

**Civil Society for Sustainable Energy –  
Local to National in Eastern Europe – SELNEE**



# **REVIEW of Climate Action and Transition to Sustainable Energy in Ukraine**



November 2020

**Title: Review of Climate Action and Transition to Sustainable Energy in Ukraine**

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## **Abbreviations**

- CMU – Cabinet of Ministers of Ukraine
- DH – district heating
- ETS – Emission Trading System
- GFEC – gross final energy consumption
- GHG – greenhouse gases
- GT – “green” tariff
- GWel – Gigawatt of installed electric capacity
- IEF NASU – Institute of Economic and Forecasts, National Academy of Science of Ukraine
- MoU – Memorandum of understanding
- MRV – Monitoring, reporting, and verification
- MSW – municipal solid waste
- Mtoe – million tons of oil equivalent
- MWh – Megawatt-hour
- NEURC – National Energy and Utilities Regulatory Commission of Ukraine
- NDC – Nationally Determined Contribution
- NGO – non-governmental organization
- NPP – nuclear power plant
- NREAP – National Renewable Energy Action Plan
- PM – Particle Matters
- PSO – Public Service Obligation
- RES – Renewable energy sources
- SAEE – State Agency of Energy Efficiency and Energy Saving
- SE – State Enterprise
- TPES – Total primary energy supply
- TPP/CHP – thermal power plant/combined heat and power plant

## Disclaimer

The current report was made in the framework of an NGO cooperation project Civil Society for Sustainable Energy – Local to National in Eastern Europe – SELNEE, 2020-2021 financially supported by CISU, Denmark. The Report contains expert estimations and opinions of NGO Renewable Energy Agency (REA), which does not reflect the opinion of the financial supporter CISU.

The Cooperating partners are the NGO Network INFORSE-Europe, Nordic Folkecenter for Renewable Energy in Denmark, Center for Environmental Solution in Belarus.

The authors' point of view may not correspond to the official position of the cooperating project partners and the financial supporter of CISU and its affiliates. All information contained in the report is exclusively an interpretation of authors.

## Introduction

Ukraine declared independence on August 24, 1991. The next year in 1992, the country signed the UN Framework Convention on Climate Change and stepped on a path of joined efforts towards preventing climate change. This was followed by ratification of the UNFCCC in 1996 and the Kyoto protocol to it in 2004, joining the Energy Community in 2010, signing the Association Agreement with EU, and approval of National Action Plans on renewable energy in 2014 and on energy efficiency in 2015. Since 2016, Ukraine is a party to the Paris Agreement showing an understanding that climate change is real and that sustainable development is essential for its future.

Although significant efforts were made since 1992, in 2020 there is a growing impression of Ukraine's movement in the energy sector in the opposite direction to the EU's climate goals. Over the past year, Ukraine has stopped working on the Concept of Green Energy Transition, a government document aimed at the transition of Ukraine's energy sector to the use of 60% of RES in the total supply of primary energy in 2050. Moreover, Ukraine has a debt for electricity generated from RES, a petition from people's deputies regarding the unconstitutionality of the “green” tariff mechanism, plans to complete two units of the nuclear power plant by 2025, and billions in subsidies to support the coal industry. Not a single MW of manoeuvre generation or energy storage and storage systems has been built; no effective mechanisms for attracting investments have been created; no electronic auctions for state support of renewable energy projects have been launched.

In this study, the authors analysed the state of Ukraine's transition to sustainable energy, including national strategic documents and alternative scenarios, identified the existing barriers that hamper this transition, and prepared proposals of priority measures that in our opinion should be taken to make the transition to sustainable energy in Ukraine happen.

On the 18th of November 2020, the outcomes of this analysis were presented at the online event that gathered more than 1700 stakeholders, including government, civil society, business, and academia that participated through the online platform and in real-time online viewing. In the final part of the event representatives of leading NGOs working in the field of ecology, energy efficiency and renewable energy sources made a joint statement to the Cabinet of Ministers of Ukraine, headed by Prime Minister of Ukraine Denis Shmyhal, about the need to develop and approve a Ukrainian Green Deal for the transition to sustainable energy.

## Executive summary

Ukraine is in general on track of transition towards renewable energy and climate neutrality, which is defined by the respective targets, measures, and indicators set in state-level approved documents (National Renewable Energy Action Plan until 2020, Energy Strategy until 2035, Heat Supply Concept until 2035). The approved targets for renewable energy development foresee achievement of 11% (GFEC) in 2020, 25% (TPES) in 2035 (including 11% from biomass), 40% (TPES) in heat energy in 2035. The main two drawbacks of the approved documents are moderate ambition level, which does not allow climate neutrality until 2050, and limited period of target setting (until 2035).

Meanwhile, during the period 2016-2020, more than 10 comprehensive studies containing calculations and forecasts for renewable energy transition till 2050-2070 has been developed by different groups of consultants, including Concept of green energy transition until 2050 (Ministry of Energy of Ukraine), Vectors of economic development of Ukraine (Cabinet of Ministers of Ukraine), Transition towards 100% RE system by 2050 (LUT and Neo Carbon Ukraine), Road Map of Ukraine's climate goals until 2030 – public vision (NGO “Ecoation”), Heinrich Boll Transition Scenario until 2050 (Heinrich Boll Foundation and IEF NASU), ASET — INFORSE-Europe 100 RE Scenario (CISU, INFORSE-Europe (Denmark) and NGO “REA” (Ukraine), Concept of transition towards 100 % RE till 2070 (Global 100RE Ukraine), Forecast of the energy transition as per Ukrainian NDC-2 (EBRD and IEF NASU), Bioenergy Road Map till 2050 (Bioenergy Association of Ukraine and NGO “REA”). The listed documents contain different outcomes:

- On renewable energy engagement — from 40 % to 100% till 2050/2070;
- Energy consumption trend — from +50% growth from current to -18% fall from current;
- Fossil fuel and nuclear energy spread out — from full shut down to engagement of coal and gas as grid balancing capacities and small-scale NPPs as baseload);
- Investment levels needed — from 100 to 680 billion EUR;
- Policies and reforms needed – from the most basic ones (such as political will for energy transition and stability of state policy towards RE support) to more advanced (like full-scale all-energy-markets competitiveness, the establishment of new markets – for liquid biofuels, renewable gases (biohydrogen, biomethane), ETS);
- GHG emission reductions – from 40% to 100% from the current level;

- Assessment of externalities, like social economic consequences, public health, climate adaptation measures, engagement of energy poverty.

The key common outcome from the available studies is the principal possibility of Ukraine achieving 100% RE and climate neutrality by 2050/2070. For this, however, comprehensive efforts have to be done to overcome existing barriers in the energy sector, such as:

- Lack of political will to approve course towards 100% RE till 2050/2070;
- Non-stable state policy for RE development (especially during 2019-2020) – changes in “green” tariff level, payment problems to RE producers, constitutional court case for admitting “green” tariffs as non-constitutional, declarations of President and national companies for the completion of construction of 2 NPP units, non-adequate declarations of Tax Service of Ukraine on non-payment of revenue tax by RE objects, NERC propositions for RE objects nationalization, ending of “green” tariff option in 2023 for bioenergy projects, general non-compliance of state of Ukraine as per MoU with the RE investors, number of international court cases from investors to the state of Ukraine for compensation of losses due to above non-stability of state policy, etc.;
- Problems in the electricity market: different PSO, cross-subsidizing, the keeping of the monopoly state of 2-3 companies, more than 1.5 years postponing of RE auctions, low flexibility of a grid, lack of stimulation of balancing capacities, a blocking of integration to ENTSO-E);
- Problems on heat market: non-liberalized market, lack of competitiveness and monopoly of communal heat supply companies, non-market principles of tariff formation, lack of stimulation tariff for RE;
- Problems on coal market: non-compliance of the grid for the closure of coal TPPs till 2030-2035 (an important prerequisite for 100% RE transition until 2050/2070), lack of schedule of TPP closure/reconstruction, a continuation of sector subsidizing, lack of re-qualification programs for personnel;
- Abandoning or non-effectiveness of RE stimulation mechanisms (CO<sub>2</sub> tax, ETS, transport electrification, energy from MSW, effective cogeneration/trigeneration);
- Problems in the bioenergy sector: non-developed (spontaneous) biomass market, lack of liquid biofuels regulation framework, sustainability criteria, prerequisites for biomethane/biohydrogen market, digestate (from biogas complexes) utilization, energy crops planting);
- The somewhat distorted image of renewable energy, energy poverty of population.



The availability of mentioned studies and the detailed elaboration of associated barriers to be addressed is the prerequisite for the urgent start of the development of the National “Green Deal” for Ukraine and the New Energy Strategy of Ukraine till 2050/2070. This document will consolidate the available studies and reflect the Ukrainian RE transition course synchronizing Ukrainian energy transition with the one in the EU-27.

## State of Ukraine's Transition to Sustainable Energy

As for June 2020, the state of Ukrainian energy transition concerning the RES is as follows:

- The share of RES in final energy consumption is assessed as 10%, or 3.5-4 Mtoe/year (last official data according to energy balance for 2018 is 2.3 Mtoe, including 1.9 Mtoe - from biomass<sup>1</sup>);
- The share of RES in the heating/cooling sector in final energy consumption is assessed as 12% or 2-2.3 Mtoe/year (last official data for 2018 is 8.1% or 2.7 Mtoe in final energy consumption<sup>2</sup>);
- The share of RES in the electricity sector is assessed as 11% (average for the year, for some short periods (days/hours) it increases up to 40%). Annually it is 1.5-2 Mtoe/year (this is the latest official data according to the analysis of operative data from National Power Company Ukrenergo daily reports<sup>3</sup>);
- The share of RES in the transport sector is assessed as 2-3% or 0.1-0.2 Mtoe/year (last official data – according to Energy balance for 2018 – 0.036 – from biofuels and 0.06 – from renewable electric<sup>4</sup>).

