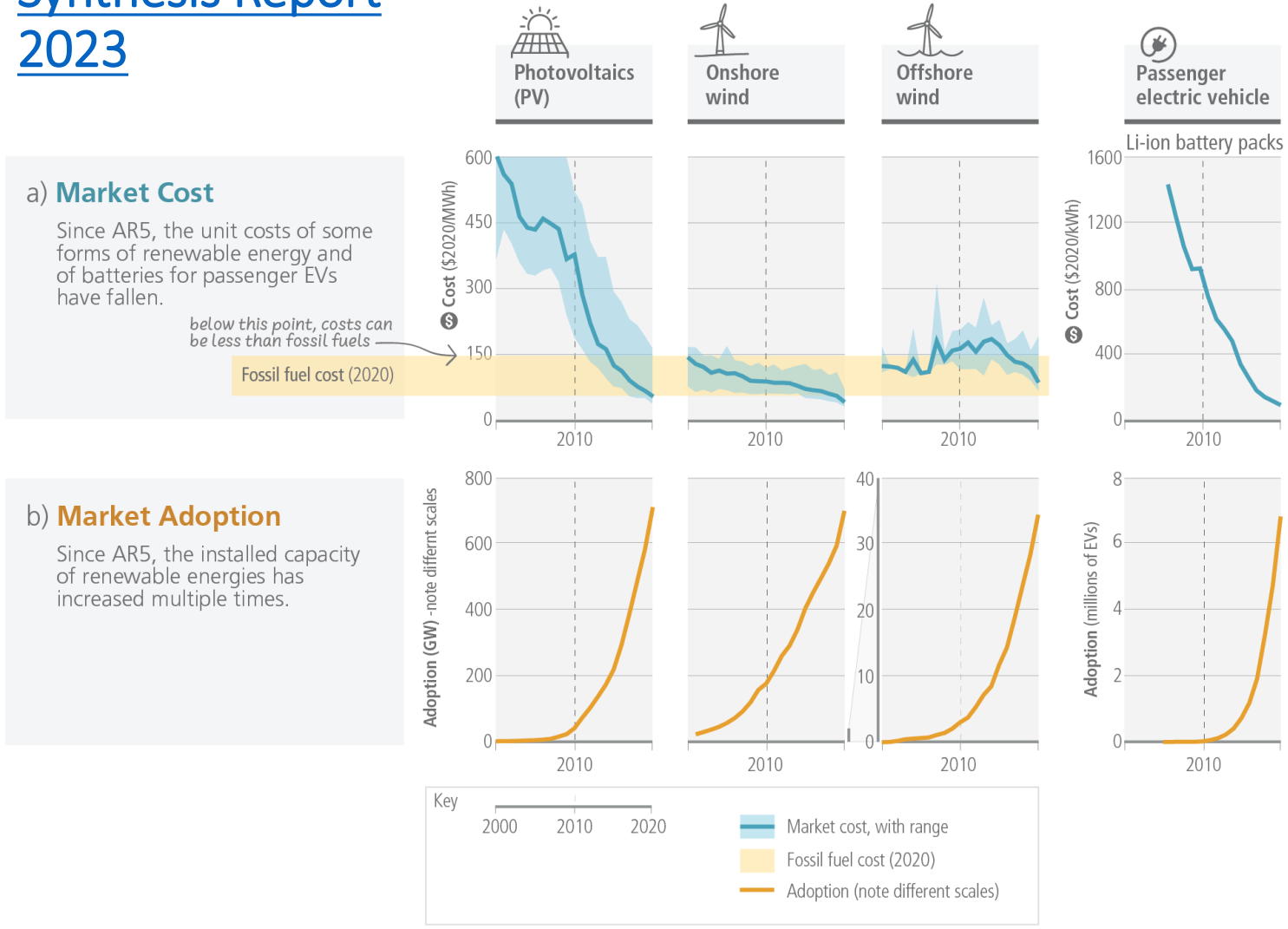
IPCC: AR6 Synthesis Report 2023

GHG, CO2 and CH4 emissions over time (in GtCO2eq) with historical emissions, projected emissions in line with policies implemented until the end of 2020 (grey), and pathways consistent with temperature goals in colour (blue, purple, and brown, respectively);

Panel (a) (left) shows pathways that limit warming to 1.5°C (>50%) with no or limited overshoot (C1) and Panel (b) (right) shows pathways that limit warming to 2°C (>66%) (C3). Bottom row: Panel (c) shows median (vertical line), likely (bar) and very likely (thin lines) timing of reaching net-zero GHG and CO2 emissions for global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot (C1) (left) or 2°C (>67%) (C3) (right).

IPCC: AR6 Synthesis Report 2023

Renewable electricity generation is increasingly price-competitive and some sectors are electrifying



The top panel (a) shows global costs per unit of energy (USD per MWh) for some rapidly changing mitigation technologies. Solid blue lines indicate average unit cost in each year.

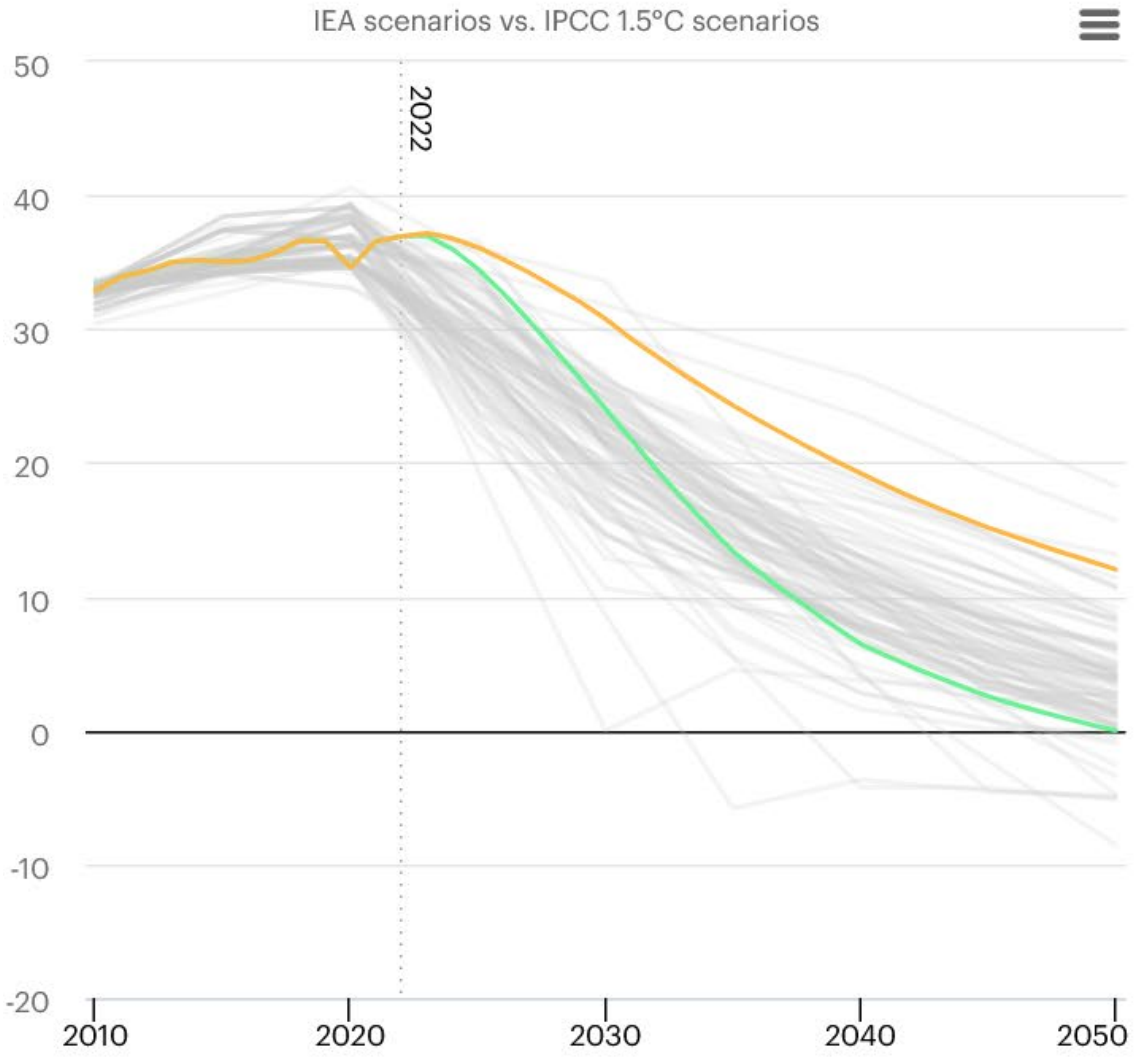
The bottom panel (b) shows cumulative global adoption for each technology, in GW of installed capacity for renewable energy and in millions of vehicles for battery-electric vehicles. A vertical dashed line is placed in 2010 to indicate the change over the past decade.

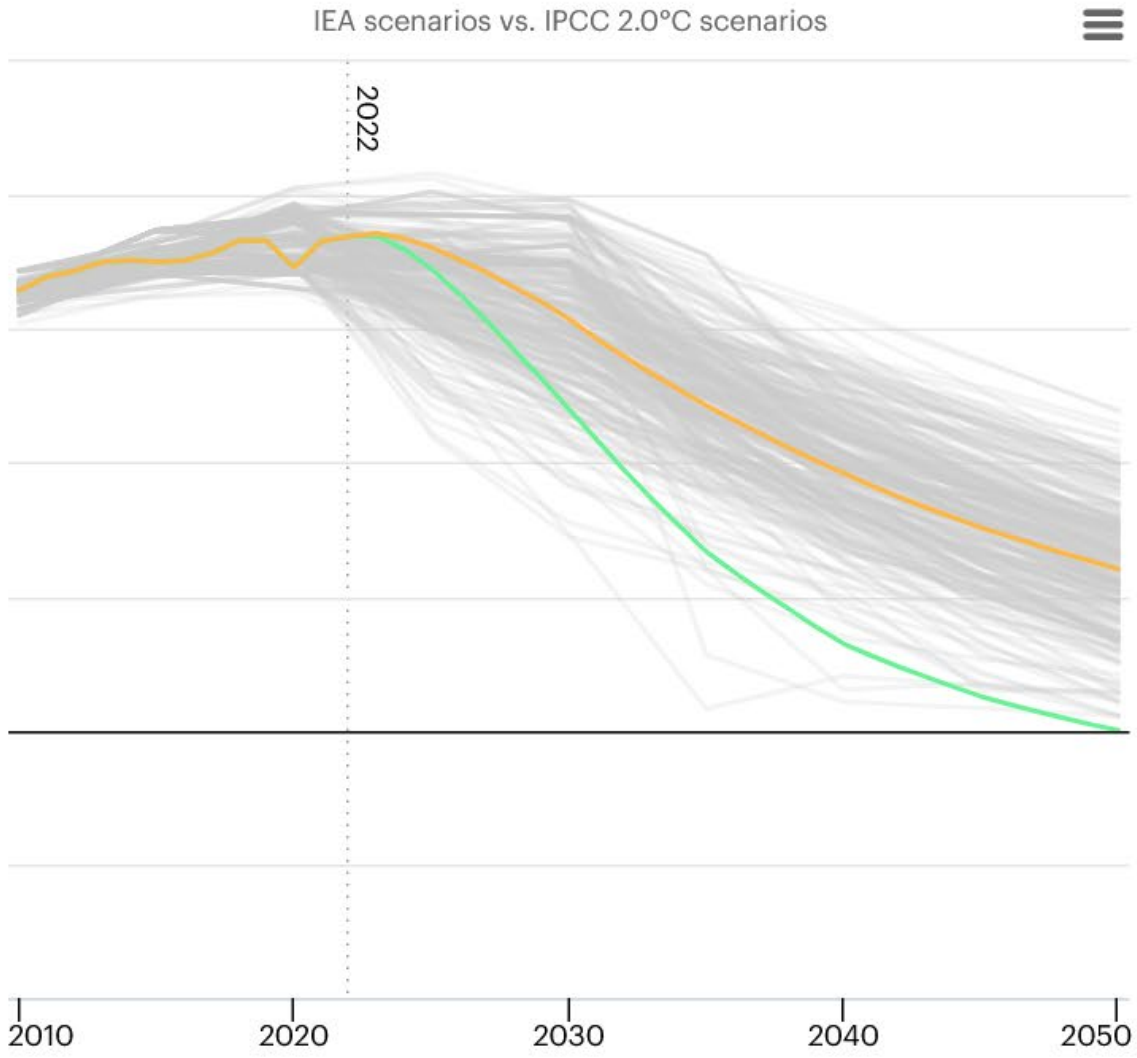
Renewable energy and battery technologies were selected as illustrative examples because they have recently shown rapid changes in costs and adoption, and because consistent data are available.

