

# DECARBONIZATION OF UKRAINE'S ENERGY SECTOR

4



Energy intensity of Ukraine's GDP remains extremely high in comparison to advanced countries. In 2015 energy intensity of Ukraine's GDP (according to purchasing power parity (PPP) in 2010 prices) was by 2.2 times higher of the respective global ratio, by 2.6 times higher than that of the OECD countries and by 3.2 times higher of 28 EU member states figure (Fig. 4.1).

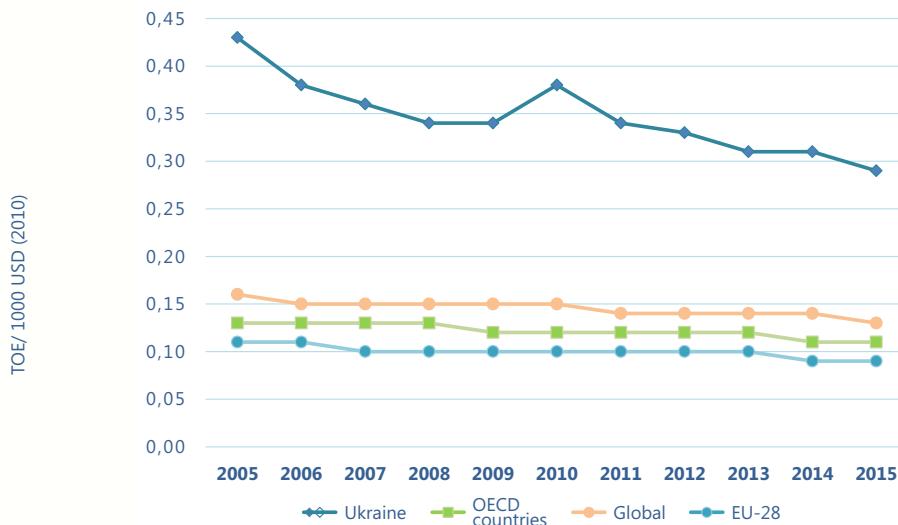
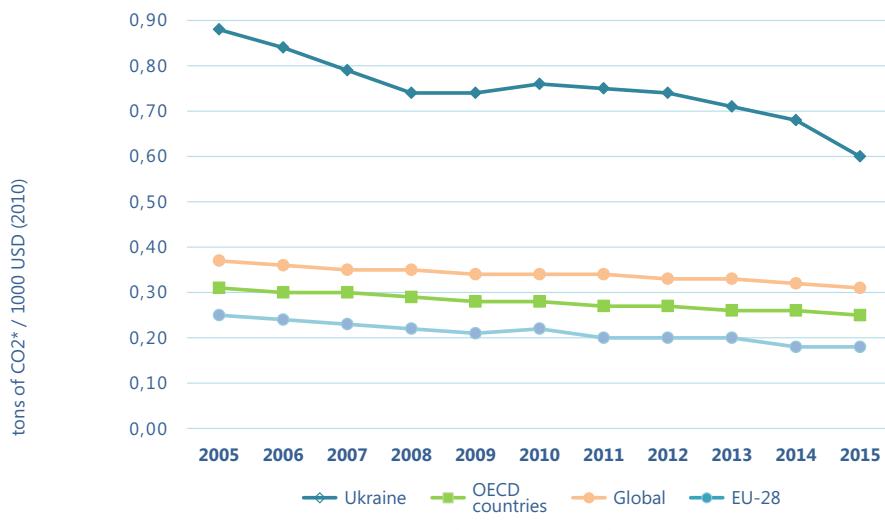


Figure 4.1. **Energy intensity of Ukraine's GDP according to PPP in 2010 prices.**

Similar situation is observed in the GDP carbon intensity level (figure 4.2), which, according to 2015 data, exceeds global ratio by 1.9 times, is 2.4 times higher than that of the OECD countries, and 3.3 times higher of 28 EU member states. GDP carbon intensity calculations included only CO<sub>2</sub> emissions, and, of them, only those resulted from fossil fuels combustion.



\* includes only CO<sub>2</sub> emissions and only from combustion of energy resources

Figure 4.2. **Carbon intensity of Ukraine's GDP according to PPP in 2010 prices**

Figure 4.3 shows dynamics in energy and carbon intensity (it includes all GHG emissions and their absorption) of Ukraine's GDP over 1990-2015 (according to IEA data)

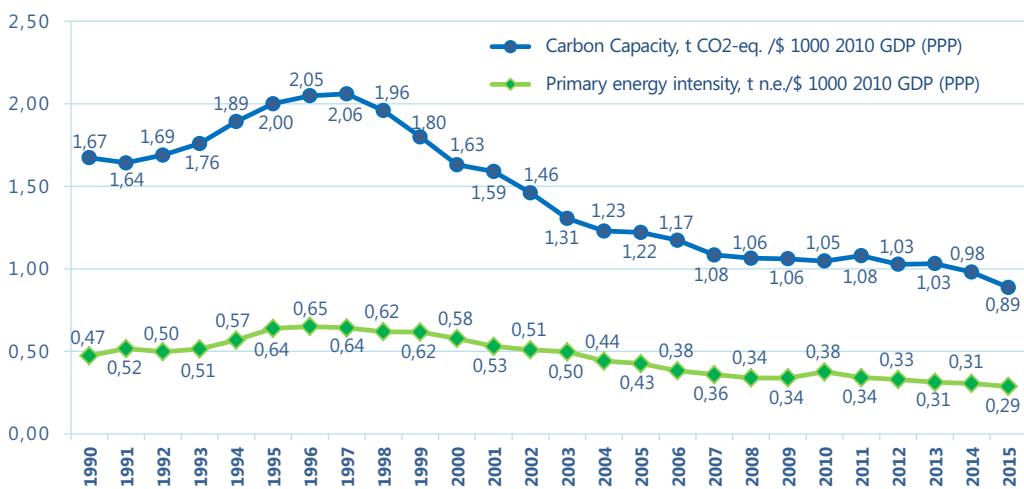


Figure 4.3. **Ukraine's GDP carbon and energy intensity over 1990-2015.**

De-carbonization process of Ukraine's energy sector is taking place, yet, under current economic and environmental policy, its pace is not sufficient. For example, according to model generated estimates, in the absence of effective policy and de-carbonization measures in Ukraine's energy sector, the GHG emissions will continue to show constant growth and in 2050 may reach 70% of 1990 level, whereas in 2012 and 2015 they amounted to 44% and 31%, respectively. Underpinning such estimates is also the fact that over 1990-2015 the dynamics of total GHG emissions was corresponding to the dynamics of GHG emissions in such sectors as «Energy» and «Industrial processes» according to IPCC terminology (Figure 2.1).

Table 4.1 presents current level of GHG emissions in «Energy» and «Industrial processes», and their projections according to Baseline (Business as Usual) scenario. This scenario is treated as hypothetic scenario, where the characteristics for most of the technologies in energy resources usage and household consumption, and also at any stage of goods or services production, stay unchanged by 2050, i.e. stay as they were as of 2012. It should be underscored, that technologies are replaced only when useful life of current capacities expires. The cost and efficiency of technologies replacing the outdated ones are compliant with modern level: with the time the cost is decreasing, while efficiency is growing. Calculation of GHG emissions according to such business as usual scenario is useful, as it enables to perform calculations under alternative scenarios, i.e. the effectiveness of measures and policies, which stimulate technological change in economy and result in its de-carbonization.