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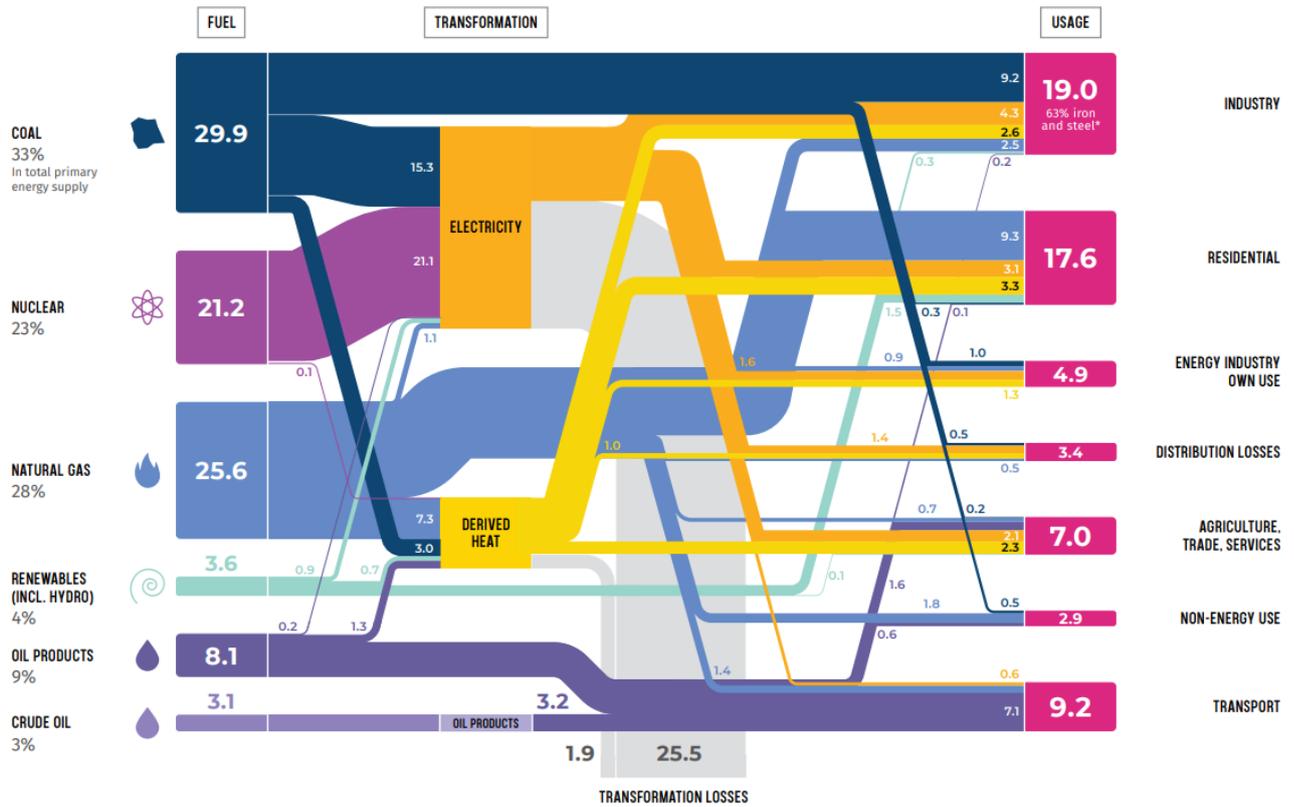
<sup>1</sup> [http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en\\_bal/arh\\_2012.htm](http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en_bal/arh_2012.htm)

<sup>2</sup> <https://uabio.org/biomass-heating/>

<sup>3</sup> <https://ua.energy/diyalnist/dyspetcherska-informatsiya/dobovyj-grafik-vyrobnystva-spozhyvannya-e-e/>

<sup>4</sup> [http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en\\_bal/arh\\_2012.htm](http://www.ukrstat.gov.ua/operativ/operativ2012/energ/en_bal/arh_2012.htm)

2016, m toe

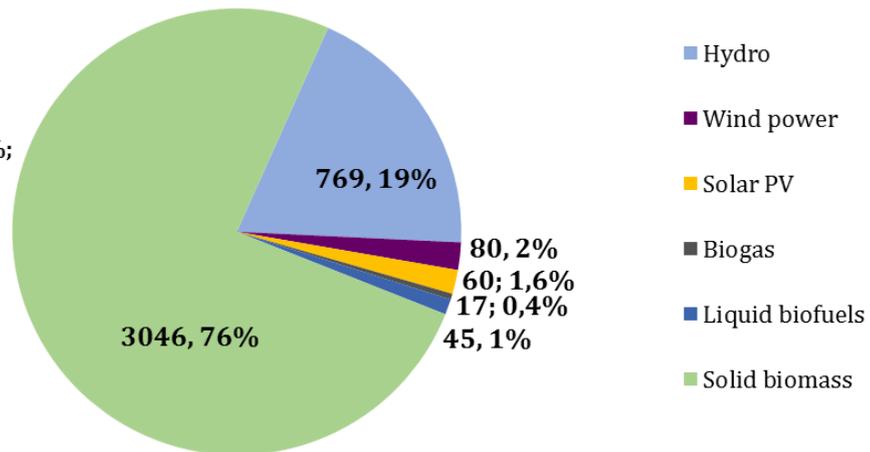


Flow diagram of different energy sources in Ukraine, 2016, Mtoe<sup>5</sup>

### Primary energy supply from RES

2017, ktoe

Wood biomass - 80%; agro biomass - 20% (mainly husk).



TOTAL: 3964 ktoe

Energy cake of all RES in Ukraine, 2017 – estimation of authors

<sup>5</sup> <https://businessviews.com.ua/ru/the-infographics-report-energy-of-ukraine-2018-eng/>

The presented figures mean that Ukraine is on the track of fulfilling the National Renewable Energy Action Plan until 2020 (RES targets all in GFEC<sup>6</sup> units): 11% in electricity, 12.4 % in heating and cooling, 10% in transport, 11% in overall GFEC) and is on the track of the Energy Strategy till 2035 concerning RES share in electricity and heating/cooling, but not transport sector. However, there are tendencies for cancellation of some of the key incentive mechanisms for RES in Ukraine during 2020:

- Restructuring of “green” tariff – decreasing by 15% for all solar PV (including already constructed) and by 7.5% for all wind power plants (original tariffs for wind - from 5.1 to 11.3 EUR cent/kWh, for solar PV – from 15 to 32 EUR cents/kWh)<sup>7</sup>;
- Actual blocking of payment for generated energy from SE Guaranteed Buyer<sup>8</sup> to RES projects since March 2020. This is claimed to be related to the new transition market model from “green” tariff to auctioning principle. The problem is still not solved. Some of the plants declared bankruptcy, others applied to court on SE Guaranteed Buyer;
- Launching of auctioning for green electricity is postponed for an unknown time (the first auction was planned to be performed in April 2020);
- Incorporation of competitiveness in the heat market and upgrading of stimulation heat tariff “0.9 principle”<sup>9</sup> for biomass is ignored, while all documents package and respective Draft Law are ready for registration and approval. These were all prepared in 2019 with wide public discussions;
- Cancellation of VAT/custom duties exception (in Jan 2020) for all RES installations;
- Propositions of NEURC (one of the functions of which is regulation of electricity market in Ukraine)<sup>10</sup> to nationalize RES installations (Dec 2019);
- Self-ignorance of the government of the newly developed by the government Ukrainian Green Deal. Public contradicting announcements of officials that coal and nuclear generation will remain the core generation for the post-2020 period without restructuring plans. The Concept for Green Energy Transition was presented by the Ministry of Energy and Environment (which is part of the government) in Jan 2020. It was discussed few times on different levels, and then nothing happens. Later on, in June-July 2020, the public announcements

<sup>6</sup> The gross final energy consumption is the energy used by end-consumers (final energy consumption) plus grid losses and self-consumption of power plants.

<sup>7</sup> Refer to the text of the Law of Ukraine: <https://zakon.rada.gov.ua/laws/show/810-IX#Text>

<sup>8</sup> <https://www.gpee.com.ua/>

<sup>9</sup> 0.9 principle is the obligatory Law-level approach of the definition of heat tariff formation from biomass in Ukraine: the short essence is: biomass heat tariff = 0.9 x gas heat tariff approved by the respective entity.

<sup>10</sup> <http://www.nerc.gov.ua/>

of different ministerial executive officers included the priority for coal and nuclear generation. It was reflected in the Resolution of CMU # 702-p<sup>11</sup>, which obliges Ukrenergo (national grid operator) for priority dispatch of coal electricity in the grid. This harms RES electricity, which priority is after coal. At the same time, in Sept 2020, the President of Ukraine publicly announced the plans for completing of construction of Khmelnytska NPP (2 units, 1 GW each)<sup>12</sup>. This encounters the wide public resonance including those from nuclear specialists who considers these plans unrealistic;

- Long process for updated Ukrainian UNFCCC Nationally Determined Contribution (NDC) development.

If these key drawbacks will not be solved urgently during 2020, the track for the fulfillment of Energy Strategy until 2035, Heat Supply Concept and other official documents and draft documents, which foresee increasing of RES share, will be broken.