International Energy Agency

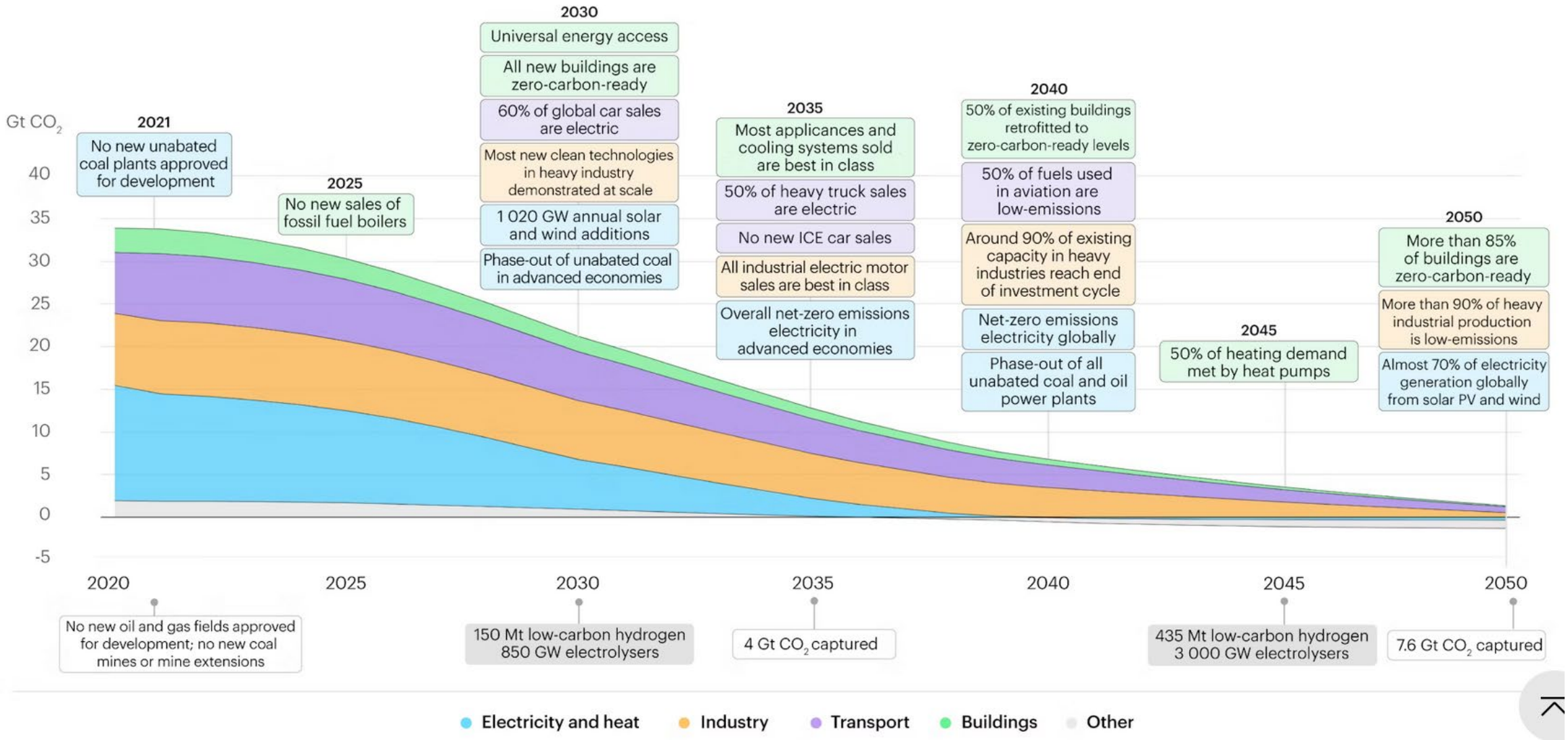
https://www.iea.org

IEA: Understanding GEC Model scenarios





IEA: Net Zero by 2050, Roadmap for the Global Energy Sector



UKRAINE'S ENERGY AND CLIMATE SCENARIOS

Pre-War Modelling

2050 Low Emission Development Strategy of Ukraine

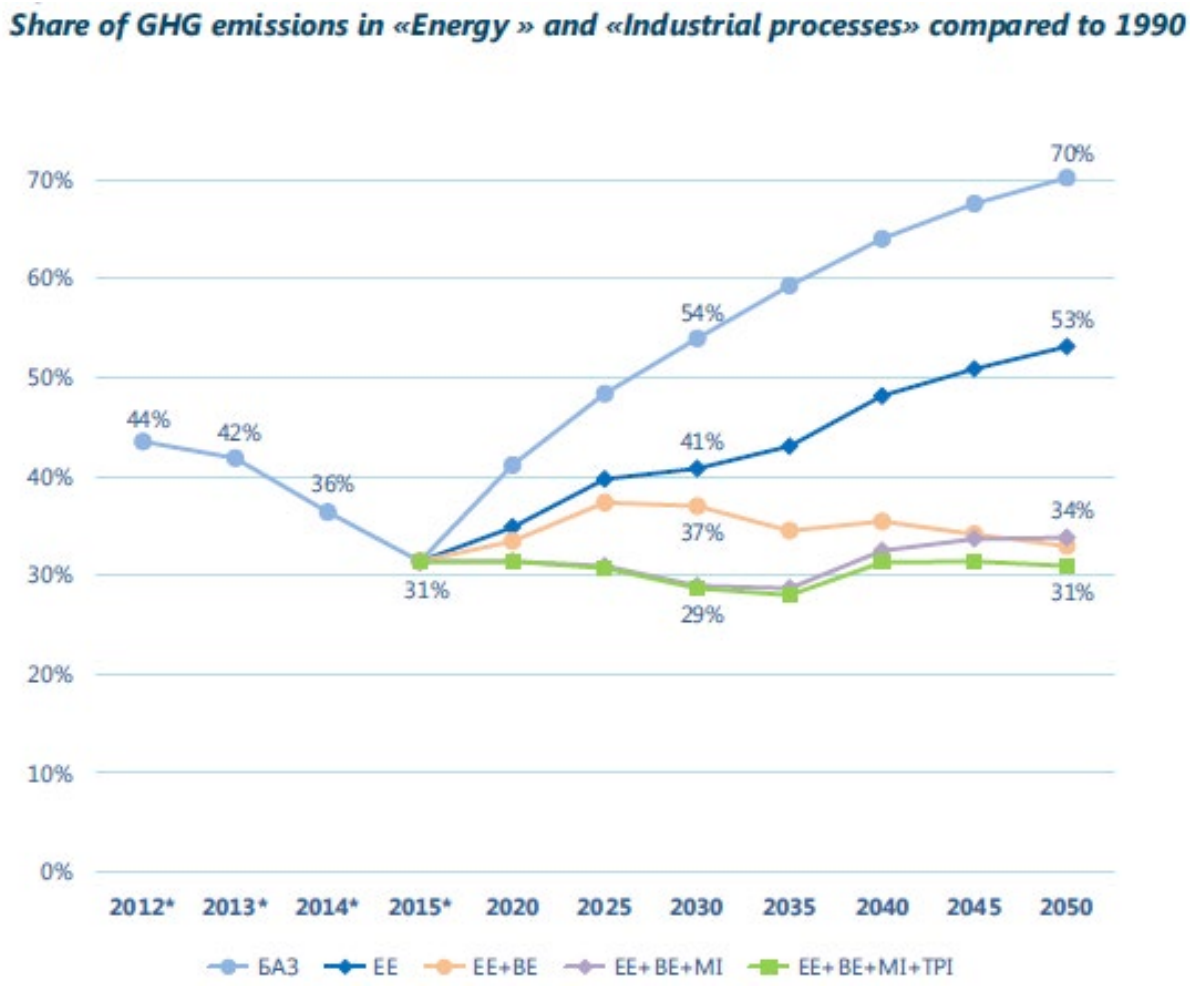
Source: *https://unfccc.int/documents/181275*

The 2050 Low Emission Development Strategy

- The LEDS determines national stakeholders agreed vision on decoupling further economic and social growth and greenhouse gases emissions.
- At the national level, the LEDS is an instrument for public administration and shaping of climate responsible behavior of both businesses and citizens, while at the international level, it supports a global target on stabilization of GHG concentration in accordance to the scenario of global average temperature increase confinement to well below 2°C of preindustrial level.
- Strategy objectives:
  - *Transition to energy system which envisions the use of energy sources with low carbon content, development of the sources of clean electricity and heat energy, increase in energy efficiency and energy saving in all sectors of economy …*
  - *Increase in the volumes of carbon absorption and uptake with the help of best climate change mitigation practices in agriculture and forestry.*
  - *Reduction in GHG emissions such as methane gas and nitrogen oxide predominantly associated with fossil fuel production, agriculture and waste.*

The LEDS: Energy Modeling Scenarios

- The LEDS describe four policy scenarios:
  - ***Energy efficiency*** *– includes policies and measures which aim to increase efficiency in the use of energy resources and energy saving accompanied with enhanced quality in energy services and energy resources supply;*
  - *Renewable energy – includes policies and measures which aim to support and stimulate the renewable energy development in Ukraine;*
  - ***Modernization and innovation*** *– includes policies and measures which aim to modernize the fixed assets used in traditional energy (energy resources generation, transition and consumption) and implementation of innovation technologies (such as smart networks, industrial production and use of hydrogen etc.);*
  - ***Market transformation and institutions*** *– includes business measures, which directly or indirectly affect structural shifts in economy and in goods and services markets; regulatory and management practices at the national and sector level; standards and codes; public aware*



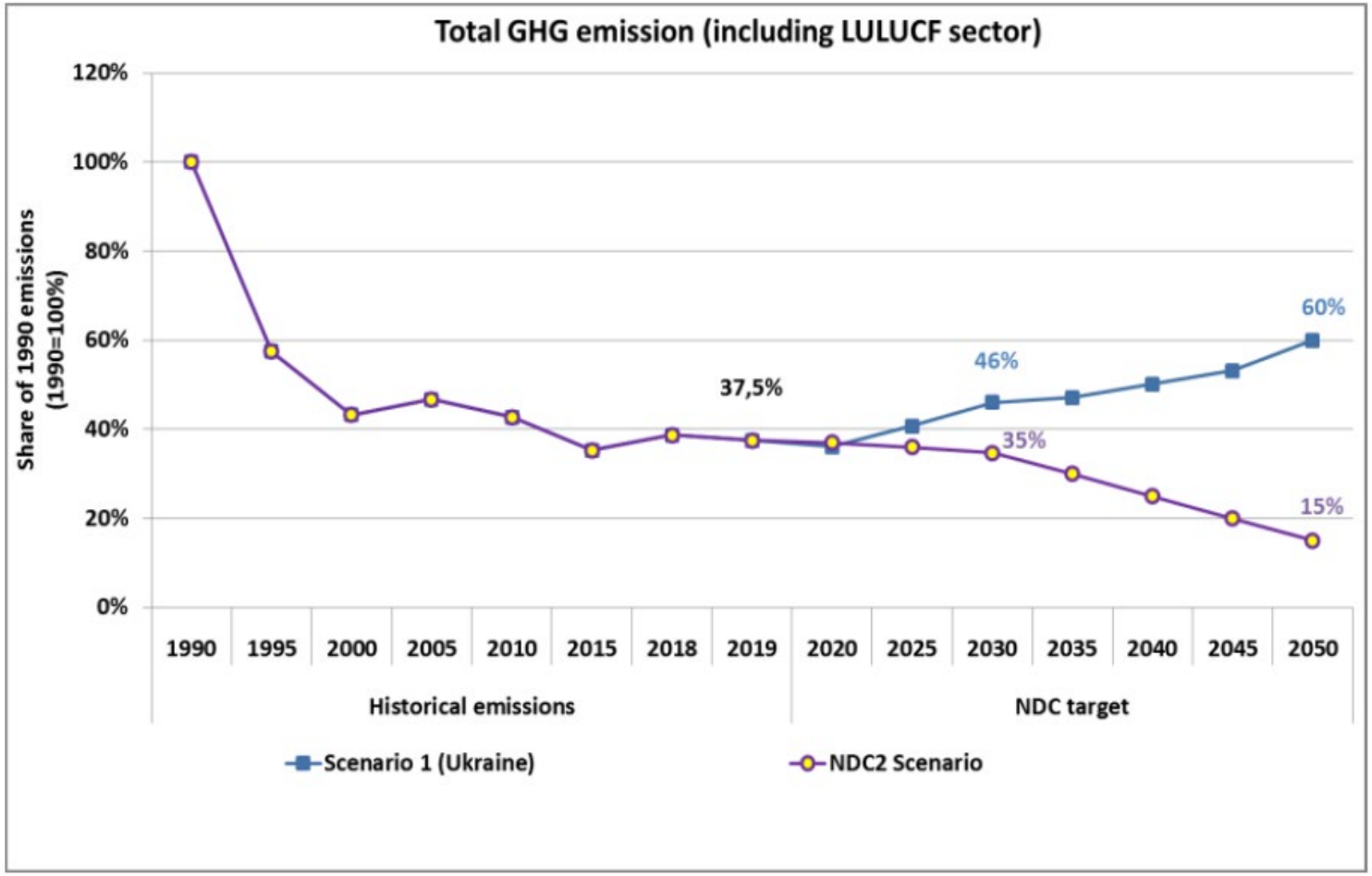
Nationally Determined Contributions of Ukraine to the Paris Agreement

Source:

https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://unfccc.int/sites/default/files/NDC/2022-06/Ukraine%2520NDC_July%252031.pdf&ved=2ahUKEwj39qyU9fSGAxUtGhAIHWh0DB8QFnoECBIQAQ&usg=AOvVaw1ujzynaQ_BKLx6v1fhmQhd

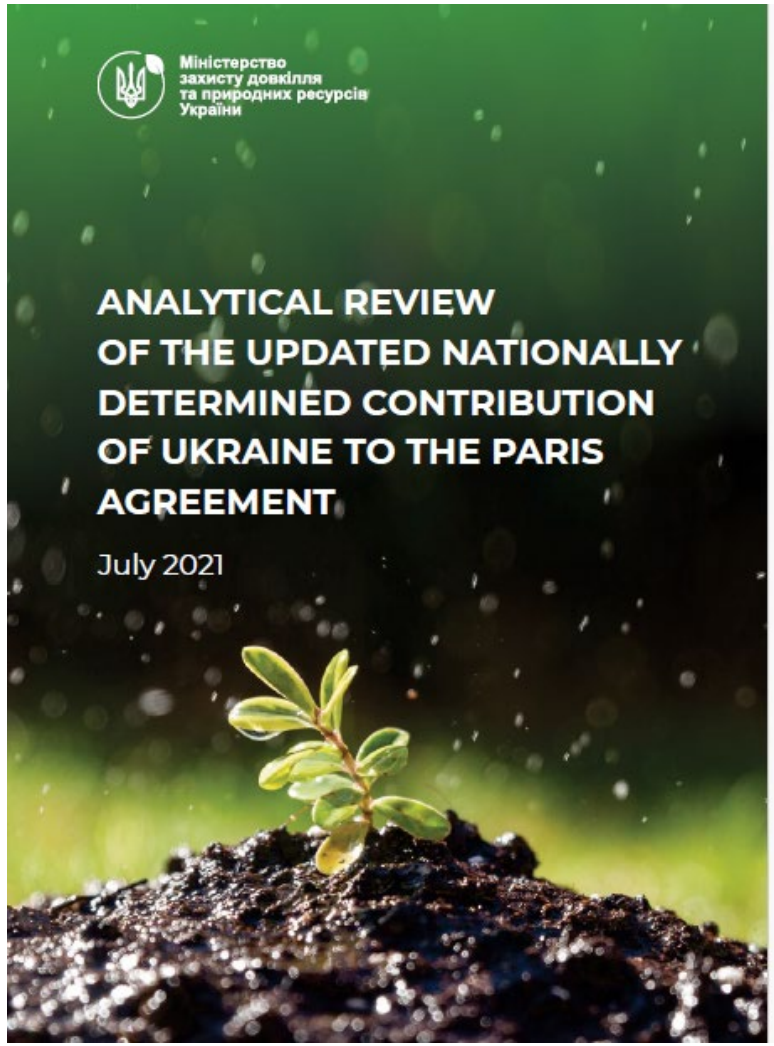
Updated Nationally Determined Contribution of Ukraine to the Paris Agreement

- Ukraine has committed itself to achieving the target of reducing GHG emissions of 65% by 2030, compared to 1990 (incl. LULUCF), reaching carbon neutrality until 2060 as foreseen in the 2030 National Economic Strategy.
- The Ukrainian NDC includes GHG emissions and targets for its uncontrolled and occupied territories, however the detailed information on the economic activities and GHG emissions on those territories is missing.
- To assessing the level of GHG emissions used the TIMES-Ukraine model, mass balance model for Waste sector and specific excel-based tools for the Agriculture and LULUCF.