Table 4.1  
**Projections of GHG emissions in «Energy» and «Industrial processes» in accordance to baseline (business as usual) scenario**

	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
Emissions, million tons of CO <sub>2</sub> -equivalent	367	265	347	408	455	500	540	570	592
Share of 1990 level, %	44	31	41	48	54	59	64	68	70

\* data of the National Cadaster of anthropogenic emissions from sources and absorption of greenhouse gases absorbers in Ukraine over 1990-2015.

In accordance to baseline scenario, under almost unchanged technical parameters of energy technologies, increase in GHG is taking place as growth in economy is assumed to take place primarily in consequence to restoration and growth in the industrial output. The model includes assumption that average annual GDP growth rates over 2016-2050 will amount to 4%, which means that by 2050 GDP will show a fourfold increase. Ukrainian population will shrink from 45.2 millions of people in 2014, to 38.9 million in 2050. Over 2014-2050 oil and gas prices will grow by 35% and 60%, respectively. In addition, the Baseline scenario conditions do not envision enhanced environmental constraints.

Quantitative model calculations of GHG emissions reduction under Baseline scenario are performed with the help of economic-mathematical optimization model of energy flows of Ukraine (model TIMES-Ukraine). This very model is also used to calculate reduction in GHG emissions when policies and measures on energy de-carbonization, included into Catalogue of policies and measures of low emissions development (hereafter Catalogue) are implemented. The Catalogue is based on best global practices and current legal framework, and was put together through broad consultations with representatives of Government authorities, business Ukrainian and international experts, scientists and public.

Dynamic General Equilibrium Model with extended energy block was used to estimate the social and economic outcomes of Ukraine's energy decarbonization policies and measures implementation. Unification of the said two models was performed through application of the same assumptions with regard to economic growth rate, in particular, aggregated GDP growth rate.

#### **4.1. Energy de-carbonization policies and measures**

In the Catalogue policies and measures were grouped by function and sector, of which targeting de-carbonization are the following trends:

- 1 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;
- 2 Renewable energy** – includes policies and measures which aim to support and stimulate the renewable energy development in Ukraine;
- 3 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.);
- 4 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

ness measures; policy on education, science and technology development.

*For each of the above given group developed are the GHG reduction scenarios based on full implementation of respective policies and LEDS measures.*

#### **4.1.1. Energy efficiency**

Implementation of 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 will enable to cumulatively reduce GHG emissions over 2012-2050 by 3 677 million tons of CO<sub>2</sub>-equivalent compared to Baseline scenario. The growth pace in GHG emissions will show substantial reduction compared to Baseline scenario. According to «Energy efficiency scenario, » in 2050 the share of GHG emissions will amount to 53% of 1990 level (table 4.2).

*Table 4.2  
GHG emission projections in «Energy» and «Industrial processes»  
according to Baseline and Alternative scenario*

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
Baseline scenario	Million tons of CO <sub>2</sub> -equivalent	<b>367</b>	<b>265</b>	<b>347</b>	<b>408</b>	<b>455</b>	<b>500</b>	<b>540</b>	<b>570</b>	<b>592</b>
	% of 1990 level	<b>44</b>	<b>31</b>	<b>41</b>	<b>48</b>	<b>54</b>	<b>59</b>	<b>64</b>	<b>68</b>	<b>70</b>
Scenario «Energy efficiency»	Million tons of CO <sub>2</sub> -equivalent	<b>367</b>	<b>265</b>	<b>294</b>	<b>335</b>	<b>344</b>	<b>363</b>	<b>406</b>	<b>429</b>	<b>448</b>
	% of 1990 level	<b>44</b>	<b>31</b>	<b>35</b>	<b>40</b>	<b>41</b>	<b>43</b>	<b>48</b>	<b>51</b>	<b>53</b>

\* Data of the National Cadaster of anthropogenic emissions from sources and absorption of greenhouse gases absorbers in Ukraine over 1990-2015.



## LEDS policies and measures in energy efficiency

### 1 Raising energy efficiency in the buildings

No	Policy /measure	Description of policy /measure
1	Planning and implementation of thermal insulation of housing stock	To prepare and implement plans for thermal insulation of buildings with due account for climate and local specificities with proper compliance to energy efficiency requirements and thermal technological characteristics of envelope structures.
2	Promotion of energy efficiency in design and construction of residential and public buildings	To adopt and ensure compliance with stricter building standards in order to raise energy efficiency in doing new construction projects, modernization, thermal insulation of residential and public buildings.
3	Monitoring energy performance of residential and public buildings	To prepare energy passports including assessment of energy performance in order to measure how much fuel and energy resources was used on heating, cooling, ventilation, hot water supply and lightning in residential and public buildings
4	Creating enabling conditions for increase in the number of buildings with close to zero energy consumption	To set standard requirements to reaching close to zero energy consumption in construction of new and modernization and technical re-equipment of the already existing building
5	Introduction of National system for technical regulation of «green construction»	To set standard requirements to buildings and settlements design to meet the environmental criteria
6	To adopt "Government sets example approach "	Budget funded institutions, and public authorities of national, regional and local level must set an example in energy efficiency by their compliance with requirements on carbon neutrality and publicity about their energy consumption

## **2 Promotion of private and government funding on energy efficiency measures**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Expansion of public - private partnership in financing of energy efficiency measures	To create the prerequisites required to facilitate the use of innovation mechanisms in financing of measures aiming to improve energy performance of buildings (for example, credit guarantees to private capital, credit guarantees to stimulate energy efficiency agreements, transfers, subsidized loans and targeted credit lines, systems of multilateral funding), which reduce energy efficiency projects risks.
<b>2</b>	Support to ESCO mechanism and its use to raise energy efficiency	To create the prerequisites required to facilitate high scale mobilization of private investments for energy efficiency purposes, substantial reduction in energy expenses in public and communal sectors of Ukraine's economy, and also to mobilize private investments to increase energy efficiency at the state and communal facilities such as schools, universities and colleges hospitals etc., including establishment of legal grounds to develop energy service contracts mechanisms for budget funded institutions, comprising an option of entering into long-term sales contracts to budget funded institutions of heat energy produced from alternative energy sources.

## **3 Increase in energy efficiency in the use of electricity and heat energy and/or fuels in all sectors of economy**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Introduction of cogeneration installations at the new and already operational energy generation entities.	To establish conditions required for equipment of the new and already operational energy generating entities with highly efficient cogeneration installations in order to use the waste heat, resultant from electricity generation and supply it to consumers
<b>2</b>	Introduction of market mechanism enabling consumer access to energy suppliers	To establish competitive environment allowing consumers to freely choose suppliers of different types of energy or fuels in order to save energy resources and\or financial resources
<b>3</b>	Facilitation the increase in efficient use of natural gas at the heat generation sources in communal energy sector	To introduce incentives for communally owned enterprises to increase efficiency in their use of natural gas at the already existing and /or modernized boiler plants.