As for the post-2020 period, currently, the main document, which contains approved targets for the energy sector and RES development is the Energy Strategy until 2035<sup>13</sup>, Heat Supply Concept of Ukraine until 2035<sup>14</sup> and supporting documents. For the post-2035 period, there is no official approved document and respective targets for the energy transition. There is, however, several alternative scenario proposals, which are quite well developed and could be used as a basis for the official Energy Strategy until 2050. The most advanced, which contains concrete targets are:

- Road Map for climate targets till 2030 - view of the public;
- Ukrainian “Green” Deal” – Green Energy Transition until 2050;
- Heinrich Boll Transition scenario till 2050;
- ASET Inforce-Europe 100% RE energy transition scenario till 2050;
- 100RE -Ukraine Platform Scenario until 2050-2070.

The analysis of these official and alternative transition strategies, concerning their targets’ reliability, barriers for their achievement, solutions needed for achievement, and level of ambitions are presented in the next chapter.

<sup>11</sup> <https://www.kmu.gov.ua/npas/pro-zabezpechennya-palivnoyi-zbalansovanosti-elektroenergetichnoyi-galuzi-ukrayini-ta-bezpeki-postachannya-elektrichnoyi-energiyi-702-220620>

<sup>12</sup> See for example: <https://ua.korrespondent.net/business/companies/4272416-zelenskyi-doruchyv-dobuduvaty-dva-enerhobloky-khaes>

<sup>13</sup> <https://zakon.rada.gov.ua/laws/show/605-2017-%D1%80#Text>

<sup>14</sup> <https://zakon.rada.gov.ua/laws/show/569-2017-%D1%80#Text>

## Review of the National Strategic Documents

### The National Renewable Energy Action Plan until 2020

The main targets for renewable energy development by 2020 are mainly based on Ukraine's commitments within the Energy Community. The targets are stated in the National Renewable Energy Action Plan adopted in 2014. Under the NREAP the targets by 2020 are:

RES in GFEC - 11% (which is equal to 8.59 Mtoe);

RES in heating/cooling systems 12.4% (5.85 Mtoe);

RES in power production - 11% (2.23 Mtoe)

RES in transport - 10% (0.51 Mtoe).

NREAP is accompanied with the respective Plan of Measures for its implementation (2014) that specifies the number of quantitative indicators for renewable energy in the power sector, heating/cooling and transport, such as the installed capacity, volume of heat and power production, volume of consumption of motor biofuels expected to be achieved by 31.12.2020. In particular, the installed capacity of equipment for the production of renewable power and heat (cold) should be 10.90 GW and 14.94 GW, respectively, by the end of 2020.

As the validity of the current NREAP is ending this year (2020), the start of the development of a new NREAP until 2030 is planned to be finalised in 2020.

**The Energy Strategy of Ukraine until 2035: Security, Energy Efficiency, Competitive Ability** is the fundamental document that foresees three stages of transformation of Ukraine's energy industry:

Until 2020	Until 2025	Until 2035
<b>Phase 1.</b> Energy sector reforms based on EU legislation implementation	<b>Phase 2.</b> Optimization and innovative development of the energy infrastructure	<b>Phase 3.</b> Ensuring sustainable energy development
Completion of the implementation of the 3rd EU Energy Package; modern energy markets formation	Integration to ENTSO-E	Innovative development and CHP plants and NPP construction instead of disposal or obsolete units

Institutional reforming of the state energy companies and integration to ENTSO-G	Modernisation of the energy grids infrastructure, smart-grids implementation	Extensive implementation of smart-grids and client-oriented networks
Increasing of domestic natural gas production	Development of heating infrastructure depending on local resources and regional specifics	Adaptation of the gas transportation system to the actual demands of the all-European gas market
Progressive decreasing of GDP energy intensity	Country's achievement to self-provision with natural gas from domestic production	Increasing domestic natural gas production
Increasing the RES share	Follow-up increasing of the RES share	Follow-up increasing of the RES share and investments to further emissions reduction

According to the Strategy until 2035:

RES in the TPES – 25% (which is equal to 24 Mtoe) including that of biomass, biofuels, and waste 11.5% (11 Mtoe).

RES in the power generation - >25%.

RES in the transport sector - 20%,

The share of alternative fuels in the local fuel and energy balances - 20%.

The Plan of Measures for the realization of the first stage (until 2020) of the Energy Strategy was elaborated and adopted in 2018. Among others, the Plan envisages the creation of the competitive heat market and implementation of the electronic biofuel trade system and “green” auctions introduction.

A target for the use of RES in heat production is set in the Concept for the implementation of the state policy in the heat supply sector (**Heat Supply Concept**) adopted in 2017. According to this document:

RES in the heat production - 30% in 2025;

RES in the heat production - 40% in 2035.

The Heat Supply Concept is accompanied by the Plan of Measures for its realization until 2020. The measures comprise several decisive actions including the improvement of the existing heat-related legislation, improvement of heat tariff policy, and stimulation of the market to use alternative energy sources for heat production. Expert opinion is that the above targets for heat production from alternative energy sources are quite justified. However, they do not cover all the sectors of heat consumption.

## Alternative Scenarios of Ukraine’s Transition to Sustainable Energy

### 1) Road Map of Ukraine’s climate goals until 2030 – public vision<sup>15</sup>

The Road Map was developed and published in February 2020 by the key ecological-oriented non-governmental organizations of Ukraine: NGO “Ecoaction”, 350org, Ukrainian Climate Network, and others. The key targets of the document are<sup>16</sup>:

#### *Targets until 2030:*

- RES share in GFEC: 30%;
- RES share in GFEC (power): 58%;
- RES share in GFEC (heat): 24%;
- Coal TPP and CHP shutdown in 2030-2035.
- 90% GHG emission reductions from coal TPPs in 2030 compared to 2018.
- Decreasing of NPP capacity from 13.8 GWel in 2018 to 5 GWel in 2030.

#### *Targets until 2050:*

- RES share in GFEC: 91%.

The targets set by the document are rather highly ambitious and challenging to be achieved until 2030, notably:

#### *Evaluation of the targets until 2030:*

- RES share in GFEC: 30% - very ambitious target, possible only with fast elimination of all respective barriers during the short period 2020-2022 and 10-15% drop in GFEC;
- RES share in GFEC (power): 58% - very ambitious target. It is possible only with fast elimination of all respective barriers during the short period in 2020-2022 and forcing the development of RES in stable political circumstances;

<sup>15</sup> [https://ecoaction.org.ua/roadmap\\_climate\\_goals.html](https://ecoaction.org.ua/roadmap_climate_goals.html)

<sup>16</sup> Summary: <https://ecoaction.org.ua/wp-content/uploads/2020/02/dk-clim-ciley-short.pdf>

The full 56-page report on the page link: <https://ecoaction.org.ua/wp-content/uploads/2020/02/dk-clim-ciley-full2.pdf>

- RES share in GFEC (heat): 24% - not the ambitious target. It is very much possible, with the elimination of respective most critical barriers (for reference: 2019 (base) RES share in the heat is around 10%, for some regions of Ukraine — 30-35%);
- Coal TPPs shutdown in 2030-2035 – the ambitious target, rather possible with the elimination of respective barriers;
- 90% GHG emission reductions from coal TPPs in 2030 compared to 2018 – the ambitious target, rather possible with the elimination of most of the respective barriers;
- Decreasing of NPP capacity from 13.8 GWel in 2018 to 5 GWel in 2030 – very ambitious target, rather challenging regardless the barriers elimination, however drop to 7-8 GWel may be considered as more realistic.

*Evaluation of the targets until 2050:*

- RES share in GFEC: 91% - very ambitious target, possible only with fast elimination of all barriers during the short period 2020-2022 and additional support and full policy orientation for green-oriented transition at all levels for the post-2030 period.

The investments of the transition scenario until 2030 are estimated as 100-120 billion EUR.

## **2) Green Energy Transition until 2050<sup>17</sup>**

The scenario has been developed in 2019-2020 by the Ministry of Energy and Environment. The main author is Serhiy Maslichenko (ex-Deputy Minister of Energy and Environment).

*The key targets of the Green Energy Transition scenario until 2050 are:*

- RES share in 2050 (power): 70%;
- Shut down of coal TPP till 2050;
- 20% - NPP power generation (current – 55-60% annual average in power generation and 20-22 % annual average in TPES);
- Carbon neutrality during 2050-2070;
- Wide transport electrification;
- Wide utilization of renewable gases – biomethane and hydrogen;

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<sup>17</sup> <https://menr.gov.ua/news/34424.html>

- General course on markets liberalization and competitiveness.

The scenario proposes a rather high ambitious energy transition, which requires fast elimination of the existing barriers, notably:

- RES share in 2050 (power): 70% – possible with the elimination of most of the barriers;
- Shut down of coal TPPs until 2050 – very possible with the elimination of respective most critical barriers;
- 20% - NPP power generation – rather possible without any barrier elimination due to prolongation of existing NPP operation, but not building of new ones based on small NPP units as it is foreseen in the document);
- Carbon neutrality during 2050-2070 – very possible with the elimination of all barriers;
- Wide transport electrification – rather possible with the elimination of all barriers;
- Wide utilization of renewable gases – biomethane and hydrogen, rather possible with the elimination of all barriers and creation of a full market of biomethane and hydrogen;
- General course on markets liberalization and competitiveness – rather possible with the elimination of respective most crucial barriers, introduction of competitiveness in heat and electricity market during 2020-2025.

The investment cost of such transition is assessed by the authors of the document as 5% of national GDP annually (GDP of Ukraine for 2018 was 130 billion USD, if it is taken as a base, it means 6.5 billion/year or 200 billion USD (170 billion EUR)/30 years until 2050).