Updated NDC: Analytical Review

- This publication is prepared by the Ministry of Environment with the aims to summarise and combine a number of analytical inputs and information largely drawn from the technical reports of the EBRD's project "Support to the Government of Ukraine on updating its Nationally Determined Contribution," in cooperation with Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine; combined with analytical review of the sectors conducted with the support of the Low Carbon Ukraine (LCU) Project and BE Berlin Economics GmBH. The EBRD project was sponsored by the government of Sweden (Sida), and this publication is drawing from the numerous deliverables under the EBRD Project, but prepared as a separate document.
- Discussions of the modelling results were conducted with the participation of the Ministry of Economy of Ukraine, the Ministry of Energy of Ukraine, the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Infrastructure of Ukraine, the Ministry of Community Development and Territories of Ukraine.



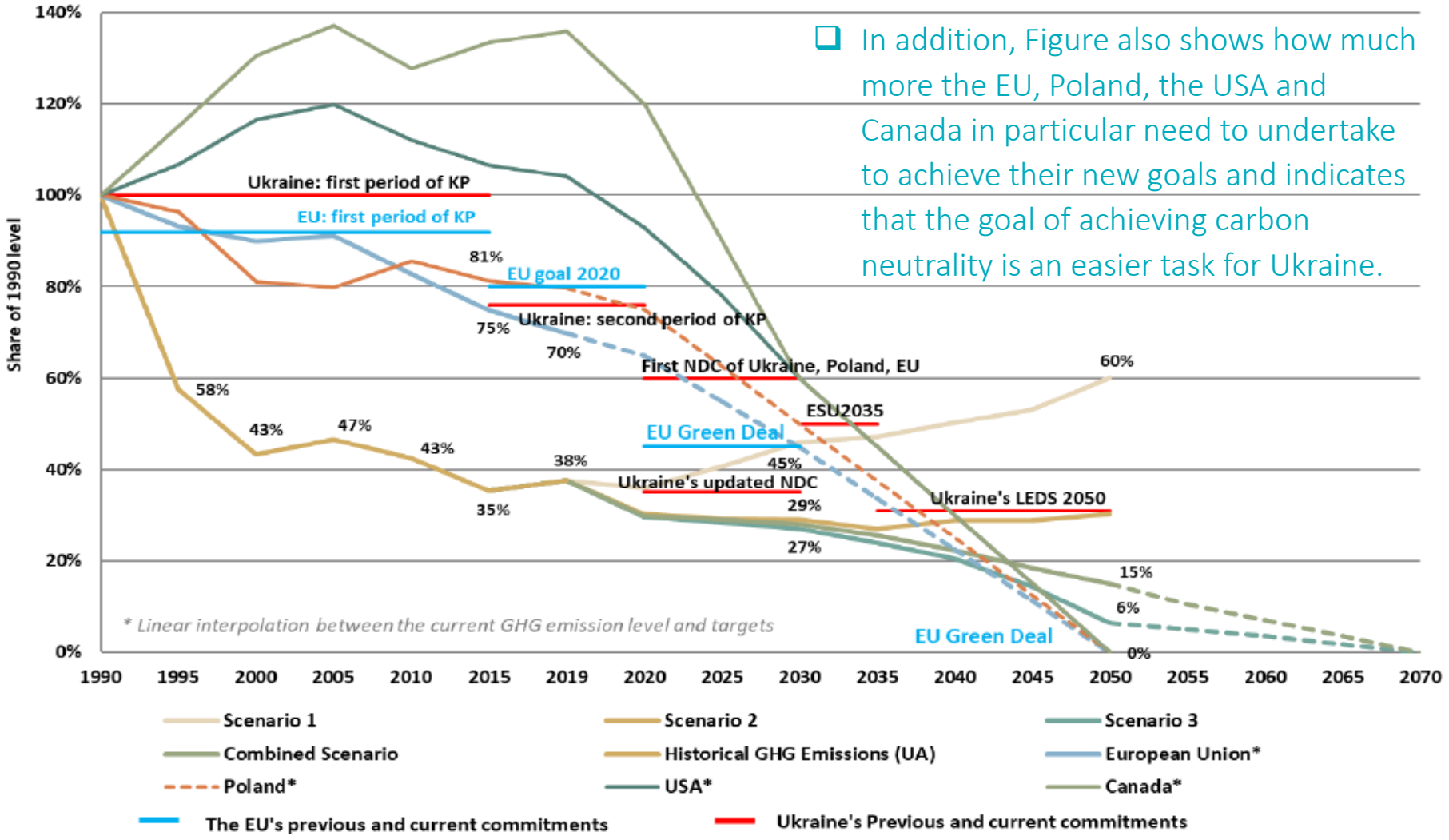
EBRD/IEF: Modeling Scenarios for Upd NDC

The following four NDC/GHG emission pathway scenarios were modelled:

- ✓ Scenario 1, or the "**Business as usual (BAU) scenario**", was set as an "exploratory scenario", assuming that no fundamental changes take place and particularly that no additional emission reduction measures are implemented during the projected period.
- ✓ Scenario 2, or the "**Reference scenario**", contains numerous targets and indicators to be achieved according to the current legislation modelled as policy constraints with a policy-specific timeline (e.g. the 2035 Energy Strategy indicators and targets and the NEEAP, NREAP and LEDS indicators).
- ✓ Scenario 3, or the "**Climate-neutral economy scenario**", contains the same set of policy targets as applied to the Reference scenario with an additional target constraint imposed on the level of GHG emissions per capita by 2070.
- ✓ Scenario 4, or the "**Combined sensitivity scenario**", was modelled on the baseline economic development scenario and included the conditions of Scenario 2 for the sectors of agriculture and LULUCF as well as various sensitivity options, including carbon tax and nuclear variables and others.

EBRD/IEF: GHG in UA, EU and selected countries

- Figure shows how Ukraine's climate commitments (in the first and second periods of the Kyoto Protocol, the first and updated NDCs, the 2035 Energy Strategy of Ukraine and the 2050 LEDS corresponded to the actual trajectory of GHG emissions and how the combined sensitivity scenario corresponds to the theoretical trajectory to reach carbon neutrality by 2070.
- Figure also shows the trajectory of GHG emissions with a new target for 2030 and carbon neutrality in 2060.



- In addition, Figure also shows how much more the EU, Poland, the USA and Canada in particular need to undertake to achieve their new goals and indicates that the goal of achieving carbon neutrality is an easier task for Ukraine.

2030 National Energy Efficiency Action Plan

Source: *https://zakon.rada.gov.ua/laws/show/1803-2021-%D1%80#Text*

The 2030 NEEAP of Ukraine

- The second National Energy Efficiency Action Plan was developed and adopted according to the Energy Efficiency Directive (EED) 2012/27/EU.
- Ukraine's NEEAP has been drawn up in accordance with the template laid down by the Energy Community Secretariat. Each action plan analyses the effects and, if necessary, revises current measures and establishes new sectoral measures in order to ensure that the objectives are met in 2030.
- The NEEAP presents an overview of expected energy savings due to current and planned activities that are aligned with the requirements of the EED. Those activities are disaggregated by relevant sectors and their due diligence has been conducted. It consists of 28 measures which were identified through comprehensive and robust consultations with all relevant stakeholders representing the Government, public and private sector, and other relevant groups.
- Energy savings calculations were undertaken for each measure taking as much as possible the bottom-up approach. It was calculated that those measure will achieve 26,307 ktoe in primary energy savings and 10,440 ktoe in final energy savings. Those present 22.3% of the expected primary energy consumption for the year 2030.

The cheapest energy is saved energy!

The 2030 NEEAP Scenarios

- The targets for energy efficiency for the year 2030 were estimated based on the following steps:
  - *Reconstruction of the Business as Usual (baseline or BAU) scenario for energy consumption.*
  - *Setting a top-down target for energy efficiency based on the Ukrainian strategic goals as stated in the Energy Strategy for 2035 for energy intensity (units of energy per units of economic output), and expected level of economic output.*
  - *Developing a bottom-up analysis for how certain policy measures could achieve these savings – as modelled in the TIMES-Ukraine model.*

Year	2017		2021		2025		2030	
Category	Primary Energy (ktoe)	Final energy (ktoe)	Primary Energy (ktoe)	Final energy (ktoe)	Primary Energy (ktoe)	Final energy (ktoe)	Primary Energy (ktoe)	Final energy (ktoe)
Business As Usual scenario	87,110	47,571	102,658	53,411	110,456	57,099	117,775	60,887
Savings from measures	-	-	-13,675	-4,157	-19,638	-6,582	-26,307	-10,440
With measures	87,110	47,571	88,983	49,254	90,818	50,517	91,468	50,447
% energy reduction from the BAU	0%	0%	13.3%	7.8%	17.8%	11.5%	22.3%	17.1%

UKRAINE'S ENERGY AND CLIMATE SCENARIOS

Post-War Modelling

Ukraine’s National Energy and Climate Plan

Source: https://me.gov.ua/Documents/Detail?lang=en-GB&id=d3c7185c-8669-4ce9-8da0-29a47b4b95a2&title=NationalEnergyAndClimatePlanOfUkraine2025-2030

The Government of Ukraine approved NECP on June 25, 2024

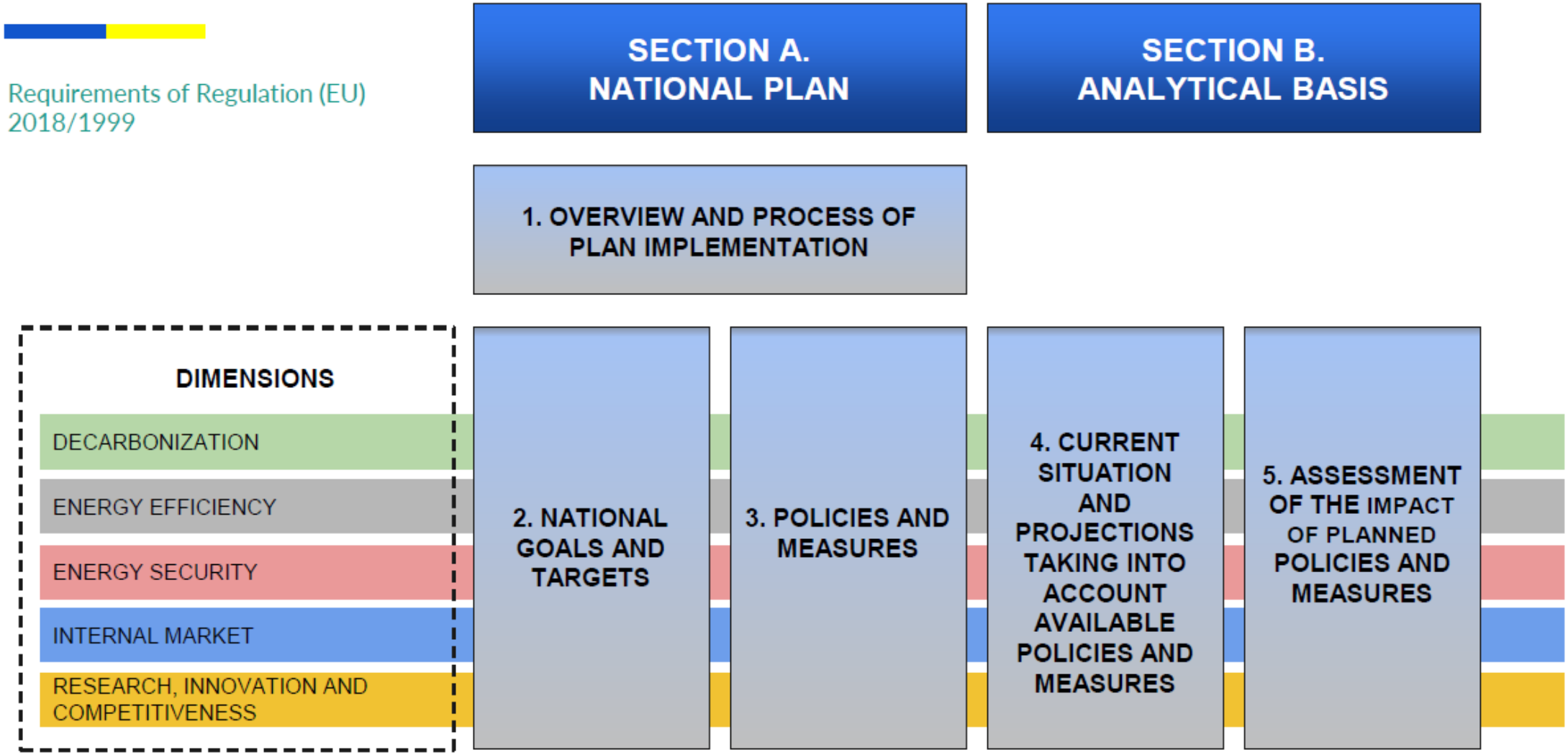
Ukraine’s NECP

- The National Energy and Climate Plan of Ukraine (NECP) is a strategic document aimed at coordinating energy and climate policies to ensure sustainable development and economic recovery of Ukraine.
- The preparation of NECP is Ukraine's obligation under the Energy Community, in accordance with the requirements of Regulation (EU) 2018/1999 and the relevant methodological recommendations of the European Commission. The document was also supposed to be prepared in accordance with the orders of the President of Ukraine dated November 8, 2019, No. 837/20192 and March 23, 2021, No. 111/2021. In addition, the development and approval of NECP is a condition for the distribution of financial assistance from the EU under the future Ukraine Facility.
- The development of the draft NECP is carried out by a group of leading experts associated with DiXi Group think tank and the Institute of Economics and Forecasting of the National Academy of Sciences of Ukraine, with the support of the Embassy of United Kingdom and the US initiative Net Zero World.