#### **4 Promotion of energy efficient technologies in agriculture**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Introduction of farming technologies which aim to reduce fossil fuel consumption	To stimulate modernization of the already existing and introduction of new modern equipment at agricultural enterprises, for example, to convert diesel using agricultural machinery to biofuel or hybrid technology; to introduce automatic operating width technology used by the farm machinery with the help of GPS
<b>2</b>	Promotion of increase in energy efficiency in agricultural produce and foods production process	To establish conditions enabling the implementation of energy efficient technologies for deep processing of agricultural produce in food and processing industry

#### **5 Promotion of energy efficient measures in production sector**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Increase in resource efficiency of production sector output	To stimulate the production sector enterprises to reduce their specific utilization of the raw and energy resources in the course of industrial output production
<b>2</b>	Lowering the share of carbon intense energy resources use by production sector	To stimulate the production sector enterprises to reduce their specific utilization of carbon intense energy resources

#### **4.1.2. Renewable energy**

Substantial intensification of renewable energy sources will make a significant contribution to energy efficiency measures, which aim to de-carbonize the energy sector. In particular, modeling results show, additional - in contrast to "Energy efficiency" scenario - reduction of GHG emissions by 2430 million tons of CO<sub>2</sub>-equivalent could be achieved cumulatively over the 2012-2050 period, compared to Baseline scenario. Thus, the share of GHG emissions will amount to 33% of the 1990 level, which will not significantly exceed the 2015 level (table 4.3).

Table 4.3

**Projections of GHG emissions in «Energy» and «Industrial processes» according to Baselines (Business as usual) and alternative scenario**

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
Baseline scenario	Million tons of CO <sub>2</sub> -equivalent	367	265	347	408	455	500	540	570	592
	% of 1990 level	44	31	41	48	54	59	64	68	70
Scenario «Energy efficiency and renewable energy»	Million tons of CO <sub>2</sub> -equivalent	367	265	282	315	312	291	299	288	278
	% of 1990 level	44	31	33	37	37	34	35	34	33

\* Data of the National Cadaster of anthropogenic emissions from sources and absorption of greenhouse gases absorbers in Ukraine over 1990-2015.



## LEDS policies and measures in renewable energy

### **1 Increase in generation and consumption of energy from renewable sources**

№	Policy /measure	Description of policy /measure
1	Introduction of standard for RES portfolio or ecological portfolio	RES standard will require electricity generating companies to supply a certain fixed percentage of electricity from renewable source (sources)
2	Overcoming the barriers on the way to renewable energy development	Existing institutional and market barriers include price distortions, market's inability to appreciate social good of renewable sources and social costs of fossil fuel technologies, insufficient information, institutional barriers when connecting to the grid, high operational costs for small projects, and high financing costs
3	Pre-investment preparation of industrial platforms for renewable energy facilities in the framework of PPP	The measure shall follow the following algorithm: government funded contracts are concluded on competitive basis with design bureaus for them to perform initial project preparations and platform search, pre-construction preparation of platforms, and infrastructure construction. After that, investment projects with the pre-set parameters are implemented. The investor refunds the money spent on initial project preparations.
4	Promotion the consumer purchase of environmentally clean energy	To introduce green certificates system in order to stimulate clean energy generation and supply
5	Promotion of generation and energy consumption from RES by entities of all forms of ownership (incorporation) in agriculture and forestry	It is envisioned to encourage introduction of practices and use of equipment contributing to reduction in GHG emissions in production of agricultural produce and foods owing to increased output and use of RES, including, installation of solar or wind energy devices; use of hydroelectricity generators for irrigation purposes, in particular; increased use by enterprises of biomass of their own production and biofuel; extending the energy audit programs
6	Joint combustion of biofuel and fossil fuel at the new and already operating power plants	It is envisioned to encourage joint combustion of biomass at the new and already operating power plants, using fossil fuel, in order to reduce the GHG emissions and use of fossil fuel in general.

**2 Sustainable production and expansion in the use of biomass (biofuel)**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Increase in sustainable production of biomass for energy supply purposes	To increase in the scope of biomass coming from agriculture and forestry (wood substance, wood wastes, wastes coming from agricultural crops and agricultural produce processing; energy crops) to be used in heat and electricity generation and as fossil fuels replacement.
<b>2</b>	Development and implementation of biomass conversion technologies	To increase the pace for development of new biomass conversion technologies as well as the market for such technologies in order to receive biofuel of the first and second generation
<b>3</b>	Expansion in the use of solid household wastes as biomass, and also biomass of park and garden waste for the purposes of heat and electricity generation	To increase the scope of biomass coming from solid household wastes and garden and park wastes, which is suitable for heat and electricity generation, first, to meet the needs of small towns and territorial communities.
<b>4</b>	Production of liquid and gaseous fuel from the raw materials coming from agriculture and forestry	To increase the output of bioethanol, biodiesel and/or other types of liquid or gaseous biofuel from the raw material coming from agriculture and forestry in order to replace fixed and mobile use of fossil fuel
<b>5</b>	Production of liquid and gaseous fuel from solid household wastes	To stimulate the use of SHW biomass for production of liquid or gaseous biofuel (gasification, pyrolysis) and its fixed and mobile use.



### **3 Biogas production and expansion of its use for heat and electricity production purposes**

<b>Nº</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Biogas production from animal origin by-products and other by-products coming from agro industrial complex	To promote the development of agricultural activities which aim to reduce the methane emissions from animal wastes by way of installation of reactor for manure fermentation, and also emissions from primary and secondary agricultural products
<b>2</b>	Generation of energy from biogas coming from SHW landfills	Stimulation the collection and use of landfill gas for the purposes of energy generation and incentivizing the use of anaerobic fermentation reactors to produce biogas from organic components of SHW
<b>3</b>	Generation of energy from biogas coming from waste water	Stimulation the installment of methane tanks and turbines at the already operating and new waste treatment facilities

### **4 Ukraine's international cooperation in renewable energy**

<b>Nº</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	European integration	Harmonization of legislative and regulatory acts of Ukraine with EU Legislation on promotion the use of energy generated from renewable energy sources
<b>2</b>	International cooperation	Facilitation of further development of Ukraine's cooperation with international (global, regional and national) institutions in the spheres directly or indirectly related to renewable energy development. Cooperation with International Renewable Energy Agency (IRENA) enabled Ukraine to get access to best global RES related practices.

#### **4.1.3. Transformation of market and institutions**

Transformation of market and institutions indirectly promote transition of Ukraine's economy to low carbon pathway. Policies and measures in this area include business measures, regulatory and management practices at the national and sectoral level, standards and codes, public outreach measures, development of education, science and production of proprietary technologies.