### **3) Heinrich Boll transition scenario until 2050<sup>18</sup>**

The transition scenario has been developed and discussed on different levels (among experts, business, deputies, Parliament Committee of Fuel and Energy) in 2019 by the Institute of Economic and Forecast of National Academy of Sciences of Ukraine using the modelling package based on TIMES energy model modified for Ukraine. The main authors are Oleksandr Diachuk and Roman Podolets. The document is very detailed, provides a comprehensive picture of the energy mix for each 5 years with a detalization of the production/consumption of energy. It also contains 3 scenarios,

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<sup>18</sup> <https://ua.boell.org/uk/2017/10/24/perehid-ukrayini-na-vidnovlyuvanu-energetiku-do-2050-r>

which differ on their ambitious level – baseline, liberal, and revolution. *The key targets of the Revolution scenario are:*

- RES share in 2050 (GFEC): 91%;
- 60% from RES in TPES is biomass (which corresponds to 50-60% of total biomass potential in Ukraine<sup>19</sup>);
- Shut down of NPPs (from 2040) and almost-full shut down of coal TPPs (in 2050).

These targets are assessed in general as highly ambitious, however due to the long-term period (until 2050) and detailed background of forecast they are rather possible to be achieved at minimal economic cost, notably:

- RES share in 2050 (GFEC): 91% – very ambitious target, possible only with fast the elimination of all barriers during the short period 2020-2022 and additional support for green-oriented state policy at all levels for the post-2030 period;
- 60% from RES in TPES is biomass - rather possible, with the elimination of all respective barriers;
- Shut down of NPPs (from 2040) and almost-full shut down of coal TPPs (in 2050) - rather possible, with the elimination of all respective barriers.

The results of the scenario are also used as background for a Roadmap for climate goals until 2030 - view of the public. The cost of such transition is assessed by the authors to 300-450 billion EUR (w/o accumulation), 380-550 billion EUR (with accumulation).

#### **4) 100RE views until 2050-2070<sup>20</sup>**

The 100RE-Ukraine Platform's scenario was proposed by the Global 100RE Ukraine Platform and the organizations behind are Ukrainian Wind Energy Association, Bioenergy Association of Ukraine, Ukrainian Hydrogen Council, Professional Association of Ecologists of Ukraine, Solar Energy Association of Ukraine, Ukrainian Association of Energy Service Companies, the Institute of Global Transformation., individual politicians and business stakeholders. The conceptual targets were first presented to the Ukrainian public in September 2019. They have

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<sup>19</sup> For biomass potential, see for example: <https://sae.gov.ua/node/586> .

Please, note, that because more than 1/3 of potential is different types of agro biomass, the potential may differ from year to year due to different agro yields. Also, as it is linked to the agro yields, which are constantly growing in Ukraine and worldwide, the potential will also grow till 2050. For example, according to the latest available document (Bioenergy Road Map by UABIO - <https://uabio.org/en/materials/9115/>) biomass potential for 2050 is assessed as 47.57 Mtoe (Table 5.2, page 32). The 60% of TPES for the Heinrich Boll Scenario is cd. 15 Mtoe.

<sup>20</sup> <https://100re.org.ua/news/119/>

been incorporated the targets of the Global 100RE Platform, and this is an official position of the association concerning the energy transition. The targets have not been incorporated in an official scenario document yet, however, it has been presented to the public, business and deputies. *The key targets are:*

- 100% of RES in GFEC and TPES in 2070;
- 0 t CO<sub>2</sub> GHG emissions in 2070 in all sectors;
- TPES drop to 80 Mtoe in 2050 and 70 Mtoe in 2070.

*The key targets until 2050 are:*

- 65% RES share in TPES;
- Full shutdown of coal and nuclear power;
- 100% of RES in heat and electricity (TPES).

*Evaluation of the key targets:*

- 100% of RES in GFEC and TPES in 2070 - rather possible, with the elimination of all respective barriers;
- 0 t CO<sub>2</sub> GHG emissions in 2070 in all sectors - rather possible, with the elimination of all respective barriers;
- TPES drop to 80 Mtoe in 2050 and 70 Mtoe in 2070 - rather possible, with the elimination of all respective barriers.

In general, the targets set are assessed as high/moderate ambitious as they are set for a quite long period (some of them – until 2070) and are focused on more gradual transition starting from cheaper decisions with minimal barriers.

*Evaluation of the targets until 2050:*

- 65% RES share in TPES – a moderate ambitious target, rather possible, with the elimination of all respective barriers;
- Full shutdown of coal and nuclear power – a moderate ambitious target, rather possible, with the elimination of all respective barriers;
- 100% of RES in heat and electricity (TPES) – a high ambitious target, rather possible, with the elimination of all respective barriers.

The cost of the transition scenario is assessed to 180-250 billion EUR (2050).

### 5) ASET INFORSE-Europe 100 RE Scenario (2018)<sup>21</sup>

The ASET Scenario was made by NGO REA, Ukraine in the framework of an INFORSE-Europe NGO cooperation project ASET. The Scenario was a continuation of Scenarios made by INFORSE-Europe and REA in 2005<sup>22</sup>. The ASET Scenario has two different scenarios.

*High Commitment Scenario targets are:*

- 100% of RES in GFEC and TPES till 2050;
- 100% reduction of GHG emissions till 2050;
- Energy efficiency: -18% reduction in GFEC in 2050 comparing to 2010-2015 average level.

*Climate action targets are:*

- RES share in 2050 (GFEC): 45%;
- 40% reduction of GHG emissions till 2050 compared to 2015;
- Energy efficiency: -9% in GFEC in 2010 comparing to 2010-2015 average level.

For the High commitment scenario 100% RES in TPES/GFEC in all sectors could not be achieved as per the current trend of energy sector development and requires full-scale energy reform in the period 2021-2022, which is impossible.

The increment of investments from 80-90% RES (which is assessed as rather possible) to 100% RES in 2050 is significant (different estimations assessed the increment as +30-100% for the additional 10% of RES).

The most plausible scenario of ASET Scenario is the Climate Action scenario.

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<sup>21</sup> Advocate for Sustainable Energy Transition (ASET Project in 2016-2017) (Gunnar Boye Oelsen, Olexandra Tryboi, Alex Epik, et al.) <http://www.inforse.org/europe/ASET.htm>

<sup>22</sup> Project Vision 2050 for Ukraine (2003-2005) (Geletukha G., Zhelyezna T., Zhovmir M., Konechenkov A., Matveev Yu, et. all): <https://www.inforse.org/europe/VisionUA.htm>

## Barriers for the Energy Transition in Ukraine

Several barriers hamper the achievement of targets formulated by national and alternative documents for the energy transition in Ukraine.

Some of the barriers are common for all documents, others are different. The list of the barriers with the link to the document with which they are connected is described below (see also Annex 1).

**Uncertainty of the Ukrainian state’s policy on RES market rules.** This related to revisions and unpredictable changes in legislation and state policies. Recent examples are the MoU with investors and amendments to the Law of Ukraine “On alternative energy sources” that reduces “green” tariff; a direct violation of Law due to non-payment to RES installations for electricity produced, postponing of RES auctions, cancellation of VAT/custom tax redemptions, propositions of NEURC to nationalize RES objects, etc. (*Energy Strategy until 2035*).

**Underdeveloped biomass market.** The following problems are on the market: unreliability of biomass supply, unstable prices for biomass, no requirements for biomass quality (standards), the mechanisms for biomass trading and contractors searching are absent. (*Energy Strategy until 2035, Heat Supply Concept of Ukraine, 100RE views until 2050-2070*).

**Cross subsidizing of energy for population due to energy poverty.** The inconvenience that RES is the best energy solution. Lack of stimulation mechanism for the promotion of energy efficiency/energy conservation for population, industry, and energy production. Comparatively low interest and even opposition of municipalities and population for the full-scale green energy transition. (*Energy Strategy until 2035, Heinrich Boll transition scenario by 2050, 100RE views until 2050-2070*).

**Comparatively low natural gas price (temporary).** The price of natural gas is on the market level for industry and state-financed institutions. The natural gas price for households and for communal enterprises that supply heat to their DH networks was about 40% below the market level until recently. The Government was planning to level the prices for all the consumers in Ukraine by January 2020, but actually, it happened earlier, in April 2019 due to a reduction of the prices at the natural gas market. (*Energy Strategy until 2035, Heat Supply Concept of Ukraine*).

**Non-liberalized electricity and heat market with large state regulation and communal monopolies.** To become an actor in the electricity or heat market, the

producer should meet many requirements and go through different complicated procedures. (*Energy Strategy until 2035, Heat Supply Concept of Ukraine, Road Map for climate targets until 2030, Green Deal until 2050, 100RE views until 2050-2070*).

**Monopoly of communal enterprises on heat market, absence of any kind competitiveness.** As a result of long-term state ownership, outdated equipment, bad management, and lack of investments, there is general ineffectiveness of the existing communal DH companies, extremely high deterioration rate of equipment and networks, and high heat prices for end customer on the market. Destruction of DH systems and full abandoning in some cities is the general trend as well. Public construction for new buildings usually ignores the existing nearby DH system due to its basic ineffectiveness. Lack of population confidence in reliability of district heating. Lack of complex Heat Strategy of Ukraine until 2050. (*Heat Supply Concept of Ukraine*).

**Absence of robust mechanism for stimulation of increased RES usage in the heat sector.** The only mechanism for stimulating RES usage in the heat sector is the incentive-reduced tariff for heat produced from alternative energy sources and intended for population and budget-financed institutions. The incentive tariff is 90% of the tariff established for the supplier of heat produced from natural gas for the respective category of consumers which is not enough incentive, especially for small and mid-scale RE installations (up to 500 kWth). (*Energy Strategy until 2035, Heat Supply Concept of Ukraine*).

**Almost full depletion of woody biomass potential for energy use.** The main source of biomass potential in Ukraine is agricultural biomass (residues and byproducts of crop production) and energy crops, while the available resources of wood biomass for energy are rather limited. (*Energy Strategy until 2035*).