National Energy and Climate Plan of Ukraine 2025-2030

Structure of NECP

Requirements of Regulation (EU) 2018/1999



* *Source: European Commission*

Ukraine’s NECP Scenarios

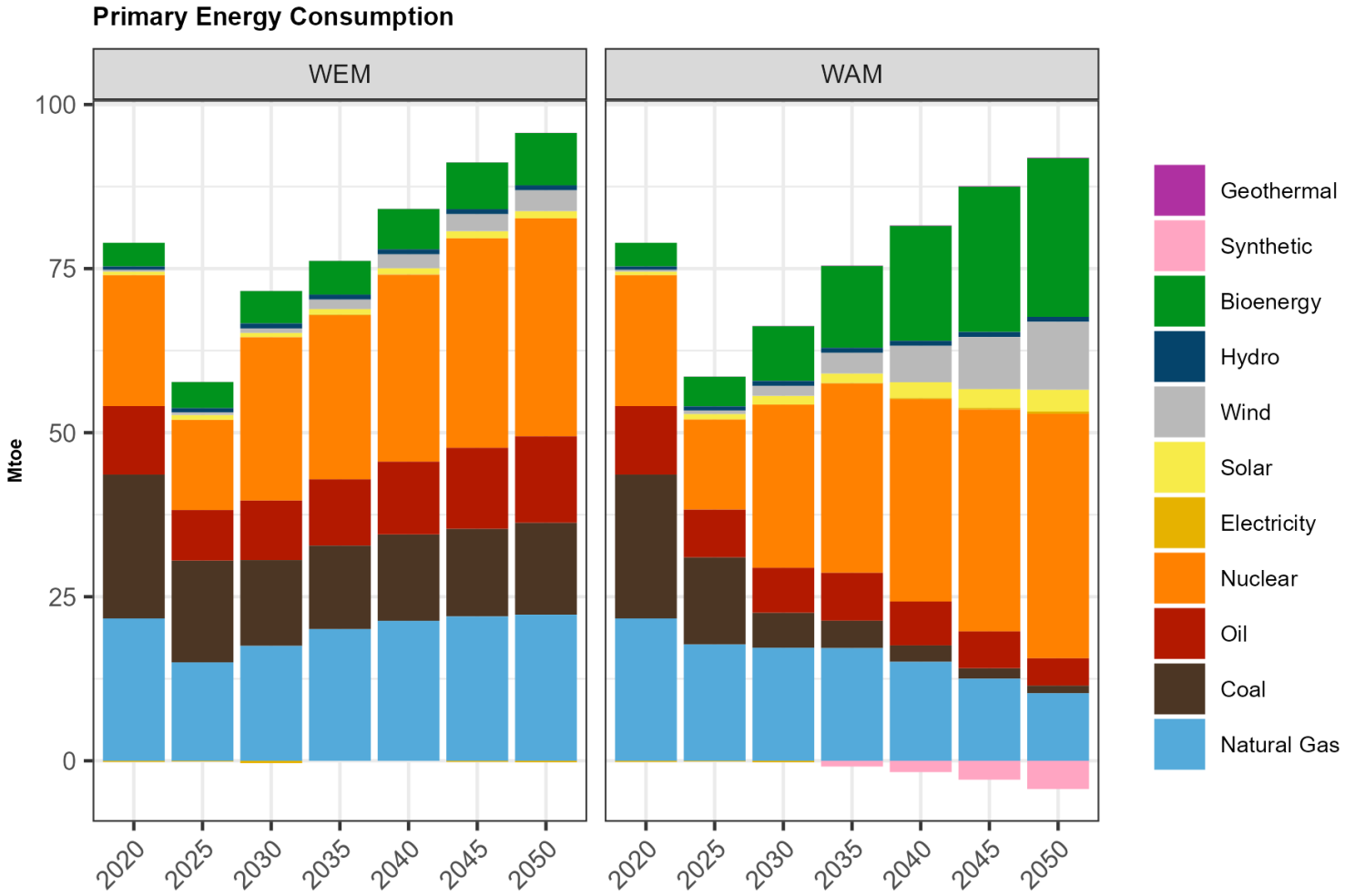
- NECP assesses whether the state's energy and climate goals can be achieved through existing (WEM scenario) and planned (WAM scenario) policies and measures, as assessed by modeling tools, including TIMES-Ukraine model.
- Two mandatory scenarios developed:

  1) with existing policies and measures (WEM) = **implemented + adopted**

  2) with **planned** (additional) policies and measures (WAM)

- **Implemented** – policies and measures for which one or more conditions are applicable as of the date of submission of the NECP: there is an applicable EU law or directly applicable national law, one or more voluntary agreements have been concluded, financial resources have been allocated, human resources have been mobilized.
- **Adopted** – policies and measures for which, as of the date of submission of the NECP, an official government decision has been made and there is a clear commitment to further implementation.
- Planned -policies that are at the stage of discussion and have a real chance to be adopted and implemented after the date of submission of the NECP.

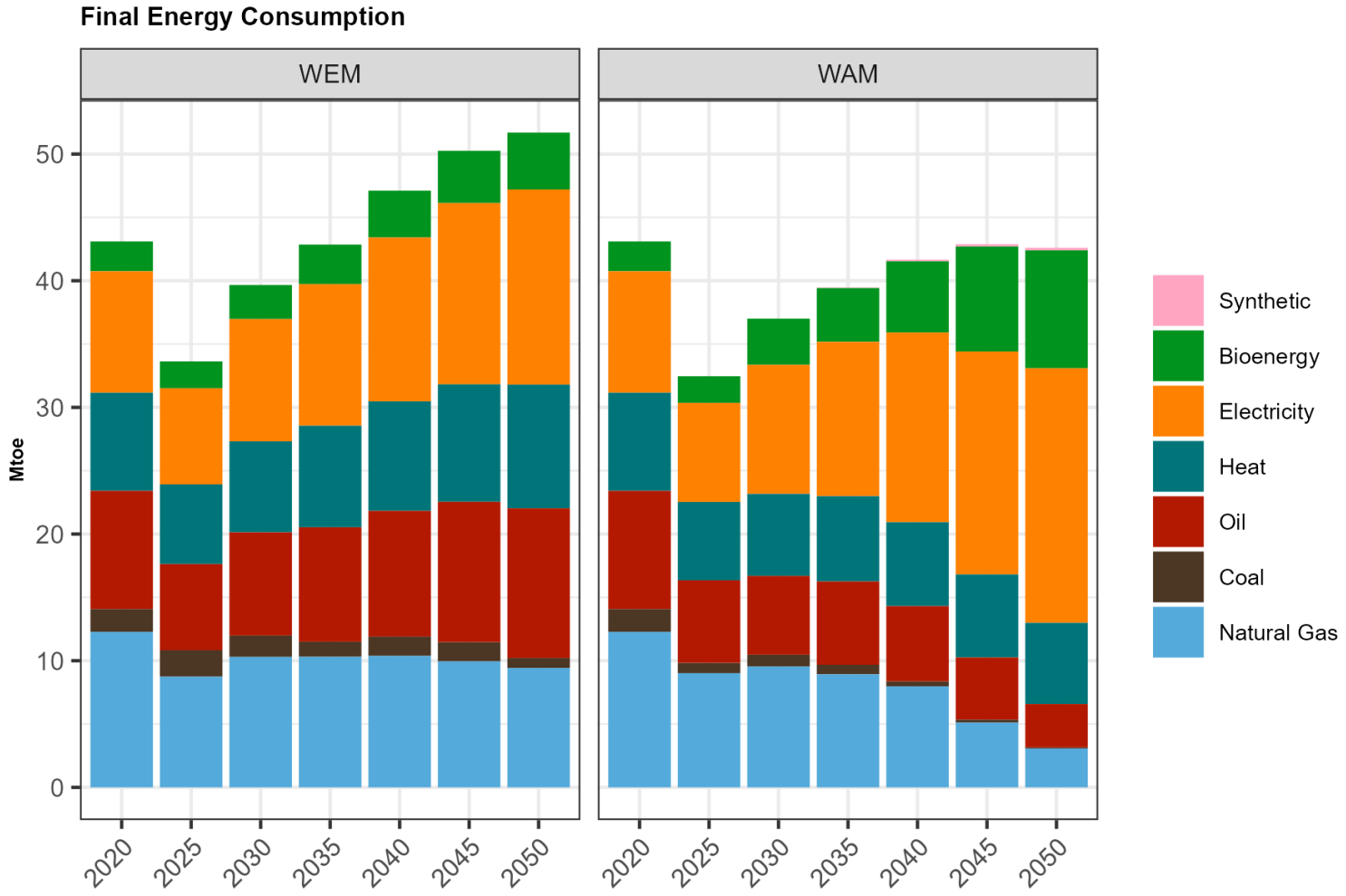
NECP Modeling Results: Total Primary Energy Supply



DECISION OF THE MINISTERIAL COUNCIL OF THE ENERGY COMMUNITY

Country	PEC, 2030
Albania	2,60
Bosnia and Herzegovina	6,50
Georgia	5,45
Kosovo	2,70
Moldova	3,00
Montenegro	0,92
North Macedonia	2,30
Serbia	14,94
Ukraine	**91,47**
Energy Community	**129,88**

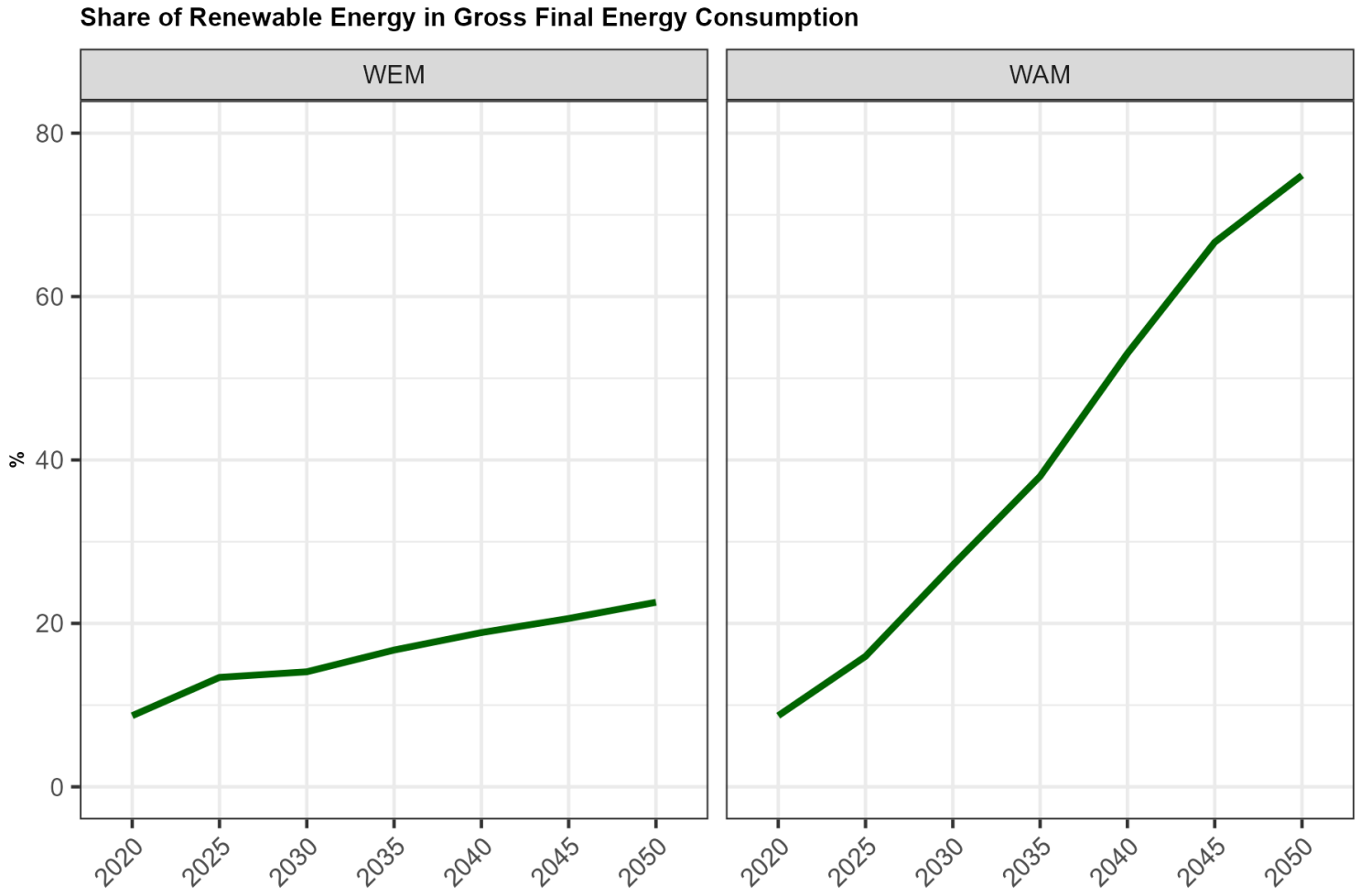
NECP Modeling Results: Final Energy Consumption



DECISION OF THE MINISTERIAL COUNCIL OF THE ENERGY COMMUNITY

Country	FEC, 2030
Albania	2,40
Bosnia and Herzegovina	4,34
Georgia	5,00
Kosovo*	1,80
Moldova	2,80
Montenegro	0,73
North Macedonia	2,00
Serbia	9,54
Ukraine	**50,45**
Energy Community	**79,06**