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*Table 4.4*

**Projections of GHG emissions in «Energy» and «Industrial processes» according to Baselines (Business as usual) and alternative scenario**

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
Baseline scenario	Million tons of CO <sub>2</sub> -equivalent	367	265	347	408	455	500	540	570	592
	% of 1990 level	44	31	41	48	54	59	64	68	70
Scenario «Energy efficiency and renewable energy, modernization and innovation»	Million tons of CO <sub>2</sub> -equivalent	367	265	265	361	244	242	274	284	285
	% of 1990 level	44	31	31	31	29	29	32	34	34

\* Data of National Cadaster of anthropogenic emissions from the sources and absorption by absorbents of GHG in Ukraine over 1990-2015



## LEDS policies and measures in modernization and innovation

### Increase in the power plants efficiency

No	Policy /measure	Description of policy /measure
1	Support to modernization of power plants already in operation	To ensure modernization of power plants already in operation to facilitate their full or partial transition to fuels with lower or zero GHG emissions level, introduction of incentives /removal of barriers
2	Increase in decommissioning pace of inefficient TPPs	To quicken decommissioning pace of inefficient energy blocks at TPP
3	Introduction of incentives, provision of support or establishment of requirements to fossil fuel based advanced technologies	To promote the development of new technologies, which will include enforcement and/or incentives for the use of advance technologies by TPP using non-renewable energy sources (coal to start with). Enforcement envisions to ensure that all or a certain part of coal using power plants would apply certain technology, such as IGCC <sup>1</sup> , CCSR <sup>2</sup> . Incentives would include direct subsidies and/or assistance with mobilizing of funding for new technologies implementation , and/or long term purchase agreements on TPP products or services

### 1 Nuclear energy development

No	Policy /measure	Description of policy /measure
1	Retention of an important role of the nuclear energy as a low carbon energy source.	To perform repeated licensing/improvement of characteristics/ enhancement in the efficiency of the already operational NPP under conditions of strict compliance with safety ratios, and also creation of effective mechanism for accumulation by nuclear plant operating organization (operator) of resources required to finance the works on nuclear blocks decommissioning. To stimulate development of new technologies, such as small module reactors, to facilitate optimum replacement of NPP capacities which will be decommissioned after 2030.

<sup>1</sup>IGCC (Integrated Gasification Combined Cycle or in Ukrainian Integrated combined gasification cycle (ICGC) – is a steam and gas plant with gasification of coal which is used to convert coal into syngas.

<sup>2</sup>CCSR – (Carbon Capture and Storage Ready) – technology for carbon catching, storage and recycling .

## **2 Modernization and intellectualization of electricity grids**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Modernization and intellectualization of electricity transmission system and distribution networks to reduce losses at electricity transmission lines	To stimulate and support implementation of programs which will aim to achieve higher efficiency in the transmission and distribution systems.

## **3 Modernization of transport industry**

<b>No</b>	<b>Policy /measure</b>
<b>1</b>	Promotion the use of transport vehicle which may use different types of motor fuels (for example, petrol and gas or use biofuel and bio component additives), electric, hydrogen cars, cars using fuel cells, as well as public electric transport development
<b>2</b>	Promotion or introduction of requirements to producers of transport vehicles using combustion engines to increase efficiency and environmental friendliness of traditional transport vehicles
<b>3</b>	Incentivizing Ukrainians to reduce the share of their use of outdated cars. To create advantages for old cars scrappage. For example, provision of rewards, introduction of car vouchers etc.
<b>4</b>	Increase the number of high-speed trains used to carry the same as before number of passenger by railways, it should be underscored, that due to optimized routes and less time required to reach destinations point the park of such trains will be smaller compared to conventional trains
<b>5</b>	More efficient planning of public transport network and routes, which among other things, include better logistics, minimized number of traffic jams in the cities etc.... Improvement of transport system management technologies, including smart system implementation.
<b>6</b>	Introduction of inter-mode load carrying transport technologies. Policy which aims to improve railway infrastructure and infrastructure of inland water ways to promote wider use of railways and water transport
<b>7</b>	Stimulation of modernization the water and river ports in order to incentivize implementation of more energy efficient technologies, and take energy saving measures throughout the entire technological chain

## **4 Development of highly efficient cogeneration at local and regional level**

<b>No</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Development of highly efficient cogeneration	Increase in general fuel usage efficiency and reduction in GHG emissions under combined generation of heat and electricity by TPP at local and regional level

## **5 Support to energy accumulation technologies implementation**

No	Policy /measure	Description of policy /measure
1	Support to energy accumulation technologies implementation	To support development and implementation of energy accumulation technologies by way of subsidies, tariff compensation and other financial incentives

## **6 Development of hydrogen production technologies**

No	Policy /measure	Description of policy /measure
1	Development of hydrogen production technologies	Provision of incentives on development and implementation of hydrogen production technologies and efficient technologies for storage of electricity in the form of hydrogen

### **4.1.4. Transformation of market and institutions**

Transformation of market and institutions indirectly promote transition of Ukraine's economy to low carbon pathway. Policies and measures in this area include business measures, regulatory and management practices at the national and sectoral level, standards and codes, public outreach measures, development of education, science and production of proprietary technologies.

Implementation of these policies and measures will enable additional reduction in GHG emissions by 267 million tons of CO<sub>2</sub>-equivalent. On the whole, compared to Baseline scenario, the scope of GHG emissions reduction will amount to 7438 million tons of CO<sub>2</sub>-equivalent (cumulatively for 2012-2050 period), which will enable to stabilize GHG emissions at the 2015 level or at 31% of the 1990 level (table 4.5).

*Table 4.5*

**Projections of GHG emissions for «Energy » and «Industrial processes» in accordance to Baseline and Alternative Scenario**

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
Baseline scenario	Million tons of CO <sub>2</sub> -equivalent	367	265	347	408	455	500	540	570	592
	% of 1990 level	44	31	41	48	54	59	64	68	70
Scenario «Energy efficiency and renewable energy, modernization and innovation, Market transformation and institutions»	Million tons of CO <sub>2</sub> -equivalent	367	265	265	359	242	236	264	265	261
	% of 1990 level	44	31	31	31	29	28	31	31	31

\* Data of National Cadaster of anthropogenic emissions from the sources and absorption by absorbents of GHG in Ukraine over 1990-2015

## LEDS policies and measures in modernization and innovation

### **1 Implementation of market mechanisms allowing for reduction in GHG emissions**

No	Policy /measure	Description of policy /measure
1	Implementation of emission trading system	Policy on implementation of market mechanism allowing for reduction in GHG emissions at its first stage envisions to implement the system for monitoring, reporting and verification of GHG emissions at installation level, and to establish emission trading system at the second stage
2	Improvement of GHG emissions taxation system and targeted use of the revenues obtained	To develop and implement the new fiscal instruments applied to GHG emissions reduction, and to update taxation system for carbon emissions or fossil fuel energy consumption

### **2 Supporting research and development and project design works**

No	Policy /measure	Description of policy /measure
1	Support to research and development, R&D products, demonstration projects and promotion of advance technologies implementation	To create prerequisites required for implementation of advanced technologies in fossil fuel use, including, integrated gasification in combined cycle (IGCC), carbon capture, storage and recycling (CCSR); advance technology on coal dust, technology of circulating fluidized bed (CFB)
2	Support and expansion of innovative research and development and project design works	To increase funding on R&D and project design works which aim to: develop the next generation technologies and to support the "green" energy companies; prepare and implement the measures, which contribute to increased absorption and uptake of carbon by terrestrial absorbents in forestry and agriculture

**3 Promotion of more active use of communities in the LEDS related policies and measures**

No	Policy /measure
1	Establish conditions required for development and passage by local executive authorities and local self-governance bodies of comprehensive and sustainable action plans on energy efficiency including clear cut goals, engagement of citizens into the process of such plans development and implementation, and providing proper information to general public about the contents of such plans and their expected results

**4 Disclosure of information on GHG emissions and GHG absorption at enterprise level**

No	Policy /measure	Description of policy /measure
1	Public reporting on GHG emissions and absorption thereof at enterprise level	Regular publication of information from emission sources and absorption thereof

**5 Application of energy efficiency criteria in the public procurement process**

No	Policy /measure	Description of policy /measure
1	Application of energy efficiency criteria in the public procurement process	Establishment of conditions allowing for procurement by government authorities of goods and services with high level of energy efficiency and due account for cost efficiency, economic feasibility, technical specification and competition compliance

**6 Training and skill upgrade for professionals**

No	Policy /measure	Description of policy /measure
1	Educational and skill training for energy management professional	Development the training and skill upgrade system for energy management system professionals through government certification program, industry associations and educational institutions
2	Provision of education and skill training for customers, designers and contractors who implement modern technologies in energy efficiency, RES and alternative fuels	Establishment of preconditions as to provision of the appropriate number of designers, and construction specialists with the level of skill allowing them to install and integrate required technologies in the sphere of energy efficiency and renewable energy sources.