**Unreadiness of agro companies to act as large-scale agro biomass suppliers and symmetrically unreadiness of biomass-to-heat producers to use agro biomass as a fuel** due to lack of technological confidence and experience, lack of technologies and respective value chains on the level of biomass suppliers and equipment producers. Despite the availability of large resources of various types of agro-biomass in Ukraine, their practical utilization for energy production has not developed significantly. By UABIO estimation, the use of straw potential is only about 3%, for maize stalks is even less, and sunflower stalks are not used at all for energy purposes. The only type of agro-biomass, which energy potential is actively utilized is sunflower husk. A positive trend of recent years is the gradual growth of the production of briquettes from straw and maize stalks. (*Energy Strategy till 2035, Heinrich Boll transition scenario till 2050*).

**Low power grid flexibility allowing plugging in up to 6-7 MWel of solar+wind generation (the limit already exceeded).** (*Energy Strategy until 2035, Road Map for climate targets until 2030*).

**Lack of power grid integration with ENTSO-E.** The ENTSO-E integration requires compliance with EU-level-based pollution requirements (as per Directive 2010/75/EU). According to official data, there is only 1 TPP integrated (partly) into ENTSO-E – Burshtyn TPP (Lviv region). According to official data, it fulfils the requirements of ENTSO-E in terms of pollution.

ENTSO-E integration also increases the flexibility of the grid with minimal cost (ENTSO-E can be virtually imaged as a large balancing capacity which does not require huge investments) which is currently the crucial barrier for solar PV and wind in Ukraine. (*Energy Strategy until 2035*).

**Lack of mechanism to stimulate power grid balancing capacities construction,** including those to engage biomass/biogas TPP/CHP for balancing. (*Energy Strategy until 2035*).

**Absence of obligatory requirements for liquid biofuel share in motor fuels and respective sustainability criteria and certification.** First Draft Law #7348 registered in 2018, Draft Law #3356-d re-registered in November 2020, but still not adopted. (*Energy Strategy until 2035, Heinrich Boll transition scenario until 2050*).

**Non-developed biomethane market.** Biomethane, under the current incentive mechanism system, cannot compete with other renewable energy sources due to relatively high production costs. Up to now, there are no examples of biogas-to-biomethane upgrading facilities in Ukraine, as there is no sufficient legal and regulatory framework for its production and use. There are no government strategic targets regarding biomethane in Ukraine, and there is absence of biomethane inter-linking with the EU market for renewable gases trading. (*Energy Strategy until 2035, Green Energy Transition until 2050, 100RE views until 2050-2070*).

**Lack of any stimulation mechanism for electric cars.** State co-financing had been considered in 2017-2018, but it was not adopted. (*Energy Strategy until 2035*).

**"Warm" credits programme has been almost shut down.** "Warm credits" is a state energy saving programme implemented by the government for citizens and Homeowners associations in Ukraine since October 2014, providing the following compensations from the state budget:

20% of the loan amount (but not more than UAH 12 ths) for the purchase of non-gas and non-electric boilers for individuals, 35% of the loan amount (but not more than

UAH 14 ths) for the purchase of energy-saving equipment/materials for individuals who are private residence owners;

40% of the loan amount (but not more than UAH 14 ths per one apartment) for Homeowners associations/Housing Associations for communal purposes.

The implementation of energy-saving measures (in terms of HOAs) has resulted in the reduction of housing and utility service expenses by an average 20–50% and even more. (*Energy Strategy until 2035*).

**Ineffectiveness of valid carbon tax mechanism.** Low level of CO<sub>2</sub> tax (0.3 EUR/tCO<sub>2</sub>). Biomass projects are paying carbon tax at the same level as fossil fuels. (*Energy Strategy until 2035, Road Map for climate goals until 2030, 100RE views until 2050-2070*).

**Absence of state-level adopted programme for TPP planned shutdown/fuel switch.** Unreadiness for the closure of coal infrastructure in Ukraine. (*Road Map for climate targets until 2030*).

**Underdeveloped UA Emission Trading Scheme** (only MRV part is adopted, no infrastructure for support of MRV in place. (*Energy Strategy until 2035*).

**Very low ambition in the NDC2** of the Paris Agreement. (*Road Map for climate goals until 2030, 100RE views until 2050-2070*).

**Subsidizing fossil fuel-based energy generation in all sectors of the economy.** (*Green Energy Transition until 2050, 100RE views until 2050-2070*<sup>23</sup>).

**Unreadiness of grid to replace 7 GWel of NPP generation in 10 years.** The enormous cost and public protest for new NPP construction during 2035-2040. According to current Energoatom plans<sup>24</sup> (Plan till 2024) two units of 420 MWel each (Rivne NPP) shall be put out of operation till 2024 without any prolongation of operation. (*Road Map for climate goals until 2030, Green Energy Transition until 2050*).

**Non-developed bio-hydrogen market, no start of the discussion on the state level.** Absence of bio-hydrogen inter-linking with the EU market for renewable gases trading. (*Green Energy Transition until 2050, 100RE views until 2050-2070*).

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<sup>23</sup> According to OECD 40 billion UAH during 2012-2016 is a direct budget subsidy for the coal sector ([https://www.iisd.org/gsi/sites/default/files/ffs\\_ukraine\\_draftinventory\\_ukr.pdf](https://www.iisd.org/gsi/sites/default/files/ffs_ukraine_draftinventory_ukr.pdf))

<sup>24</sup> [https://www.energoatom.com.ua/uploads/2020/sp\\_2020\\_2024.pdf](https://www.energoatom.com.ua/uploads/2020/sp_2020_2024.pdf)

**Low grid flexibility and low grid transmission capacity for provision of targets until 2050** (additional complex grid infrastructure with enormous investments needed). (*Green Energy Transition until 2050*).

**Lack of stimulation mechanism for the promotion of complex full-cycle waste management/treatment technologies** (including RDF, direct combustion, recycling, etc.). (*Green Energy Transition until 2050*).

**Lack of mechanism for stimulation of effective cogeneration and trigeneration.** (*Green Energy Transition until 2050*).

**Lack of mechanism for stimulation of energy crops planting and utilization for energy.** In particular, the absence of the term "energy crops" in the legislation of Ukraine, complicated procedure of state and communal property land lease, short terms of the land lease agreements, the necessity of significant investments at the first stages of energy crops planting, the long payback period for projects. (*Green Energy Transition until 2050*).

**Lack of mechanism for stimulation of the digestate utilization after biogas complexes.** (*100RE views until 2050-2070*).

## Proposals of Priority Measures for the Energy Transition in Ukraine

To overcome the barriers described above different measures should be taken to facilitate the energy transition in Ukraine. The list of measures with the link to the document with which they are connected is below (see also Annex 1).

**Unlocking the payments to RES electricity producers** according to the MoU with investors and amendments to the Law of Ukraine “On alternative energy sources”: 40 percent in the 4th quarter of 2020 and 15 percent quarterly during 2021. (*Energy Strategy until 2035*).

**Introduction of biomass exchange electronic platform for transparent biomass trading.** Adoption of respective Draft Law prepared by SAE and UABIO in 2018 is needed. Electronic platform establishment envisages obligations to trade via the platform for certain types of biomass sellers (state and communal enterprises that produce solid biomass both of forest and agricultural origin) and purchasers (energy producers that receive “green” tariff for electricity and 90% stimulating tariff for heat energy) from 20% of the annual volume of biomass trading or consumption in 2020 to 100% in 2024. It also envisages the introduction of quality standards for biomass to support transparent biomass trading. (*Energy Strategy until 2035, 100RE views till 2050-2070*).

**Cancellation of all non-market-based subsidies in end-customer tariff formation.** (*Energy Strategy until 2035*).

**Introduction of market-level gas prices for all sectors.** (*Energy Strategy until 2035*).

**Launching of auctioning mechanism for RES-to-grid projects** according to the amendments to the Law of Ukraine “On alternative energy sources” (everything is technically and legislatively ready). (*Energy Strategy until 2035*).

**Implementation of pilot/demonstration projects** based on existing agro companies for agro biomass utilization with the build-up of the whole value chain from the field to the energy end customer (using international financing, for example, FINTECCC Programme by EBRD with low loan interest). (*Energy Strategy until 2035*).

**Implementation of stimulation mechanism for grid balancing capacities.** (*Energy Strategy until 2035, Road Map for climate goals until 2030*).

**Facilitation of integration of Ukrainian grid to ENTSO-E** is one of the priorities of *Energy Strategy until 2035*.

**Adoption of full-ready Law #3356-d for liquid biofuel mix to motor fuels, the introduction of sustainability criteria, and certification.** Transposition of sustainability criteria for biomass and biofuels for at least as per RED-II. (*Energy Strategy until 2035, Heinrich Boll transition scenario by 2050*).

**Introduction of legislative amendments for creation of biomethane registry and mechanism of origin verification for biomethane utilization inside Ukraine and trading between Ukraine and the EU-27.** In addition, it is necessary to establish strategic targets regarding biomethane production in Ukraine. It is highly important to adopt a legal framework for biomethane – to envisage its definition, to establish legal grounds for the establishment of the register of the biomethane production and consumption, to foresee the necessity to obtain a guarantee of the biomethane origin. (*Energy Strategy until 2035, Green Deal until 2050*).

**Re-launching of "warm" credits programme with the level of financing at least as it was in 2014-2018.** (*Energy Strategy until 2035*).

**Immediate cancellation of carbon tax payment for biomass and biogas.** Reform of CO<sub>2</sub> tax mechanism – coming from "CO<sub>2</sub> tax" to classical "energy tax", with taxation of carbon content in fuel on the stage of first entrance/first sell event. Increasing of the level of energy tax at least to 3 EUR/tC (or 10 EUR/t CO<sub>2</sub>-eq.). (*Energy Strategy until 2035, Road Map for climate targets until 2030, 100RE views until 2050-2070*).