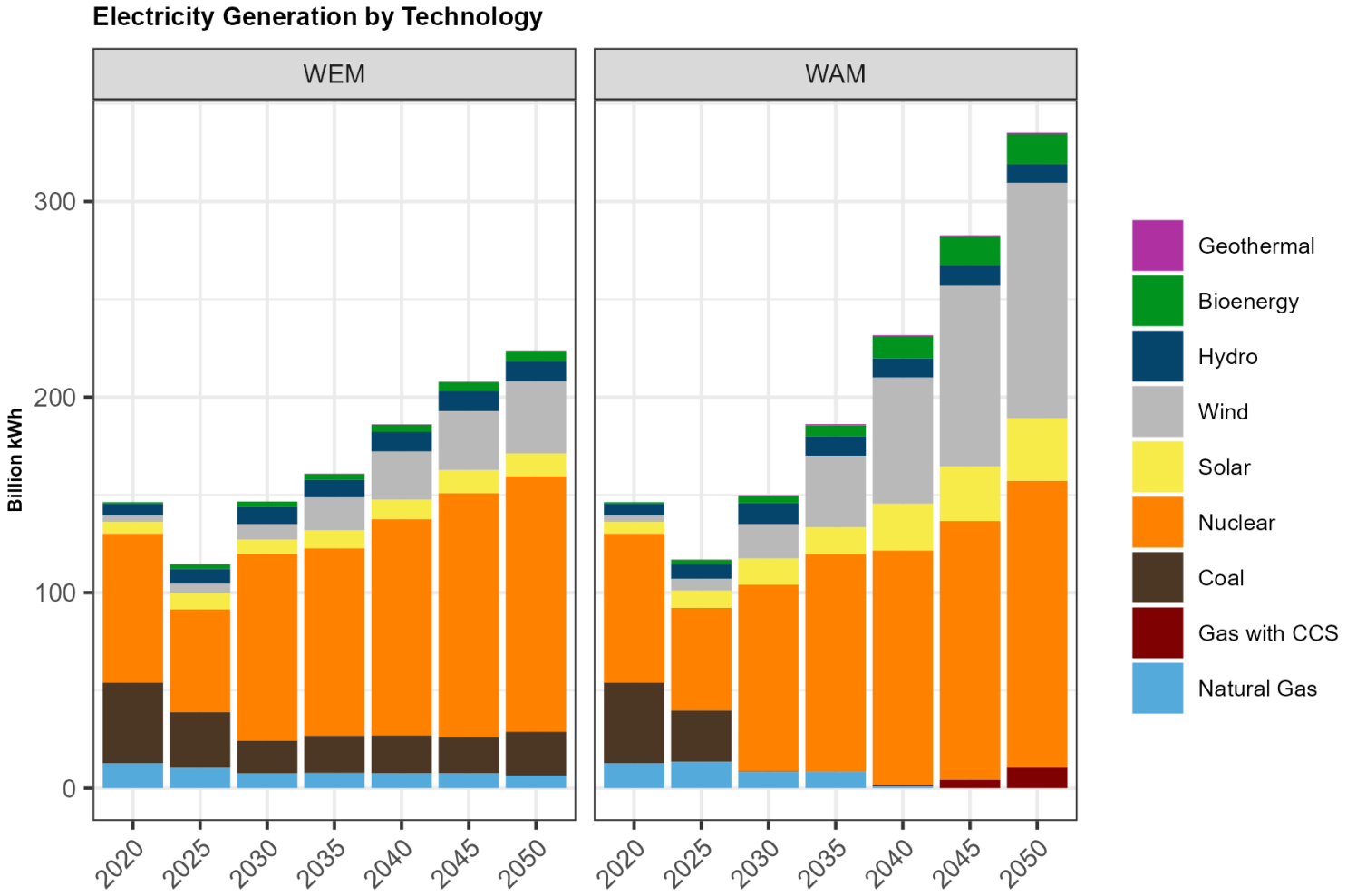
NECP Modeling Results: Share of RES in GFEC



DECISION OF THE MINISTERIAL COUNCIL OF THE ENERGY COMMUNITY

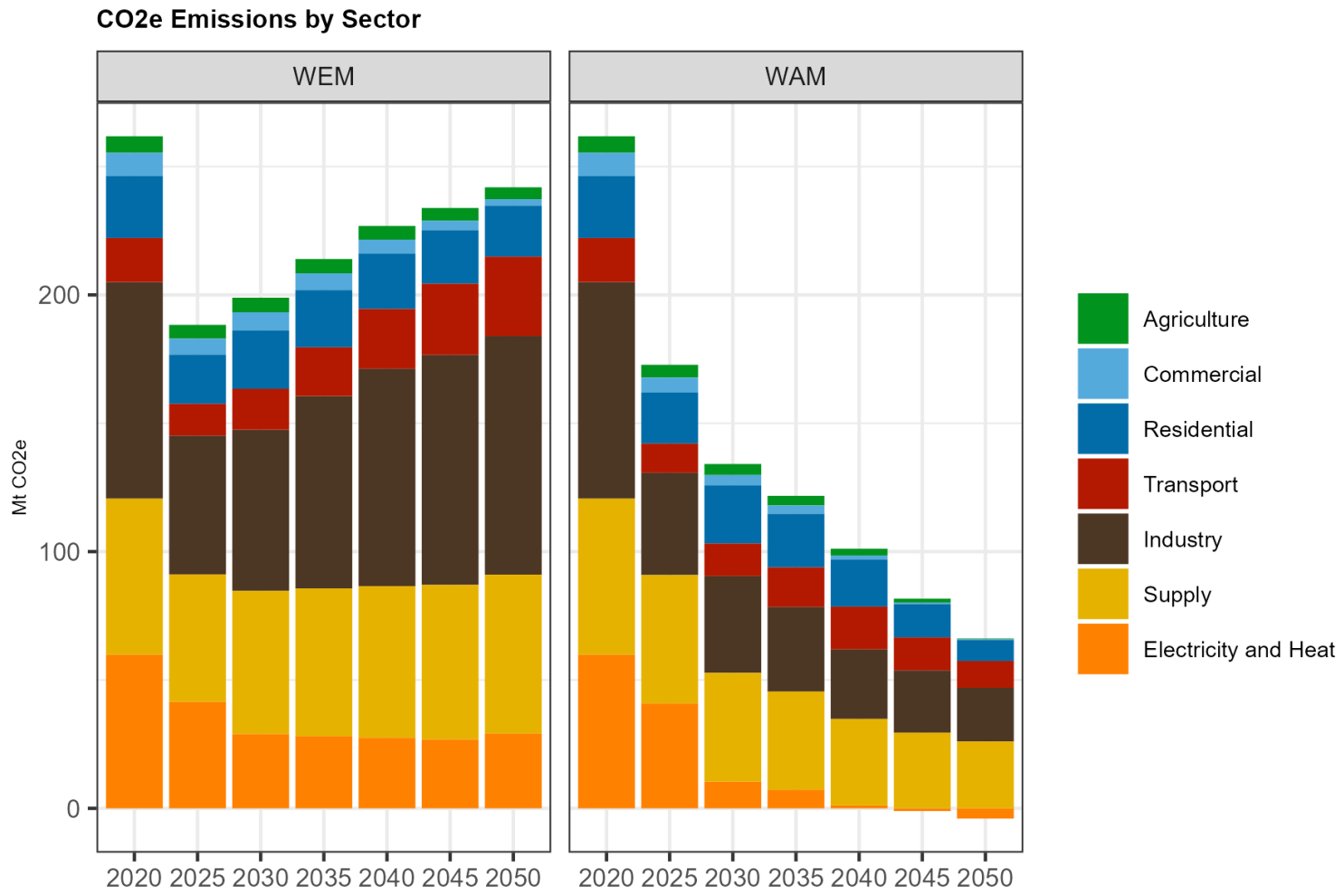
Country	% RES, 2030
Albania	52,0%
Bosnia and Herzegovina	43,6%
Georgia	27,4%
Kosovo*	32,0%
Moldova	27,0%
Montenegro	50,0%
North Macedonia	38,0%
Serbia	40,7%
Ukraine	**27,0%**
Energy Community	**31,0%**

NECP Modeling Results: Electricity Generation



- The power sector decarbonizes even in the WEM scenario.
- Coal is phased-out by 2030 (in case of high carbon prices) and replaced by renewables and nuclear in the WAM scenario.
- In WAM scenario gas-based generation gradually switches to biomethane, so that in 2045-2050 there was no fossil gas.

NECP Modeling Results: GHG Emissions



DECISION OF THE MINISTERIAL COUNCIL OF THE ENERGY COMMUNITY

Country	% from 1990 and MtCO2eq, 2030
Albania	+53,2%, 12,00 Mt
Bosnia and Herzegovina	-41,2%, 15,65 Mt
Georgia	-47,0%, 20,50 Mt
Kosovo*	-16,3%, 8,95 Mt
Moldova	-68,6%, 9,10 Mt
Montenegro	-55,0%, 2,42 Mt
North Macedonia	-82,0%, 2,20 Mt
Serbia	-40,3%, 47,82 Mt
Ukraine	**-65,0%, 309,00 Mt**
Energy Community	**-60,9%, 427,64 Mt**

New Long-term
2050 Ukraine Low Emission Development Strategy

Projected emission reductions and removals by 2050 (draft)

WEM: GHG emissions from Agriculture are projected to increase steadily from 2025 to 2050 in all scenarios.

Energy & IPPU and Waste emissions decrease slightly. LULUCF absorption significantly decreases from 2022 to 2040, but by 2050 restores to more than 2025 level.

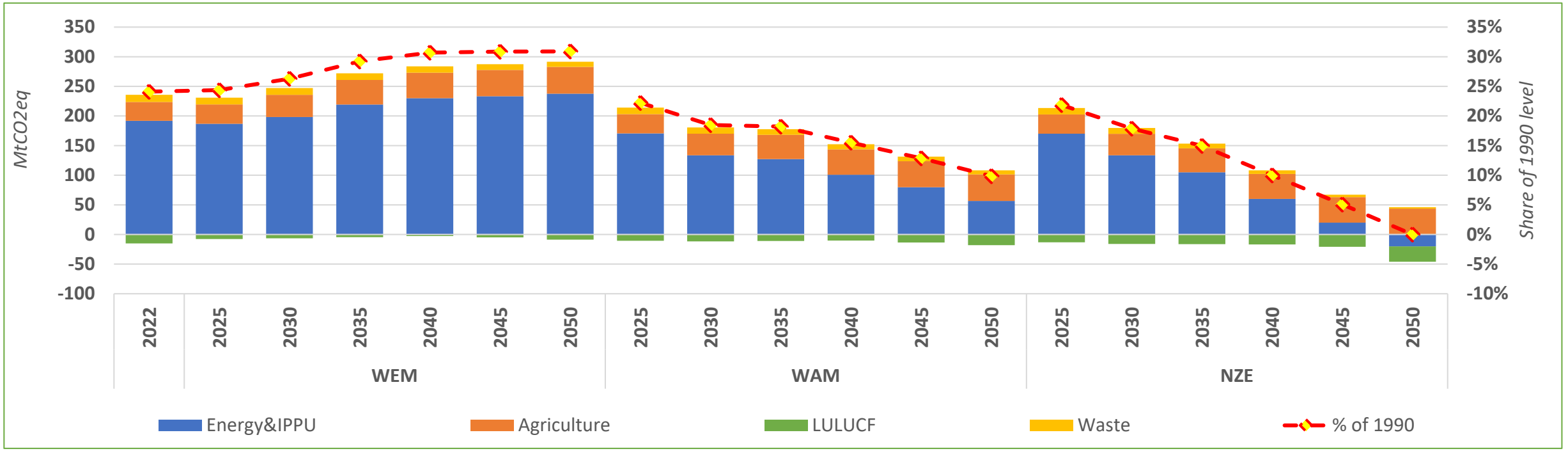
As a percentage of 1990 levels emissions increase from 24.1% in 2022 to 30.9% by 2050, indicating limited impact in emission reduction under this scenario.

WAM: Significant emission reductions in Energy & IPPU by 2050, reflecting additional mitigation measures and slight reduction in waste. LULUCF emissions become more negative, enhancing its carbon sink capacity by 2050.

As a percentage of 1990 levels emissions decline significantly from 22.2% in 2025 to 9.9% by 2050, demonstrating a stronger commitment to climate policies.

NZE: Sharp decrease and eventual negative emissions in Energy & IPPU by 2050, suggesting key carbon removal efforts. Enhanced contribution of LULUCF as a carbon to carbon sequestration. Considerable fall in Waste sector emissions.

As a percentage of 1990 levels total GHG emissions decline to 0.0% by 2050, indicating successful attainment of net-zero emissions target in this scenario.



Renewable Energy: Key Policies and Results

***Policies for electricity generation from RES*:**

introduction of new market instruments such as feed-in premium, corporate PPAs, auctions for the distribution of support quota for RES, Renewable Energy Guarantees of Origin; Strategy for the development of distributed generation for the period until 2035.