**7 Extension of awareness raising program on climate change outcomes, climate change prevention and adaptation thereto**

No	Policy /measure
1	To carry out awareness raising campaign to promote broad understanding by Ukrainian citizens of climate change problem, climate change prevention actions and adaptation thereto (including such co benefits as clean air and citizens health).



### **8 Improvement of requirements to eco design labelling of energy related products**

No	Policy /measure	Description of policy /measure
1	Implementation of Eco design for products	To give priority to products with the highest energy saving potential. Eco design establishes minimum requirements, while energy labelling informs buyers on energy and environmental characteristics

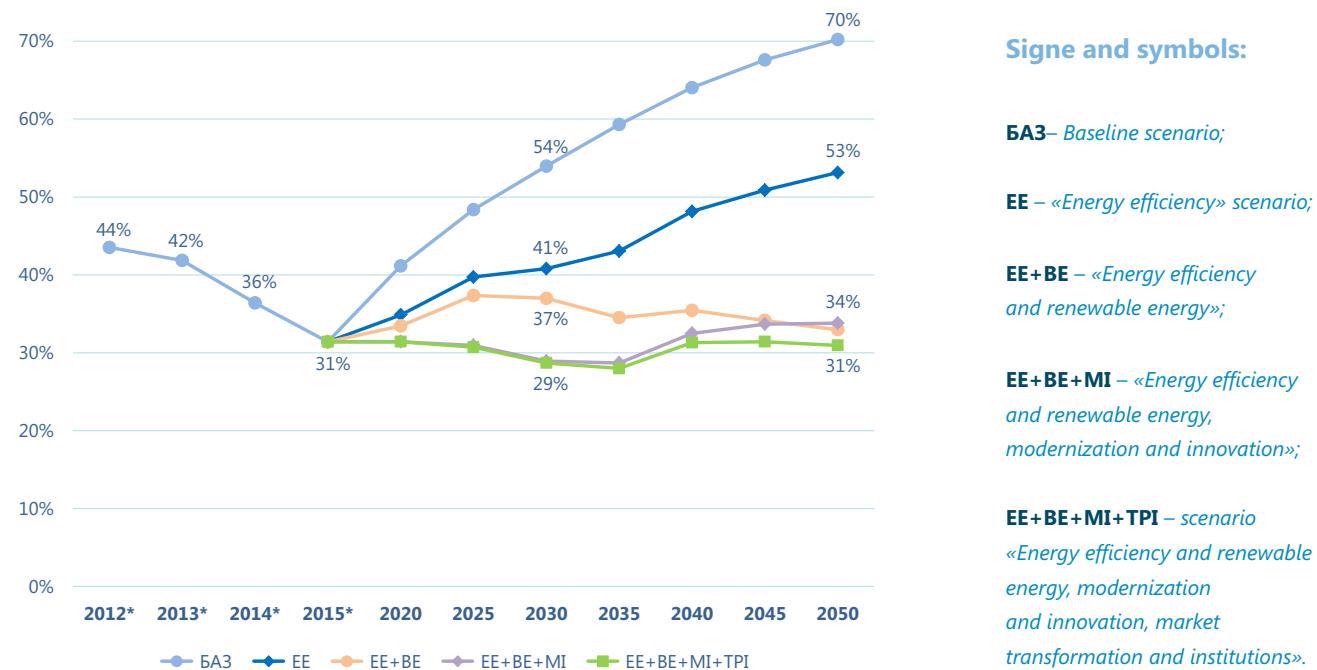
### **9 Improvement the organization of labor relations to encourage, where possible, the use of remote work.**

No	Policy /measure	Description of policy /measure
1	Improvement the organization of labor relations	To create conditions favorable to improvement the organization of labor relations at the national and local level in order to reduce the need for employees travel by transport vehicles

Figure 4.4 shows projected dynamics in GHG emissions for «Energy» and «Industrial processes» in comparison to 1990 (1990=100%) in accordance to Baseline and Alternative scenarios

*Figure 4.4.*

**Share of GHG emissions in «Energy » and «Industrial processes» compared to 1990**



\* Data of National Cadaster of anthropogenic emissions from the sources and absorption by absorbents of GHG in Ukraine over 1990-2015

## 4.2. Model assessment of social and economic outcomes

Assessments of economic outcomes of low carbon policies and measures show that their implementation is characterized with generally positive macroeconomic effects (Figure 4.5). Boosted investment processes is the main factor that triggers quality changes, which in turn, result in the raised efficiency in production owing to lower specific consumption of energy resources. Increased efficiency in technology and production processes contribute to additional cumulative growth in the goods and services output (6%) and GDP (13%) by 2050.

Enhanced productivity and increased output have positive affect on real income of households. It is expected that by 2035 additional increase in household consumption can amount to 8%, and will reach 13% by 2050.

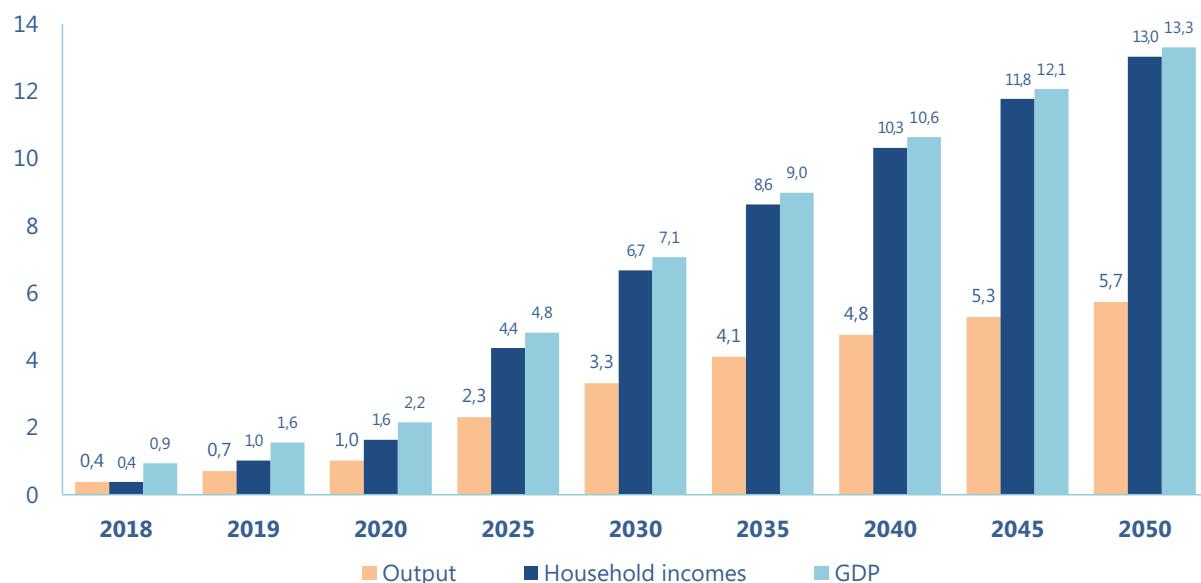


Figure 4.5. Macroeconomic assessments of energy de-carbonization (percentage of Baseline scenario)