**Introduction of competitiveness in DH** through the adoption of Draft Law of Ukraine "On amendments to certain laws of Ukraine on competition introduction in district heating systems" already prepared by SAE and UABIO in 2019. It envisages the framework for the economic model, which includes annual auctions for thermal energy, organized by the single-buyer operator, with the submission of two separate price bids for heating and non-heating seasons; setting the size of mandatory reserve capacities of an operator to be paid by third parties; and setting the upper limit for heat energy price on the auction for independent heat energy producers on the level of 90 percent of the tariff set for the operator in the competitive system, which is defined as the one having at least 50 Gcal/h connected consumer heat load in the heating season. (*Heat Supply Concept of Ukraine*).

**Fundamental changes in DH systems.** The possible introduction of RAB-regulation in district heating as an intermediary step from monopoly to competitiveness. Introduction of definition "effective DH system", "generation stages of DH systems" as per the EU-27. Introduction of "zoning principle" for DH systems. Equalization of

gas prices and respective DH tariffs for all categories of consumers. (*Heat Supply Concept of Ukraine*).

**Upgrade of "0.9 principle" for stimulation of biomass heat production**, with possible introduction of premium tariff for heat production from biomass. To ensure economic efficiency for all biomass-to-heat energy producers it is necessary to provide them with the possibility to choose the procedure of the heat tariffs formation — according to the «principle of 90%» or according to the usual «cost+» procedure. (*Heat Supply Concept of Ukraine*).

**Informational campaigns** reaching out to the population with the engagement of public leaders (like energy ambassadors e.g., Ruslana in 100RE Ukraine) demonstrating the advantages of DH against individual heating. Informational campaign for population, state co-financing, or grant financing for small-scale individual RES projects. (*Heat Supply Concept of Ukraine, Heinrich Boll transition scenario by 2050*).

**Pilot projects for DH companies** on the municipal level based on internationally financed programs (like SUDH, NEFCO, and others with lower interest rate or grant financing). (*Heat Supply Concept of Ukraine*).

**Development and adoption of comprehensive Heat Strategy of Ukraine** (analogically to Energy Strategy of Ukraine) during 2020-2021. (*Heat Supply Concept of Ukraine*).

**Development and adoption of Plan for TPP decommissioning and/or fuel switch in 2020-2021.** (*Road Map for climate goals until 2030*).

**Implementation of obligatory requirements for modern nitrogen, PM and sulphur cleaning for existing TPPs** (at least according to Directive #2010/75/EU or better). (*Road Map for climate goals until 2030*).

**Cancellation of any kind of state subsidies on coal.** Cancellation of all existing subsidies on fossil fuel. (*Road Map for climate goals until 2030, 100RE views until 2050-2070*).

**Cancellation of subsidized electricity tariffs for the population.** (*Road Map for climate goals until 2030*).

**Creation of state programme for the gradual transition of personnel from closing coal mining/processing industry and TPPs to renewable energy projects.** (*Road Map for climate goals until 2030*).

**Development and launching of UA ETS for large-scale installations at full scale till 2022 and its linking with the EU ETS.** (*Road Map for climate goals until 2030*).

**Changing of NDC for 2021/2022 to a more ambitious one** – at least 70% of emission reductions until 2030 compared to 1990 and 100% emission reductions in energy sector until 2050 as per average scenario of temperature increasing according to Paris agreement. (*Road Map for climate goals until 2030, 100RE views until 2050-2070*).

**Adopt the ready document Green Energy Transition until 2050** and start its implementation at the state level. (*Green Energy Transition until 2050*).

**Implementation of the legislative framework for bio-hydrogen projects**, starting with pilot projects aimed at bio-hydrogen supply to Germany (according to Deutsche Wasserstoff Strategie 2020, where biohydrogen import is assessed as 10 billion nm<sup>3</sup> till 2030). (*Green Energy Transition until 2050*).

**Implementation of RAB-regulation incentive mechanism for start of local and transmission power grid reconstruction with the attraction of private capital.** (*Green Energy Transition until 2050*).

**Implementation of the legislative framework for full-cycle waste management/treatment, implementation of stimulation mechanism for MSW incineration** (based on "gate" fee). (*Green Energy Transition until 2050*).

**Transposition of the EU Directive #2012/27/EU on Energy efficiency** with definition of "effective cogeneration and trigeneration" and respective incentives for cogeneration and trigeneration projects. (*Green Energy Transition until 2050, Heinrich Boll transition scenario by 2050*).

**Adoption of ready-to-go stimulation mechanism for energy crops planting** proposed by SAEE and UABIO in 2020 (additional financial support to companies during first 3 years of plantation start, simplifying the procedure of land allocation for energy crops). (*Green Energy Transition until 2050*).

**Improvement of macroeconomics and investment climate** through the creation of the stable legislative framework for RES for at least 2 decades, transparent liberalized markets of energy carriers, electricity, heat, independent court system, cheap loan interest rates at local banks. (*Heinrich Boll transition scenario by 2050*).

**Engagement of additional sources of biomass** – protection forest lines, pruning waste, processing waste, MSW of all kinds, increasing of productivity of agriculture

to afford increased amounts of agro residues from fields. (*Heinrich Boll transition scenario by 2050*).

**Demonstration of profitability of agro biomass supply business** on the level of agro holdings (for own energy needs and exterior third parties) through the build-up of the whole value chain from the field to the energy end customer (using international financing, for example, FINTECCC Programme by EBRD with low loan interest). (*Heinrich Boll transition scenario by 2050*).

**Creation of full-scale opened markets of energy carriers**, electricity, and heat with minimal state regulation. (*100RE views until 2050-2070*).

**Integration of 100% RE views of all associations in Ukraine** and its reflection on the level of New Green Energy Strategy till 2050 which shall be adopted during 2021. (*100RE views until 2050-2070*).

**Implementation of full legislative framework for biomethane, biohydrogen, bio-synthetic renewable gases**, and linking with the EU networks for international trading. (*100RE views until 2050-2070*).

**Implementation of legislative framework and stimulation mechanism for digestate utilization**. (*100RE views until 2050-2070*).

- **Distribution of funds from tax directly to the CO<sub>2</sub>-neutral projects**. Increasing of the level of energy tax at least to 3 EUR/tC (or 10 EUR/t CO<sub>2</sub>-eq.) for the 2020-2030, and then to 10 EUR/tC for 2030-2040 and for 100 EUR/tC for 2040 onwards. Supplementary introduction of "green" premium mechanism based on the highest CO<sub>2</sub> emission reduction benchmarks. Supplementary mandatory certification of GHG emission reduction projects as per ISO 50001. (*100RE views until 2050-2070*).

## Annex 1 – Matrix for comparison of scenarios, targets, associated barriers and solutions

#	Document	Targets in documents	Barriers to achieve	Solutions/measures for facilitation	Estimated investment needed	Assessment of credibility
1	<p><b>Energy strategy until 2035 (approved)</b></p>	<ul style="list-style-type: none"> <li>- RES share in 2035 (TPES): 25%</li> <li>- RES share in 2035 (power): 25%</li> <li>- RES share in transport: 20%</li> <li>- Biomass in TPES: 11%, 11 Mtoe</li> <li>- TPES growth from 90 Mtoe (current) to 96 Mtoe</li> </ul>	<ul style="list-style-type: none"> <li>- Unconfidence of investors in stability of state policy on RES market rules, retrospective reviews and unpredictable changes in legislation (recent examples: MoU with investors which lowers green tariff, direct violation of State Law due to state non-payment to RES objects, postponing of RES auctions, etc.);</li> <li>- Underdeveloped biomass market;</li> <li>- Cross-subsidizing of energy for population due to energy poverty;</li> <li>- Comparatively low natural gas price (temporary);</li> <li>- Non-liberalized electricity and heat market with large state regulation and communal monopolies;</li> <li>- Absence of robust mechanism for stimulation of RES in heat sector;</li> <li>- Almost full depletion of woody biomass energy potential;</li> <li>- Unreadiness of agro companies to act as large-scale agro biomass suppliers and symmetrically unreadiness of biomass-to-heat producers to use agro biomass as a fuel (lack of technological confidence and experience, wrong beliefs);</li> <li>- Low power grid flexibility allowing to plug in up to 6-7 MWel of solar+wind generation (the limit already exceeded);</li> <li>- Lack of power grid integration with ENTSO-E;</li> <li>- Lack of mechanism to stimulate power grid balancing capacities construction;</li> <li>- Absence of obligatory requirements for liquid biofuel share in motor fuels and respective sustainability criteria and certification (first Draft Law # 7348 registered in 2018, Draft Law #3356-d re-registered in November 2020 but still not adopted);</li> <li>- Non-developed biomethane market;</li> <li>- Lack of any stimulation mechanism for electric cars (state co-financing has been considered in 2017-2018 but not adopted);</li> <li>- "Warm" credits programme by SAEE has been almost shut down.</li> <li>- Ineffectiveness of valid carbon tax mechanism (biomass projects are paying carbon tax at the same level as fossil fuels).</li> </ul>	<ul style="list-style-type: none"> <li>- Adoption of legislation for RES without retrospective reviews and random changes;</li> <li>- Full payments to RES electricity producers;</li> <li>- Introduction of biomass exchange electronic platform for transparent biomass trading (adoption of respective Draft Law prepared by SAEE and UABIO in 2018);</li> <li>- Cancellation of all non-market based subsidies in end-customer tariff formation;</li> <li>- Introduction of market level gas prices for all sectors;</li> <li>- Launching of auctioning mechanism for RES-to-grid projects (everything is technically and legislatively ready);</li> <li>- Implementation of pilot/demonstration projects on the basis of existing agro companies for agro biomass utilization with build-up of whole value chain from the field to the energy end customer (using international financing, for example FINTECCC Programme by EBRD with low loan interest);</li> <li>- Implementation of stimulation mechanism for grid balancing capacities;</li> <li>- Facilitation of integration of Ukrainian grid to ENTSO-E;</li> <li>- Adoption of full-ready Law # 3356-d for liquid biofuel mix to motor fuels, introduction of sustainability criteria;</li> <li>- Introduction of legislative amendments for creation of biomethane registry and mechanism of origin verification for biomethane utilization inside Ukraine and trading between Ukraine and the EU-27;</li> <li>- Re-launching of "warm" credits programme with the level of financing at least as it was in 2014-2018;</li> <li>- Immediate cancellation of carbon tax payment for biomass and biogas.</li> </ul>	<p>2% of GDP annually - according to the document</p>	<ul style="list-style-type: none"> <li>- RES share in 2035 (TPES): 25% - rather possible with the elimination of most of barriers</li> <li>- RES share in 2035 (power): 25% - rather possible with the elimination of most of barriers</li> <li>- RES share in transport: 20% - possible only with the elimination of all barriers and even more efforts;</li> <li>- Biomass in TPES: 11%, 11 Mtoe - very much possible, with the elimination of respective most critical barriers;</li> <li>- TPES growth from 90 Mtoe (current) to 96 Mtoe - rather not possible regardless the elimination of barriers: TPES is dropping for the last 20 years without demonstration of any growth tendency and regardless the exterior factors, like losing of territories, economy drops, earnings drop, etc., so rather will continue to drop further or stabilize, but not grow. This growth shall be judged as a mistake in target set of Energy Strategy.</li> </ul>