Policies for heat generation from RES:

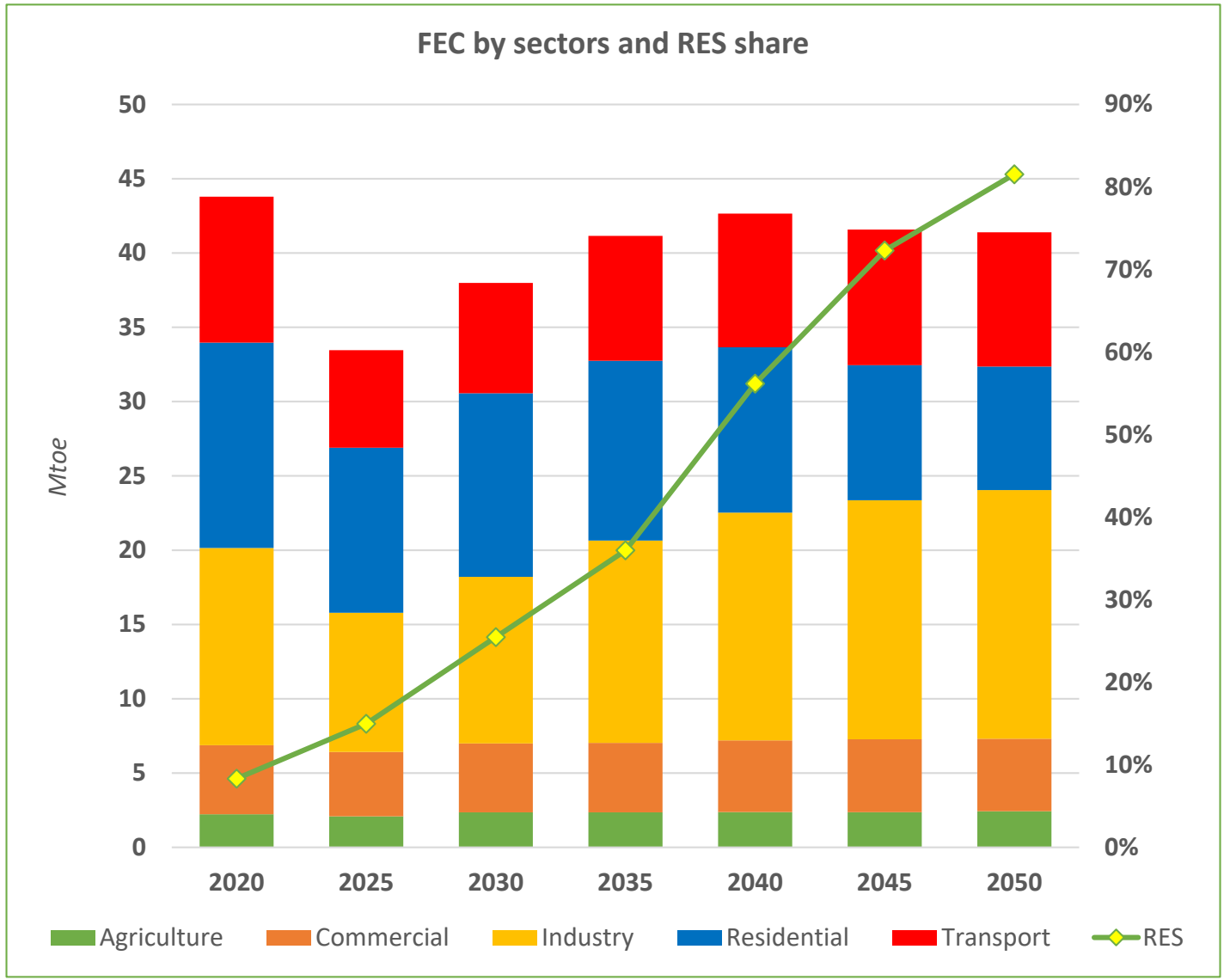
incentive tariff for thermal energy producers from RES; bioenergy development is planned in the Energy Strategy, National Renewable Energy Action Plan and NECP.

Policies for RES in transport:

mandatory use of liquid biofuel (biocomponents), which meets sustainability criteria, in transport.

Policies for prosumers:

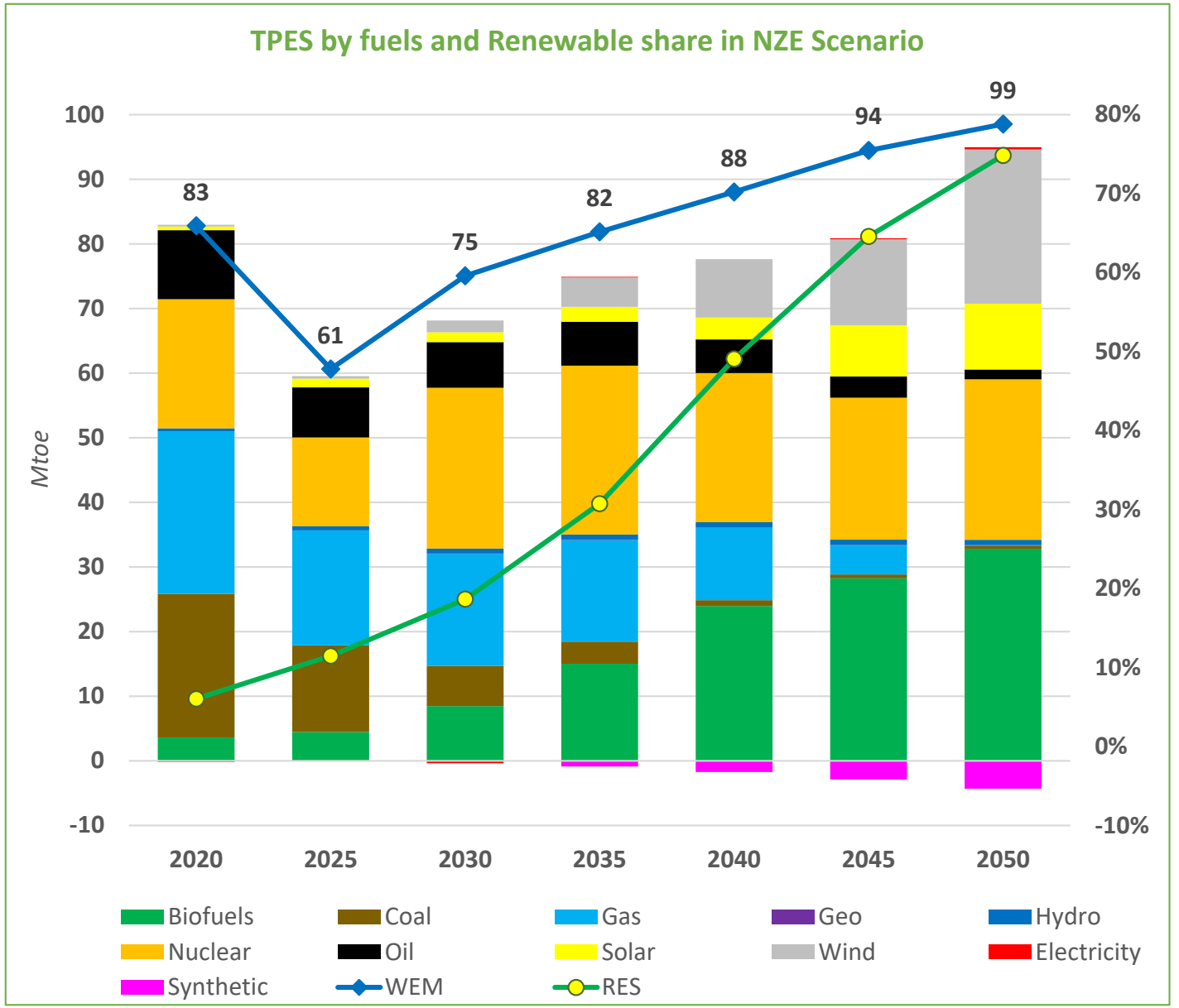
net billing, "GreenDIM" Energy Efficiency Fund Program; new incentives are planned in the draft Concept of the State Programme for Stimulating the Development of Distributed Electricity Generation from RES for the Period Until 2030.



Decarbonisation in Energy System-wide

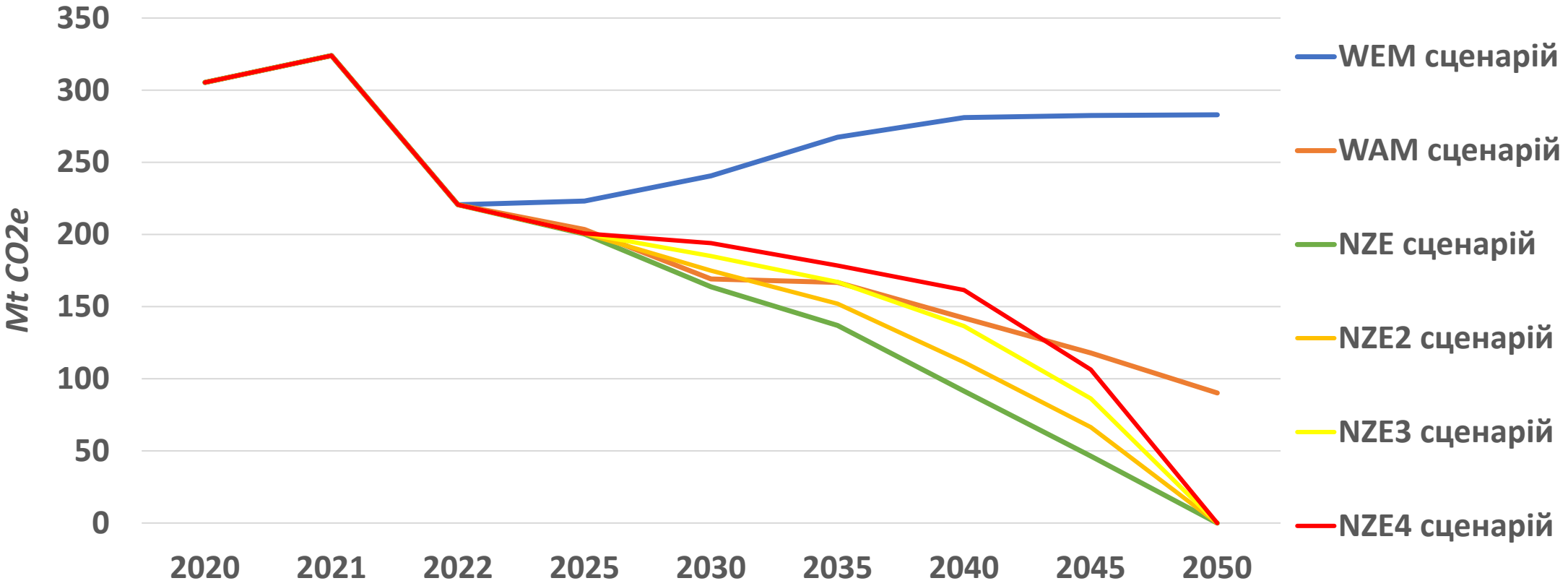
Key insides:

- Share of renewables significantly rise from 6% in 2020 to 75% by 2050. Biofuels harvesting grows ninefold, solar by 17 times and wind by 90 times. This shift shows strong emphasis on renewable energy sources providing independence from commodities imports.
- Coal use experience a major decline by 2050 with less than 2% of 2020 level left for coking coal purposes. Coal phased out in power generation by 2035.
- Natural gas is completely phased out by 2050 being superceded by biomethane in all sectors to different extent.
- Nuclear energy fluctuates: After peaking in 2035, nuclear energy production decreases slightly as existing units decommissioning, exceeding the level of 2020 by 24% and comprising 27.3% of the TPES.
- Comparing to WEM, TPES in NZE scenario is slightly lower but forms a completely different structure.
- Export of hydrogen could start in 2035 and grow until 2050.



Different trajectories to achieve climate neutrality for the draft LT-LEDS

- Total GHG emissions in Ukraine in 2022 were 24.1% of the 1990 level, by 2030, they will be approximately 26.3% under the WEM scenario and 18.5% under the WAM scenario
- Under different conditions of achieving climate neutrality in 2050, GHG emissions in 2035 can be 15-20% of the 1990 level, i.e. 80-85% lower than in 1990.



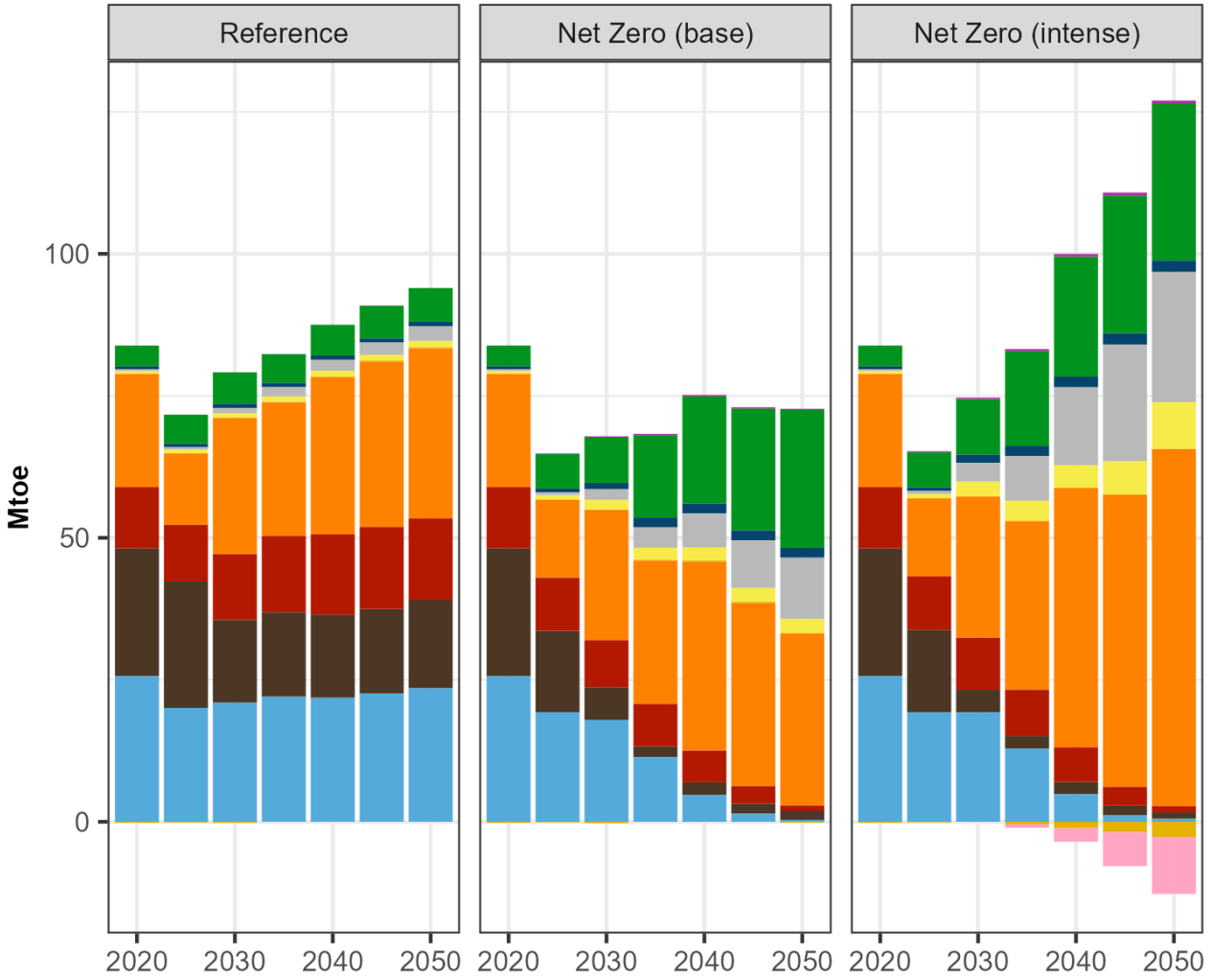
PROJECT'S ENERGY AND CLIMATE SCENARIOS

Net Zero World Initiative, UNECE, IEF/PNNL, IEF/DEA,
IEF/Henrich Boell Foundation and other