At the industry level, the start of low carbon development policies and measures implementation will bring about moderate structural shifts, which will be manifested in the increased share of services, and, construction - as the main suppliers of investment products - and also in the shares of some processing industries, notably, chemical and metal industry (Figure 4.6.) Slowdown in goods, and services output growth rate should characterize the industries related to fossil fuels extraction and processing.

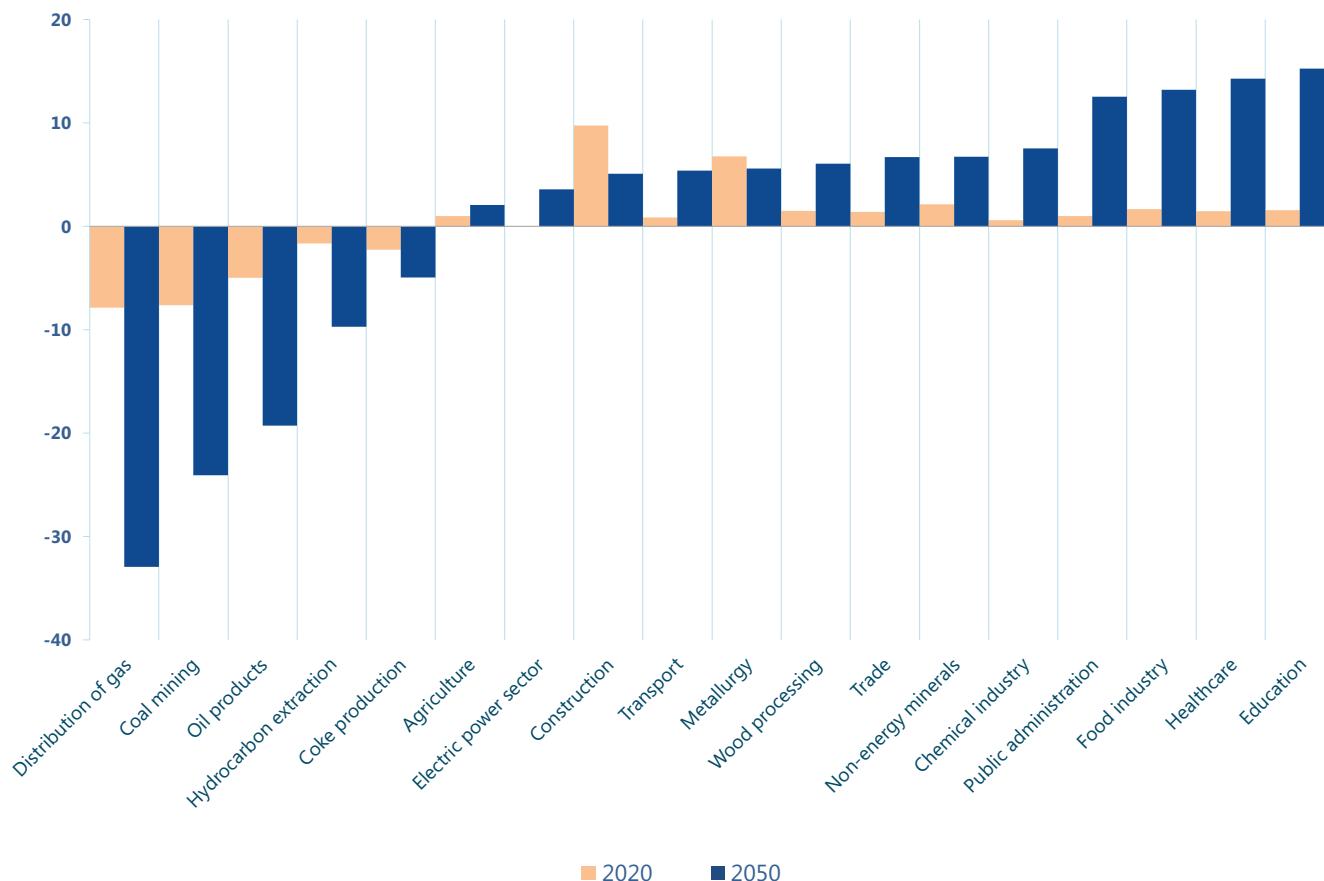


Figure 4.6. **Changes in the goods and services output by the industry (percentage baseline scenario)**

Overall, de-carbonization of Ukraine's energy sector will result in positive social and economic outcomes. Specifically, it is expected that GDP and real income of household will show additional growth. Under increase in total goods and services output, the share of economic activities with high gross value added will be growing at the industry level. Reduced scope of fossil fuels consumption will contribute to increased level of national energy security and lowered import dependency.

In 2050, given the policies and measures of Ukraine's energy sector de-carbonization are implemented, GHG emissions in «Energy» and «Industrial processes» will be expected to stay within 31-34% of 1990 level or 260-285 million tons of CO<sub>2</sub>-equivalent.

# REDUCING NON CO<sub>2</sub> EMISSIONS

5





**In 2015 methane emissions in Ukraine amounted to 62.7 million tons of CO2-equivalent, which is by 67.1% lower than in 1990. The largest sources of CH4 (61%) emissions are coal mines, as well as the processes of oil and natural gas extraction, transportation, storage and consumption. In agriculture emissions amount to 21%, in wastes treatment sector to 18%.**

**Nitrogen oxide emissions in 2015 totaled at 37.21 million tons of CO2-equivalent, which is by 43.3% lower compared to 1990. Producing over 85% nitrogen oxide emission agriculture is a prevailing source of such emissions in Ukraine.**

## 5.1. Reducing leaks in the fossil fuel extraction, processing, transportation and storage

### 1 Reducing leaks in gas sector

No	Policy /measure	Description of policy /measure
1	Reduction of leaks in gas extraction with the help of new methane capture technologies	To implement new methane capture technologies at different technological stages of extraction process can reduce methane emissions by 2.5%
2	Reduction of leaks in natural gas transportation process through modernization of Ukraine's gas pipelines system	To introduce innovations and technologies to reduce technical and process design related losses at Ukraine's gas pipeline system, and, in consequence, to that, to reduce GHG emissions in the process of natural gas transportation in the main and distribution gas pipelines.