2	<p><b>Heat Supply Concept of Ukraine (approved)</b></p>	<p>- RES share in 2035 (heat production): 40%</p>	<ul style="list-style-type: none"> <li>- Monopoly of communal enterprises on the heat market, absence of any kind competitiveness;</li> <li>- General ineffectiveness of existing DH companies, extremely high deterioration rate of equipment and networks, and high heat prices for end customer as a result;</li> <li>- General trend on destruction of DH system and full abandoning in some cities;</li> <li>- Public construction for new buildings usually ignores existing nearby DH system due to its basic ineffectiveness;</li> <li>- Non-market based gas prices for population (lower than market based);</li> <li>- Underdeveloped biomass market;</li> <li>- Absence of robust stimulation mechanism for promotion of RES in heat sector;</li> <li>- Lack of population confidence in reliability of district heating;</li> <li>- Lack of complex Heat Strategy of Ukraine till 2050.</li> </ul>	<ul style="list-style-type: none"> <li>- Introduction of competitiveness in DH through adoption of Draft Law of Ukraine "On amendments to certain laws of Ukraine on competition introduction in district heating systems" already prepared by SAEE and UABio in 2019;</li> <li>- Possible introduction of RAB-regulation in district heating as intermediary step from monopoly to competitiveness;</li> <li>- Introduction of definition "effective DH system", "generation stages of DH systems" as per the EU-27;</li> <li>- Introduction of "zoning principle" for DH system;</li> <li>- Equalization of gas prices and respective DH tariffs for all categories of consumers;</li> <li>- Upgrade of "0.9 principle" for stimulation of biomass heat production, with possible introduction of premium tariff for heat production from biomass;</li> <li>- Informational campaigns among population with engagement of public leaders (like Ruslana in 100RE Ukraine) demonstrating the advantages of DH against individual heating;</li> <li>- Pilot projects for DH companies on the municipal level based on internationally-financed programmes (like SUDH, NEFCO and others with lower interest rate or grant financing);</li> <li>- Development and adoption of complex Heat Strategy of Ukraine (analogically to Energy Strategy of Ukraine) during 2020-2021;</li> </ul>	<p>10-20 billion EUR - estimation of authors</p>	<p>- RES share in 2035 (heat production): 40% - rather possible with the elimination of most of specific barriers.</p>
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3	<p><b>Road Map for climate goals until 2030 - view of public</b></p>	<p>2030:          - RES share in GFEC: 30%          - RES share in GFEC (power): 58%          - RES share in GFEC (heat): 24%          - Coal TPP shutdown in 2030-2035          - 90% GHG emission reductions from coal TPPs in 2030 compared to 2018          - Decreasing of NPP capacity from 13.8 GWel in 2018 to 5 GWel in 2030          2050:          - RES share in GFEC: 91%</p>	<p>- Absence of state-level adopted programme for TPP planned shutdown/fuel switch;          - Low power grid flexibility allowing to plug in up to 6-7 MWel of solar+wind generation (the limit already exceeded);          - Lack of mechanism to stimulate power grid balancing capacities construction (including those to engage biomass/biogas TPP/CHP for balancing);          - Unreadiness of grid to replace 7 GWel of NPP generation in 10 years;          - Non-liberalized electricity and heat market with large state regulation and communal monopolies;          - Unreadiness for closure of coal infrastructure in Ukraine;          - Ineffectiveness and low level of CO2 tax (0.3 EUR/tCO2);          - Underdeveloped UA Emission Trading Scheme (only MRV part is adopted, no infrastructure for support of MRV in place);          - Very low ambitious NDC as per Paris Agreement.</p>	<p>- Development and adoption of Plan for TPP decommissioning and/or fuel switch in 2020-2021;          - Implementation of stimulation mechanism for grid balancing capacities;          - Implementation of obligatory requirements for modern nitrogen, PM and sulphur cleaning for existing TPPs (at least according to Directive #2010/75/EU or better);          - Cancellation of any kind of state subsidies on coal;          - Cancellation of subsidized electricity tariffs for population;          - Creation of state programme for gradual transition of personnel from closing coal mining/processing industry and TPPs to renewable energy projects;          - Reform of CO2 tax mechanism - coming from "CO2 tax" to classical "energy tax", with taxation of carbon content in fuel on the stage of first entrance/first sell event. Increasing of the level of energy tax at least to 3 EUR/tC (or 10 EUR/t CO2-eq.);          - Development and launching of UA ETS for large-scale installations at full scale till 2022 and its linking with the EU ETS;          - Changing of NDC for 2021/2022 to more ambitious one - at least 70% of emission reductions till 2030 compared to 1990 and 100% emission reductions in energy sector till 2050 as per average scenario of temperature increasing according to Paris agreement.</p>	<p>100-120 billion EUR - estimation of authors</p>	<p>2030:          - RES share in GFEC: 30% - very ambitious target, possible only with fast elimination of all barriers during the short period 2020-2022 and 10-15% drop in GFEC;          - RES share in GFEC (power): 58% - very ambitious target, possible only with fast elimination of all barriers during short period 2020-2022 and forcing development of RES in stable political circumstances;          - RES share in GFEC (heat): 24% - not ambitious target - very much possible, with the elimination of respective most critical barriers (2019 (base) RES share in heat is around 10%, for some regions of Ukraine - 30-35%);          - Coal TPP shutdown in 2030-2035 - ambitious target - rather possible with the elimination of most of the barriers;          - 90% GHG emission reductions from coal TPPs in 2030 compared to 2018 - ambitious target - rather possible with elimination of most of the barriers;          - Decreasing of NPP capacity from 13.8 GWel in 2018 to 5 GWel in 2030 - very ambitious target - rather impossible regardless barriers elimination, however drop to 7-8 GWel may be considered as more realistic          2050:          - RES share in GFEC: 91% - very ambitious target, possible only with fast elimination of all barriers during short period 2020-2022 and additional support for green-oriented state policy at all levels for post-2030 period.</p>
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4	<p><b>Ukrainian "Green Deal" Green Energy Transition Till 2050 (draft)</b></p>	<ul style="list-style-type: none"> <li>- RES share in 2050 (power): 70%;</li> <li>- Shut down of coal TPP till 2050;</li> <li>- 20% - NPP power generation;</li> <li>- Carbon neutrality during 2050-2070;</li> <li>- Wide transport electrification;</li> <li>- Wide utilization of renewable gases</li> <li>- biomethane and hydrogen;</li> <li>- General course on markets liberalization and competitiveness</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of political will to adopt the developed Draft Green Deal (temporary);</li> <li>- Subsidizing of fossil fuel based energy generation in all sectors of economy;</li> <li>- Enormous cost and public protest for new NPP construction during 2035-2040;</li> <li>- Non-developed biomethane market;</li> <li>- Non-developed bio-hydrogen market, no start of discussion on state level;</li> <li>- Non-liberalized electricity and heat market with large state regulation and communal monopolies;</li> <li>- Low grid flexibility and low grid transmission capacity for provision of mentioned targets (additional complex grid infrastructure with enormous investments needed);</li> <li>- Lack of stimulation mechanism for promotion of complex full-cycle waste management/treatment technologies (including RDF, direct combustion, recycling, etc.);</li> <li>- Lack of mechanism for stimulation of effective cogeneration and trigeneration;</li> <li>- Lack of mechanism for stimulation of energy crops planting and utilization for energy.</li> </ul>	<ul style="list-style-type: none"> <li>- Adopt the ready document Green Energy Strategy till 2050;</li> <li>- Introduction of legislative amendments for creation of biomethane registry and mechanism of origin verification for biomethane utilization inside Ukraine and trading between Ukraine and the EU-27;</li> <li>- Implementation of legislative framework for bio-hydrogen projects, starting with pilot projects aimed on bio-hydrogen supply to Germany (according to Deutsche Wasserstoff Strategie 2020, where biohydrogen import is assessed as 10 billion nm3 till 2030);</li> <li>- Implementation of RAB-regulation incentive mechanism for start of local and transmission power grid reconstruction with attraction of private capital;</li> <li>- Implementation of legislative framework for full cycle waste management/treatment, implementation of stimulation mechanism for MSW incineration (on the basis of "gate" fee);</li> <li>- Transposition of the EU Directive # 2012/27/EU On Energy efficiency with definition of "effective cogeneration and trigeneration" and respective incentives for cogeneration and trigeneration projects;</li> <li>- Adoption of ready-to-go stimulation mechanism for energy crops planting proposed by SAEE and UABIO in 2020 (additional financial support to companies during first 2 years of plantation start);</li> <li>- Simplify the procedure of land allocation for energy crops.</li> </ul>	<p>5% of national GDP annually - according to the document</p>	<ul style="list-style-type: none"> <li>- RES share in 2050 (power): 70% - possible with the elimination of most of the barriers;</li> <li>- Shut down of coal TPP till 2050 - very possible with the elimination of respective most critical barriers;</li> <li>- 20% - NPP power generation - rather possible without any barrier elimination due to prolongation of existing NPP operation, but not building of new ones on the basis of small NPP units as it is foreseen in the document;</li> <li>- Carbon neutrality during 2050-2070 - very possible with elimination of all barriers;</li> <li>- Wide transport electrification - rather possible with the elimination of all barriers;</li> <li>- Wide utilization of renewable gases - biomethane and hydrogen - rather possible with the elimination of all barriers;</li> <li>- General course on markets liberalization and competitiveness - rather possible with the elimination of respective most crucial barriers.</li> </ul>