Ukraine's Decarbonization Pathways

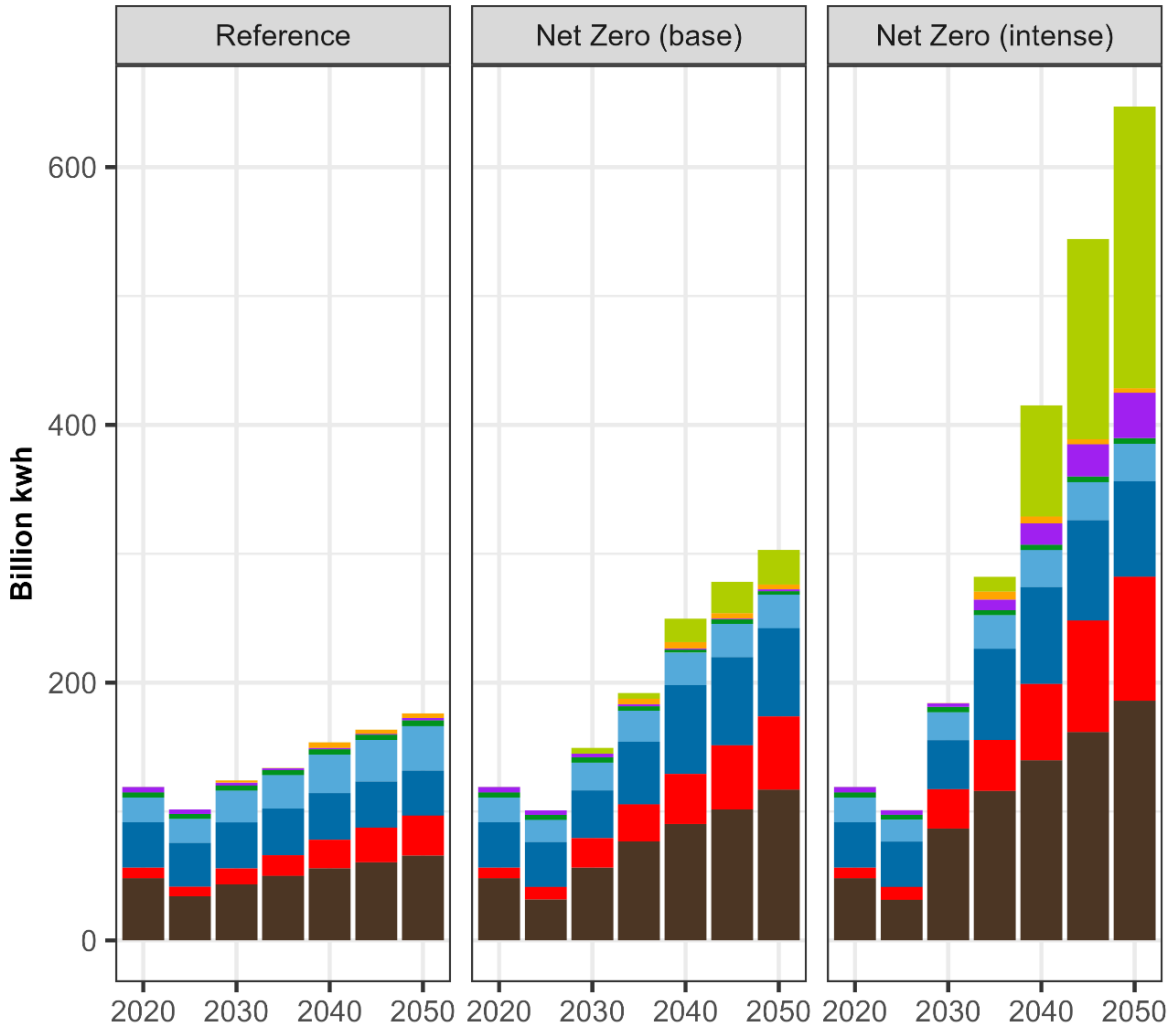
- In a collaborative effort to promote the resilience and sustainability of the energy system as part of Ukraine's reconstruction, this project has harnessed the expertise of the leading DOE National Laboratories and distinguished Ukrainian research institutes and think tanks.
- The modeling team used the TIMES-Ukraine model, developed by the Institute for Economics and Forecasting (IEF) of the National Academy of Sciences of Ukraine, and improved in 2023 with the support of the DOE national laboratories to model decarbonization pathways.
- Developed scenarios for achieving net-zero emissions in the energy sector, which are aligned with the goals of the 2050 Energy Strategy of Ukraine.
- The report explored three main scenarios: Reference, Net Zero Base, and Net Zero Intense. Both Net Zero scenarios are designed to achieve net-zero greenhouse gas (GHG) emissions in the energy sector; the Net Zero Intense scenario assumes higher economic growth and clean energy exports.

NZWI: Total primary energy supply (TPES)



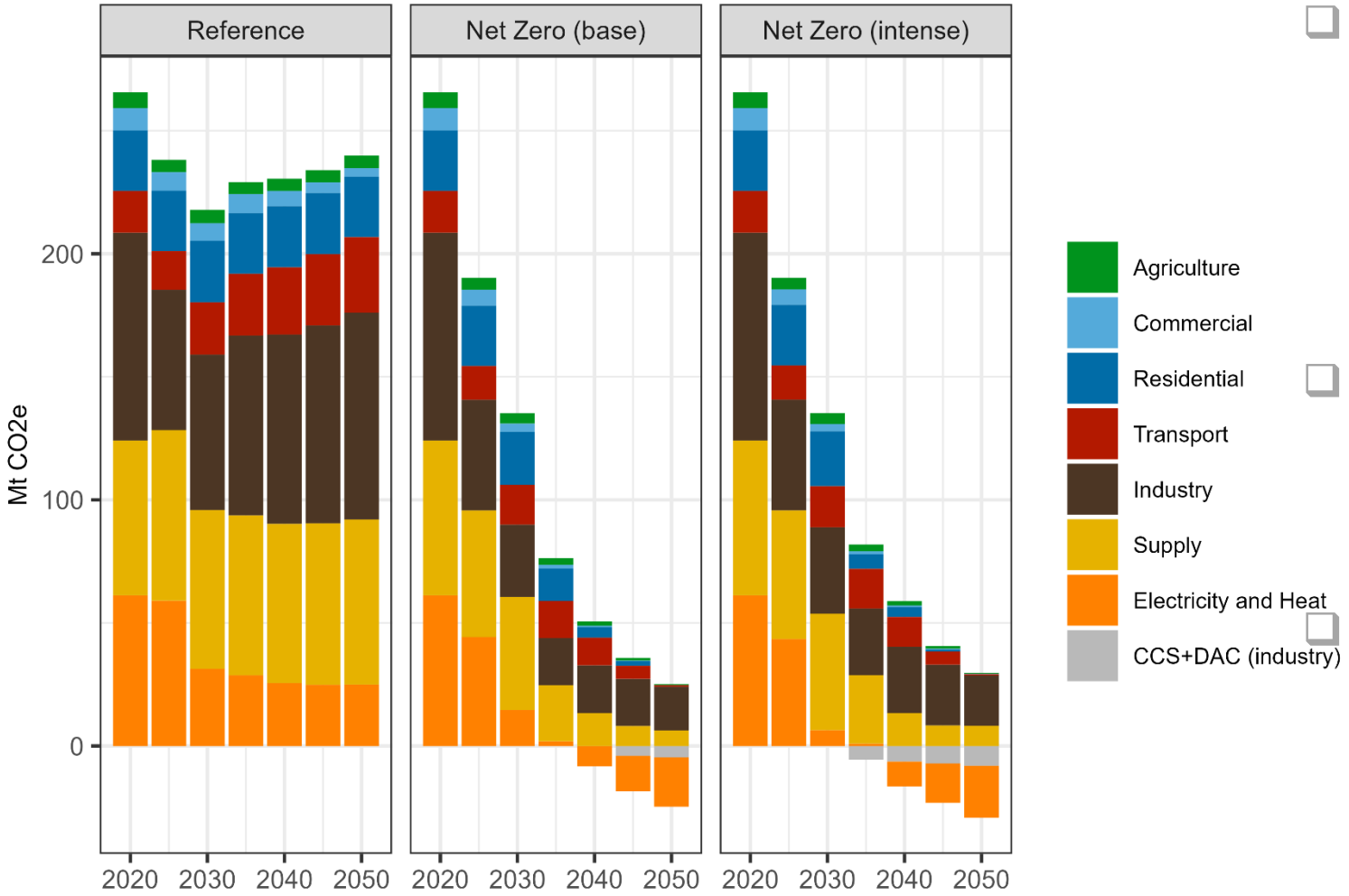
- The structure of TPES doesn't not change much in Reference scenario.
- In the Net Zero scenarios there is a rapid phase-out of fossil fuels – first coal, followed by natural gas and oil – and increases in wind, biofuels, solar, hydro, and nuclear.
- In 2050, TPES needs are met by domestic production. Renewable sources make up just over 50% of TPES in 2050, with nuclear providing another 49%.
- Building retrofitting and electrification of industry and transport contribute to the permanent reduction of TPES.

NZWI: Electricity Consumption



- In the Reference scenario, electricity consumption grows slowly.
- Electrification is much more rapid in the Net Zero Base scenarios, with complete electrification of light-duty vehicles, along with moderate electrification of freight transport, heating, cooking, and water heating in buildings, light and heavy industry.
- The increase in electricity consumption is much more rapid in the Net Zero Intense scenario, reaching roughly more than five times 2020 levels by 2050.
- The increase electricity consumption is driven by greater economic growth, greater industrial production, and deeper electrification, and for hydrogen production.

NZWI: Net Zero CO2 Emissions

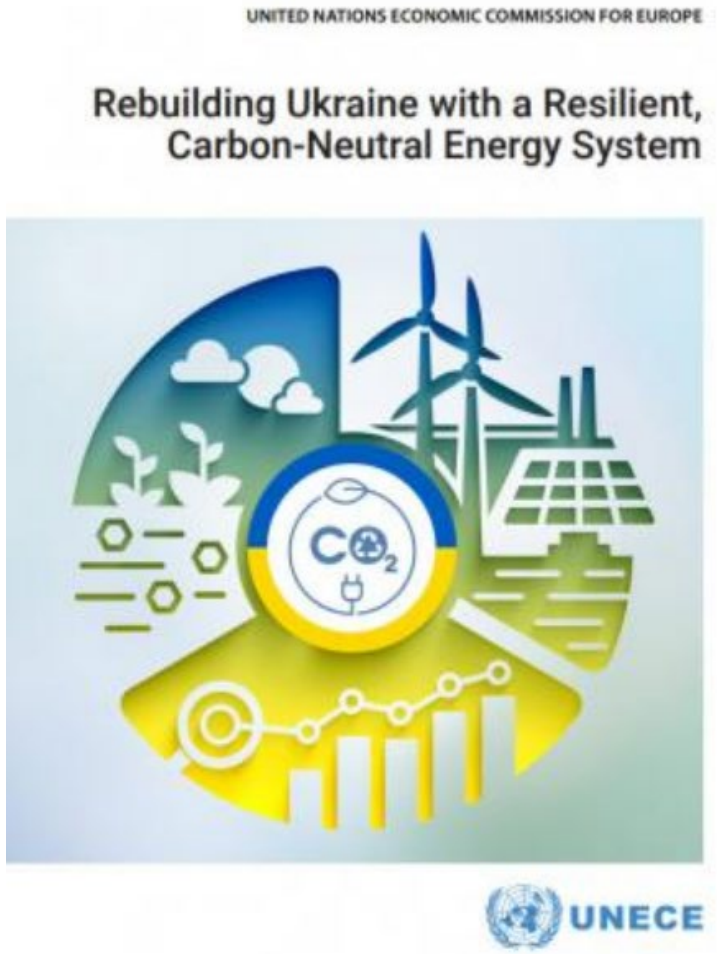


- To achieve net zero CO2 emissions by 2050, emissions should be reduced in all sectors, including in times of economic recovery after the war, though not all sectors will be able to reach net zero by 2050, especially heavy industry and energy supply sector.
- Therefore, CCUS technologies both in the power and heat sectors and industry, as well as DAC technologies should be implemented starting in 2040 or earlier.
- In implementing CCUS technologies (which are still uncertain) at bioenergy power and heat plants, it is possible to achieve negative GHG emissions as biofuels are considered climate-neutral energy resources.

The net-zero transition significantly improves energy security and resiliency of the national economy, which will contribute to its adaptability to future climate changes and conditions.

UNECE project: Carbon Neutrality in Ukraine

- Since Ukraine is a candidate for joining the EU, Ukraine's climate targets should be the same as in the EU - climate neutrality (net zero) by 2050 with the subsequent increase in negative GHG's emissions.
- The Carbon Neutrality scenario assumes faster rates of GHG emissions reduction in the first decades and slower rates at the end of the modelling horizon.
- This publication builds on the recommendations from the Pathways to Sustainable Energy Project and the UNECE Carbon Neutrality Project. The project supports countries' efforts to reach carbon neutrality and attract investments into clean infrastructure projects. The publication forms part of the UNECE Carbon Neutrality Toolkit.
- Countries are invited to put into practice the UNECE Carbon Neutrality toolkit.