### 2 Reducing leaks in oil extraction transportation and processing

No	Policy /measure	Description of policy /measure
1	Reducing leaks in oil extraction transportation and processing	To prevent oil evaporation losses in oil and oil products production, storage and transportation, and also at oil refineries through implementation of respective innovations and technologies

### 3 Removal, usage and recycling the coalmine methane from underground coal mines

No	Policy /measure	Description of policy /measure
1	Removal, usage and recycling the coalmine methane from underground coal mines	To promote geology study, extraction and use of coal fields methane, degassation and recycling of methane, in particular, installation of cogeneration plants



***Ukraine's oil processing industry is characterized by exacerbated manifestation of crises in the market due to reduced production of oil, decrease in import of essential raw materials and low depth of raw materials processing (only at the level 55%) due to outdated equipment and substantial worn out of production facilities. Ukraine needs to update its technological support in oil refineries to 93% level of oil processing.***

## **5.2. Improvement of waste treatment**

In this sphere, the policy aims to create preconditions, which will enable to increase the share of SHW utilization, to maximize their re-introduction in economy as secondary resources. Through waste generation reduction programs, this policy will facilitate reduction in the scope of waste from residential, commercial and administrative sectors. Decreasing generation of waste immediately at the source of its original generation helps to reduce the GHG emissions from both waste burial, and from upstream production processes along manufacturing chain. In addition, GHG emissions associated with SHW transportation will be reduced.

### **1 Reducing the scope of waste and prevention of waste generation**

<b>Nº</b>	<b>Policy /measure</b>
<b>1</b>	Drafting regulations introducing extended responsibility of producers of goods with expiration date (packaging, medicine, electric home appliances, tires, cars, etc.)
<b>2</b>	Development and implementation by local executive authorities and local self-governance bodies of solid household wastes treatment
<b>3</b>	Implementation of financial and economic mechanism to develop the SHW treatment infrastructure and services, namely, VAT exemption, and customs duties privileges enabling to bring into Ukraine the sort of equipment, which is not produced in Ukraine.

### **2 Social advertising campaigns which aim to reduce SHW generation**

### **3 Improvement the SHW treatment methods, promotion of recycling and utilization**

#### **4 Improvement of waste water treatment**

<b>Nº</b>	<b>Policy /measure</b>	<b>Description of policy /measure</b>
<b>1</b>	Reduction in waste water generation	To introduce new water consumption and waste water reduction technologies, carry out public awareness campaign to reduce water consumption
<b>2</b>	Improvement of waste water and waste water sludge treatment	To apply new technologies and management methods to improve waste water and sludge treatment
	Expansion of district waste water treatment capacities to enable them to provide services to the areas which are not yet covered with such services	To establish prerequisites required to expand district wastewater treatment infrastructure (pipeline system, pumping stations, and purification facilities) to the areas, which currently are not yet covered by such systems.
	Spreading out or expansion the regenerated water usage	To establish prerequisites required to expand district waste water treatment infrastructure (pipeline system, pumping stations, purification facilities) up to "regenerated water" safety level and delivery, in order to use such water for watering of lawns, sport fields, and agricultural lands or to meet other not drinking water needs.

#### **5.3. Agriculture**

*Methane and nitrogen oxide are main GHG emissions produced by Ukraine's agriculture. Their sources include digestive fermentation by grazing animals - CH4; cleaning, collection and usage of manure - CH4 and N2O, agriculture used land – N2O , which comes from application of nitrogen containing fertilizer (nitrogen fertilizer, manure, plant residues).*

Energy efficiency and renewable energy policies and measures for agriculture are presented in Section 4.1



## LEDS policies and measures in agriculture

### **1 Improvement of animal origin co-products treatment process components**

No	Policy /measure	Description of policy /measure
1	Drafting nationally acceptable recommendations on animal feeding practice improvement	To draft and implement recommendations on energy value increase in feeding staff which will result in smaller amount of feed staff conversion into methane. Usage of specific natural or synthetic additives will also contribute to higher digestibility of feeding staff and will inhibit methane output
2	Promotion the implementation by agricultural enterprises of all ownership (incorporation) forms of the improved technologies for manure disposal, storage and use	Incentives will be provided mostly to small and mid-size agribusinesses for them to introduce advanced manure treatment technologies such as fermentation, avoidance of contact with air in storage process, blending to reduce the loss of nutrition substances, application of advanced methods of field manuring which preclude manure dusting or spreading on the surface, and, hence, reduce N2O emissions)

### **2 Optimization the system of agricultural crops fertilization**

No	Policy /measure	Description of policy /measure
1	Enhancement efficiency in the use of fertilizers	To implement scientifically justified technologies in application of fertilizers and other chemical substances, which will help to reduce N2O emissions, because nitrogen surplus that was fixated by plants may either go to subterranean waters and/or emitted into air.
2	Rational water use in agricultural lands	Incentivizing more efficient use of water by implementing best practices in prevention of washing out of nitrogen from the surface and subsequent N2O emissions into air.



# CARBON SINK BY LAND USE LAND USE CHANGE AND FORESTRY SECTOR

6



## 6.1. Land use and forestry sector and its contribution to GHG balance

Ukraine occupies the territory of 60354.9 thousand hectares or 0.4% of the Earth surface, of which the land amounts to 57928.5 thousand hectares. Ukraine owns 8.7% of the world stock of black soil, 2.3% of cropland (8th in the world) and 2.2% of basal area under cereal crops. Agricultural use lands take almost 70% of Ukraine's territory, forests and other lands, covered in woods and bushes vegetation - 17.6%, and settlement land constitute 4.2%. Fig. 6.1 shows the structure of Ukraine's land resources.

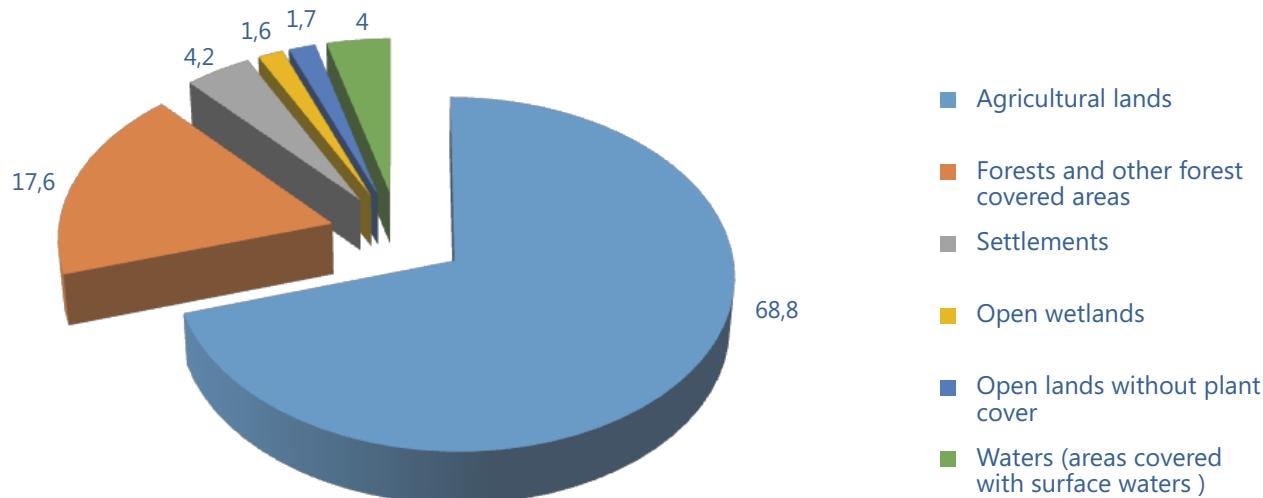


Fig. 6.1 structure of Ukraine's land resources (percentage) in 2015  
(according to the data of Geocadastre of Ukraine)

Forests is the main sink of GHG emissions in LULUCF sector. According to the State register of Ukraine's forests, the total territory of forest resource is 10.8 million hectares including reclamative afforestation. Prevailing in Ukraine is the State form of forest ownership; about 87% of forests are managed by State entities and organizations. The sector's specific feature includes imbalanced land usage structure, excessive ploughness of territory, and low level of forest cover of the territory (average forest cover in Ukraine amounts to 15.9%, while that in European countries is 37%).