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5	<p><b>Heinrich Boll transition scenario by 2050 (2018)</b></p>	<p>Revolution scenario:          - RES share in 2050 (GFEC): 91%;          - 60% from RES in TPES is biomass;          - Shut down of NPPs (from 2040) and almost-full shut down of coal TPPs (in 2050).</p>	<ul style="list-style-type: none"> <li>- Potential lack of necessary cash flow from investors (10-15 billion EUR/year average, for reference during the "record 2019" around 3.7 billion EUR has been attracted, total for last 10 years - around 10 billion EUR);</li> <li>- Absence of sustainability criteria for demonstration of credibility of large-scale amounts of biomass-to-energy utilization (around 29 Mtoe will be utilized, which is close (and may exceed in low agro yield years) to full biomass energy potential of Ukraine);</li> <li>- Lack of stimulation mechanism for promotion of energy efficiency/energy conservation for population, industry and energy production;</li> <li>- Lack of technologies and respective value chains on the level of biomass suppliers and equipment producers;</li> <li>- Energy poverty of population, strong inconvenience that RES is the best energy solution.</li> </ul>	<ul style="list-style-type: none"> <li>- Improvement of macroeconomics and investment climate through creation of stable legislative framework for RES for at least 2 decades, transparent liberalized markets of energy carriers, electricity, heat;</li> <li>- Transposition of sustainability criteria for biomass and biofuels for at least as per RED-II;</li> <li>- Engagement of additional sources of biomass - protection forest lines, pruning waste, processing waste, MSW of all kinds, increasing of productivity of agriculture to afford increased amounts of agro residues from fields;</li> <li>- Transposition of the EU Directive # 2012/27/EU On Energy efficiency;</li> <li>- Demonstration of profitability of agrobiomass supply business on the level of agro holdings (for own energy needs and for exterior third parties) through build-up of whole value chain from the field to the energy end customer (using international financing, for example FINTECCC Programme by EBRD with low loan interest);</li> <li>- informational campaign for population, state co-financing or grant financing for small-scale individual projects.</li> </ul>	<p>300-450 billion EUR (w/o accumulation), 380-550 billion EUR (with accumulation) - according to the document</p>	<p>Revolution scenario:          - RES share in 2050 (GFEC): 91% - very ambitious target, possible only with fast elimination of all barriers during short period 2020-2022 and additional support for green-oriented state policy at all levels for post-2030 period.          - 60% from RES in TPES is biomass - rather possible, with the elimination of all respective barriers;          - Shut down of NPPs (from 2040) and almost-full shut down of coal TPPs (in 2050) - rather possible, with the elimination of all respective barriers.</p>
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6	<p><b>ASET INFORSE- Europe 100 RE Scenario (2018)</b></p>	<p>High Commitment Scenario:          - 100% of RES in GFEC and TPES till 2050;          - 100% reduction of GHG emissions till 2050;          - Energy efficiency: -18% reduction in GFEC in 2050 comparing to 2010-2015 average level          Climate action:          - RES share in 2050 (GFEC): 45%          - 40% reduction of GHG emissions till 2050 compared to 2015;          - Energy efficiency: -9% in GFEC in 2010 comparing to 2010-2015 average level</p>	<ul style="list-style-type: none"> <li>- Lack of investments needed for implementation of High Commitment scenario;</li> <li>- Absence of State level Strategy with 100% RE till 2050</li> <li>- Lack of energy efficiency incentives for population, industry, public sector;</li> <li>- Lack of power grid flexibility.</li> </ul>	<ul style="list-style-type: none"> <li>- Open up the full scale at least (20 billion EUR/year average for 2020-2050) bankable investment programme for RES projects (0% loans, direct grant financing, co-financing with international institutions, like EBRD, WB);</li> <li>- Integration of views of different documents in New Green Energy Strategy with fixing 100% RE target till 2050;</li> <li>- Implementation of energy efficiency incentives at all levels;</li> <li>- Increasing grid flexibility and stability (ENTSO-E integration, capacitors construction, balancing capacities construction, smart grid concept realization).</li> </ul>	<p>n/a (estimated more than 600 billion EUR)</p>	<p>High commitment:          - 100% RES in TPES/GFEC in all sectors could not be achieved as per current trend of energy sector development and requires full-scale energy reform in period 2021-2022 which is impossible. The increment of investments from 80-90% RES (which is assessed as rather possible) to 100% RES in 2050 is significant (different estimations assessed the increment as +30-100% for additional 10% of RES). The most plausible scenario is Climate Action scenario.</p>
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7	<p><b>100RE views till 2050-2070</b></p>	<ul style="list-style-type: none"> <li>- 100% of RES in GFEC and TPES in 2070;</li> <li>- 0 t CO<sub>2</sub> GHG emissions in 2070 in all sectors;</li> <li>- TPES drop to 80 Mtoe in 2050 and 70 Mtoe in 2070;</li> <li>- 65% RES share in TPES;</li> <li>- Full shutdown of coal and nuclear power;</li> <li>- 100% of RES in heat and electricity (TPES).</li> </ul>	<ul style="list-style-type: none"> <li>- Subsidizing of fossil fuel based energy generation in all sectors of economy;</li> <li>- Non-liberalized electricity and heat market with large state regulation and communal monopolies;</li> <li>- Underdeveloped biomass market;</li> <li>- Lack of integrity of views between different associations and public in Ukraine;</li> <li>- Comparatively low interest and even opposition of municipalities and population for full-scale green energy transition;</li> <li>- Absence of biomethane and bio-hydrogen inter-linking with the EU market for renewable gases trading;</li> <li>- Lack of mechanism for stimulation of digestate utilization after biogas complexes;</li> <li>- Low CO<sub>2</sub>/energy tax;</li> <li>- Very low ambitious NDC as per Paris Agreement.</li> </ul>	<ul style="list-style-type: none"> <li>- Cancellation of all existing subsidies on fossil fuel;</li> <li>- Creation of full-scale opened markets of energy carriers, electricity and heat with minimal state regulation (with independent state regulators like NEURC at each market);</li> <li>- Introduction of biomass exchange electronic platform for transparent biomass trading (adoption of respective Draft Law prepared by SAEE and UABIO in 2018);</li> <li>- Integration of 100% RE views of all associations in Ukraine and its reflection on the level of New Green Energy Strategy till 2050 which shall be adopted during 2021;</li> <li>- Implementation of full legislative framework for biomethane, biohydrogen, bio-synthetic renewable gases and linking with the EU networks for international trading;</li> <li>- Implementation of legislative framework and stimulation mechanism for digestate utilization;</li> <li>- Reform of CO<sub>2</sub> tax mechanism - coming from "CO<sub>2</sub> tax" to classical "energy tax", with taxation of carbon content in fuel on the stage of first entrance/first sell event.</li> </ul> <p>Distribution of funds from tax directly to the CO<sub>2</sub> neutral projects. Increasing of the level of energy tax at least to 3 EUR/tC (or 10 EUR/t CO<sub>2</sub>-eq.) for the 2020-2030, and then to 10 EUR/tC for 2030-2040 and for 100 EUR/tC for 2040 onwards. Supplementary introduction of "green" premium mechanism based on the highest CO<sub>2</sub> emission reduction benchmarks. Supplementary mandatory certification of GHG emission reduction projects as per ISO 50001;</p> <ul style="list-style-type: none"> <li>- Changing of NDC for 2021/2022 to more ambitious one - at least 70% of emission reductions till 2030 compared to 1990 and 100% emission reductions in energy sector till 2050 as per average scenario of temperature increasing according to Paris agreement.</li> </ul>	<p>180-250 billion EUR (2050) - according to document</p>	<ul style="list-style-type: none"> <li>- 100% of RES in GFEC and TPES in 2070 - rather possible, with the elimination of all respective barriers;</li> <li>- 0 t CO<sub>2</sub> GHG emissions in 2070 in all sectors - rather possible, with the elimination of all respective barriers;</li> <li>- TPES drop to 80 Mtoe in 2050 and 70 Mtoe in 2070 - rather possible, with the elimination of all respective barriers;</li> </ul> <p>2050:</p> <ul style="list-style-type: none"> <li>- 65% RES share in TPES - rather possible, with elimination of all respective barriers;</li> <li>- Full shutdown of coal and nuclear power - rather possible, with the elimination of all respective barriers;</li> <li>- 100% of RES in heat and electricity (TPES) - rather possible, with the elimination of all respective barriers.</li> </ul>
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