PNNL/IEF: Decarbonization scenarios of the heat sector

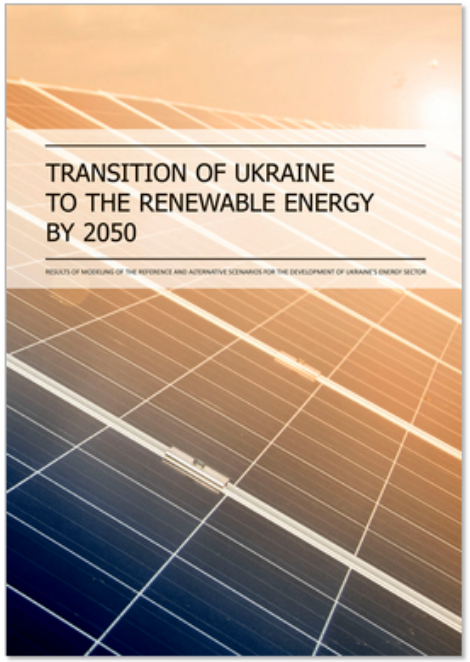
- District heat can remain an important heating source in Ukraine in a resilient, decarbonized future and could help bolster energy security.
- The models find that about 100% of district heating in 2050 will come from a mix of low-carbon domestic resources, including electric heat pumps (powered by local renewables), industrial waste heat, synthetic fuels (hydrogen and methane), and biofuels (biogases).
- Models show that a future, resilient, and EU-oriented Ukraine will significantly shift the fuels used in district heating and electricity generation.
- Reaching economy-wide GHG net-zero emissions in 2050 in Ukraine will require almost a complete elimination of direct emissions in the buildings.

INFORMING UKRAINIAN RECONSTRUCTION THROUGH BUILDING RETROFITS AND DECARBONIZATION MODELING

Pacific Northwest National Laboratory (USA)
Institute for Economics and Forecasting (Ukraine)
March 2023

PNNL-34146

Transition to 100% Renewables in Ukraine



Transition of Ukraine to the Renewable Energy by 2050

pdf

Heinrich Boell Foundation Regional Office in Ukraine has initiated a challenging research on the possibility of maximum transition of the Ukrainian energy sector to renewable energy sources (RES) by 2050. The public institution "Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine," which is the main partner in this project, has modeled three scenarios of energy sector development. The research was carried out with the use of commonly known economic and mathematical model (TIMES-Ukraine models and the computable general equilibrium model of Ukraine) that are regularly used by the IEF.

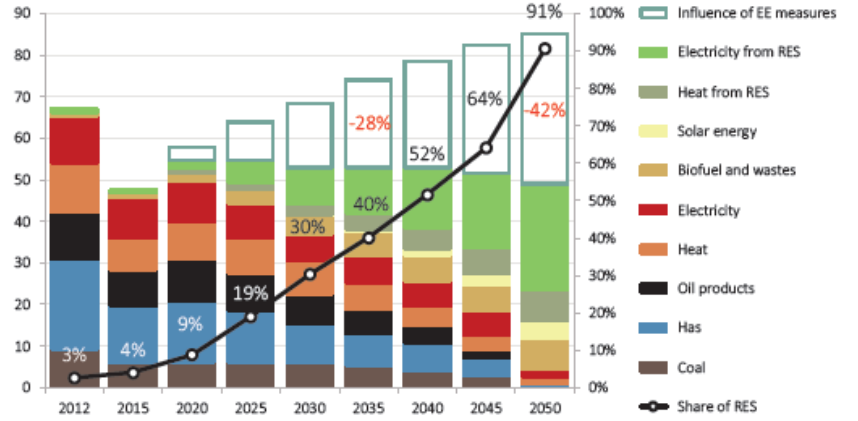


Figure 5.4 Final energy consumption under the Revolutionary Scenario

Units: mln toe.

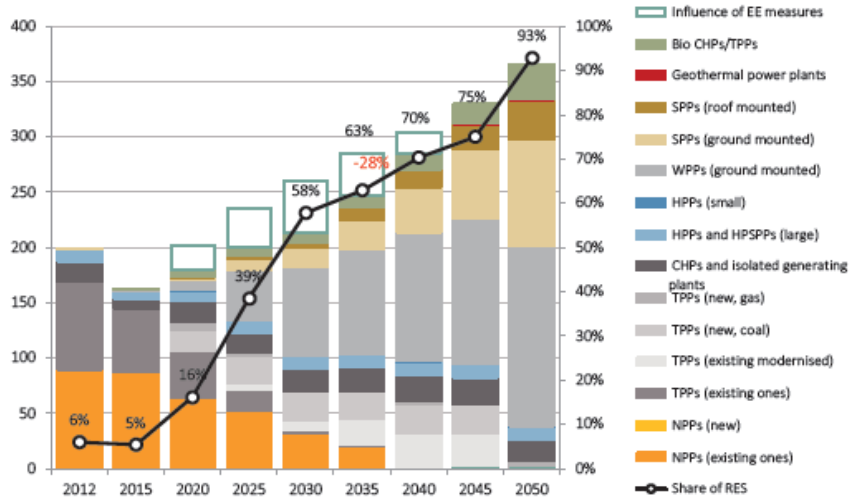
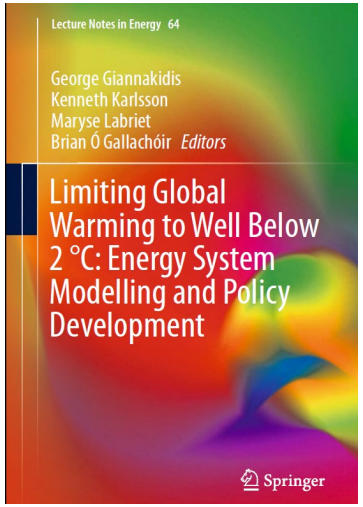
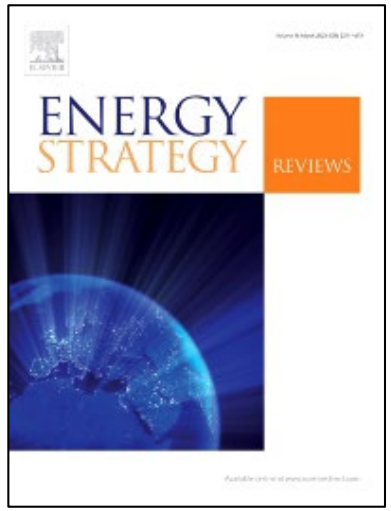


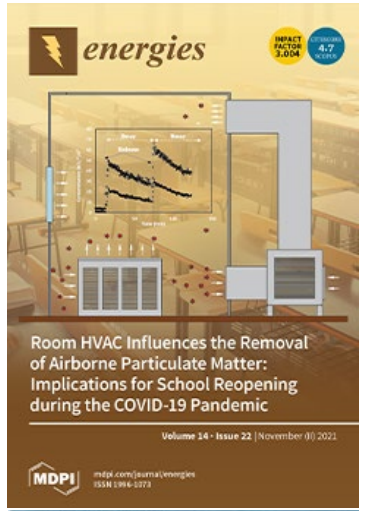
Figure 5.23 Electricity generation under the Revolutionary Scenario

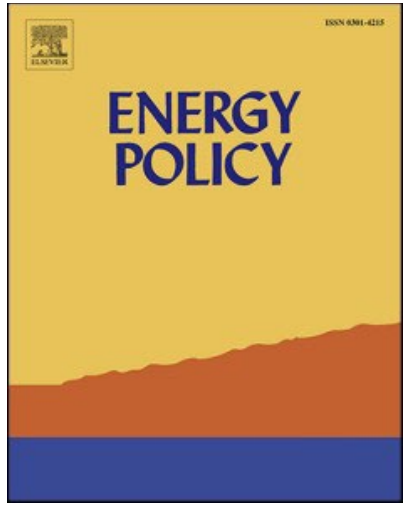
Units: bln kWh.

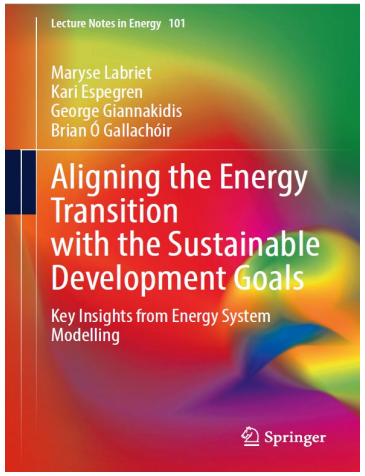
Practical TIMES-Ukraine scenarios and results

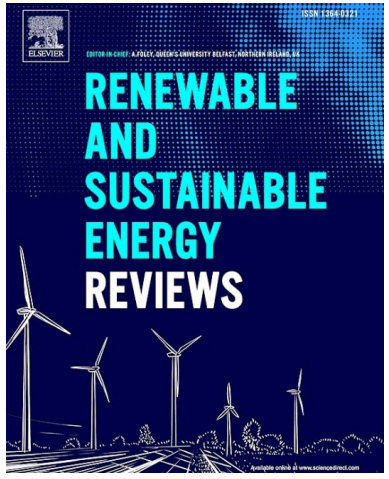


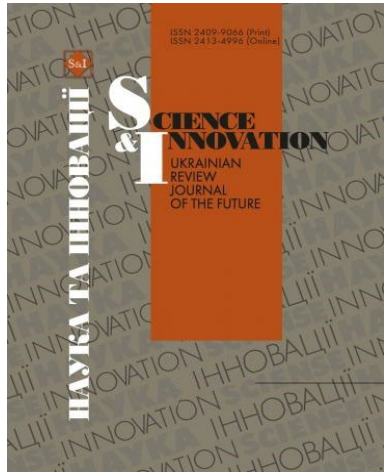


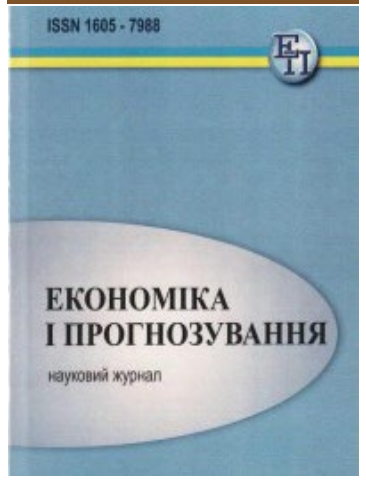












Municipal TIMES-Zhytomyr model

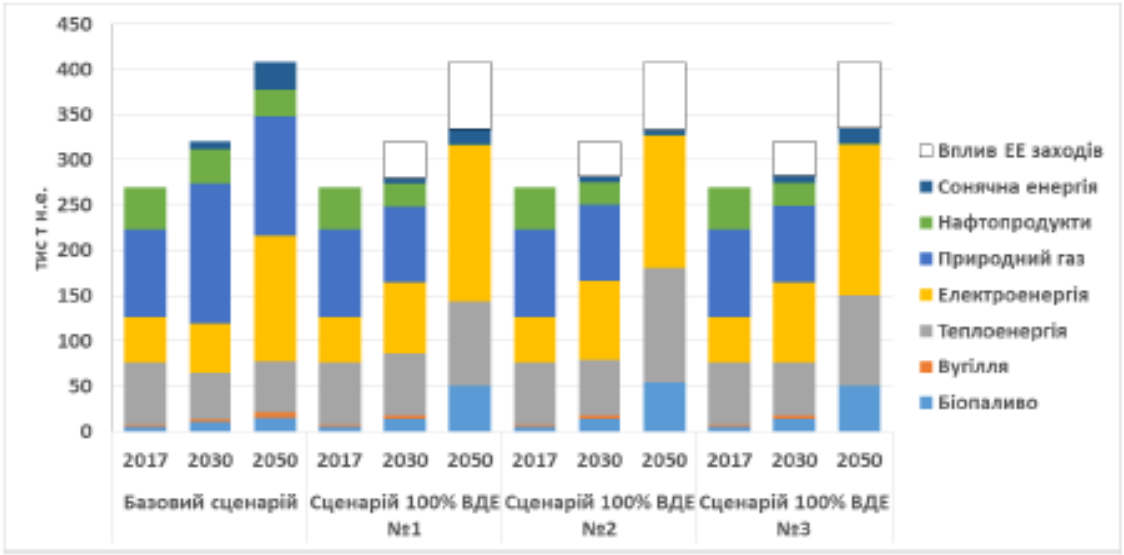
Виконано на замовлення міжнародної кліматичної організації "350.org"
у співпраці з Житомирською міською радою

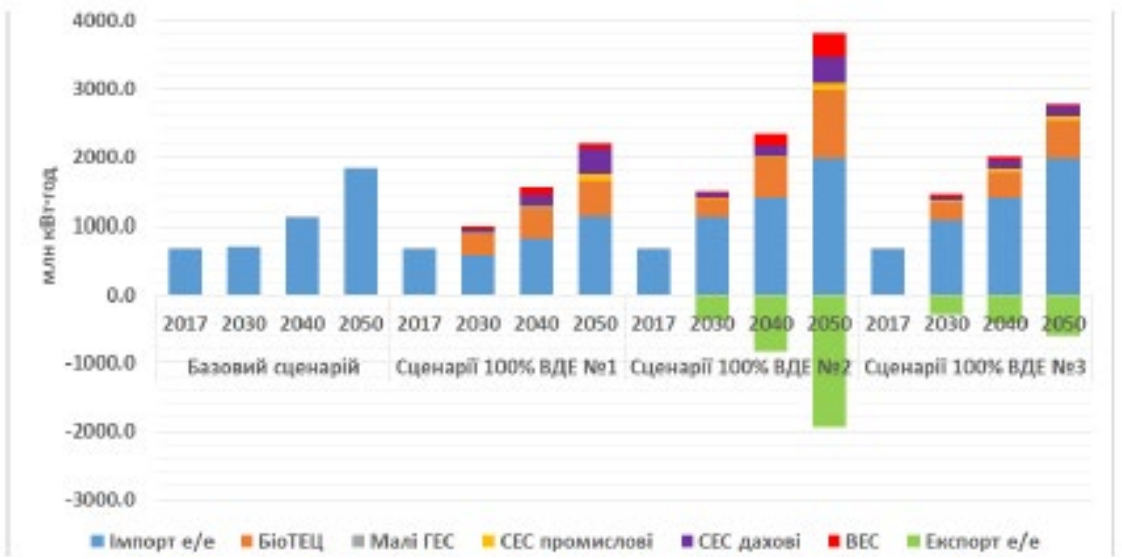
ПЕРЕХІД М. ЖИТОМИР
НА 100% ВІДНОВЛЮВАНИХ ДЖЕРЕЛ ЕНЕРГІЇ
ДО 2050 РОКУ

ЗВІТ
за результатами економіко-математичного моделювання
сценаріїв розвитку енергетики м. Житомир

Автори:
Олександр ДЯЧУК
Андрій СЕМЕНЮК

2020 рік





Thank You!

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