LULUCF sector contribution to total emission/absorption balance is positive. According to National Cadaster of anthropogenic emissions from sources and absorption of greenhouse gases absorbers over 2015 in Ukraine the sector absorbed about 5% of the total GHG emissions. In absolute terms, for the period 2010 - 2015 the level of absorption in the sector stayed within the range of 13-30 million t CO<sub>2</sub> equivalent per annum.

Forestlands are net GHG absorbers - on average for the period 2010-2015 the scope of GHG absorption by forests amounted to 65.5 million t of CO<sub>2</sub> equivalent per annum. GHG emissions in the sector were mostly coming from croplands, pastures, wetlands, settlements and other lands. The scope of GHG emissions from croplands on average totaled at 38.8 million t CO<sub>2</sub> equivalent per annum (Fig. 6.2).

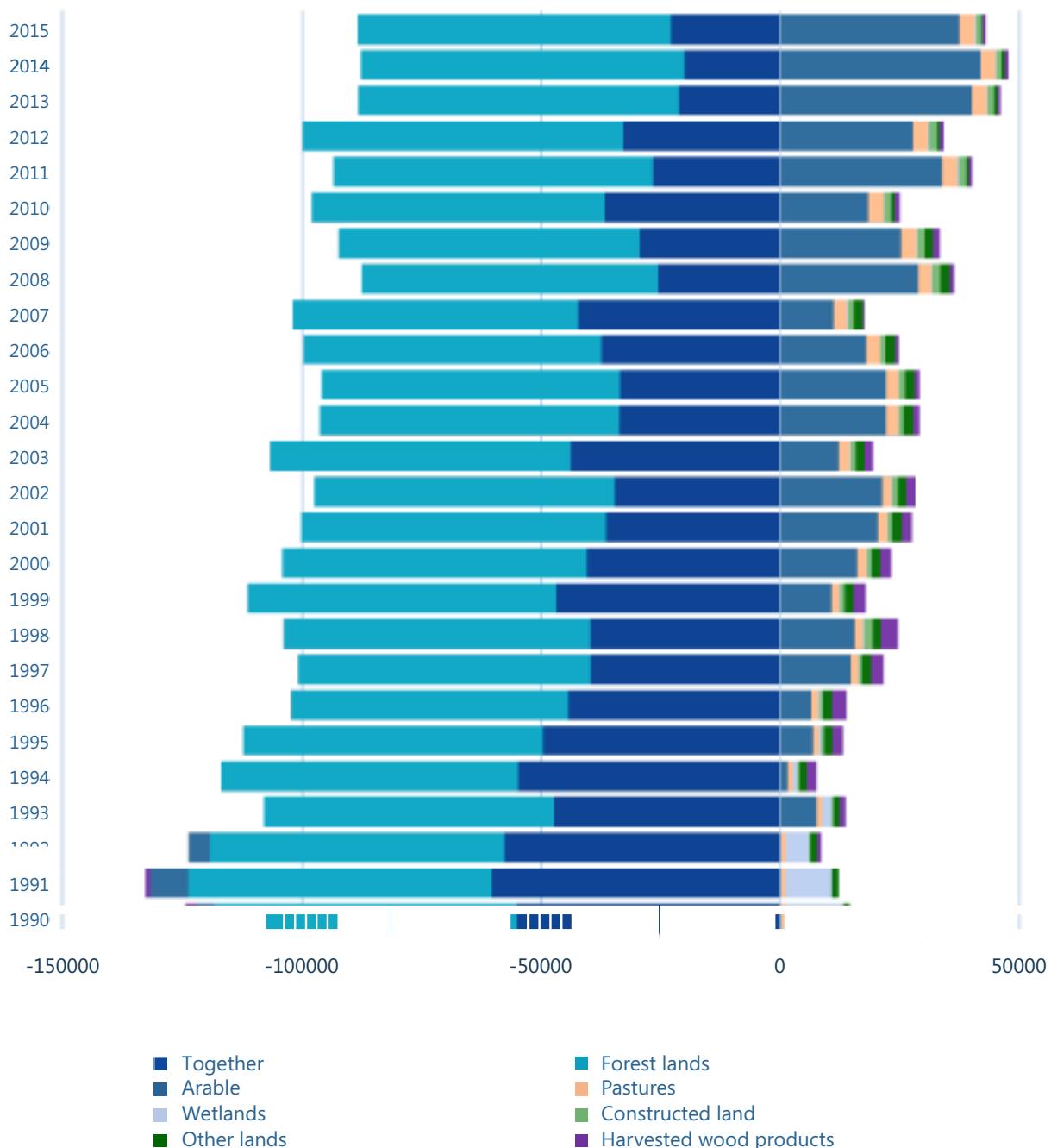


Fig. 6.2. Dynamics in CO<sub>2</sub> emissions and absorption (million tons) in LULUCF sector over 1990-2015 (source: NIR-2017)

\* 1990-2015 data of the National Cadaster of anthropogenic emissions from sources and absorption of greenhouse gases absorbers

## **6.2 Low carbon policies and measures in land development and forestry**

Forest cultivation, sustainable forestry and reduction in the loss of forest cover are the most appropriate activities to increase GHG emissions absorption in LULUCF sector. Of agricultural practices, the optimum include non-exhaustive farming, cattle grazing and organic soil restoration. Ukraine's specific feature include imbalanced land usage structure, excessive ploughness of territory, and also low level of forest cover of the territory (average forest cover in Ukraine amounts to 15.9%, while that in European countries is 37%).

Within the territories of cities and other inhabited localities, the total area of green planting of all types as of 01.01.2015 amounted to 652,1 thousand hectares.

Ukraine belongs to the group of countries with the highest share of agricultural lands in its total area of – 70.8% as of 01.01.2015, including agricultural arable lands – 68.8%, pastures and hay fields – 13.0%.

### **LEDS policies and measures in LULUCF sector**

#### ***1 Optimizing the land use structure, increase in the forest area, wood lines and green plants, enhancement of interagency coordination***

*Policies and measures aim to:*

- reduce cropland in the land use structure;
- increase the area of lands covered with forest vegetation, to create new forests (afforestation) and to timely restore the forests (reforestation);
- Rationally place forests and declarative afforestation, which constitute ecological carcass in the landscape, and restore field protection strips and other types of declarative afforestation;
- to take stock of green vegetation in the inhabited localities, assess their status and carbon sequestration;
- to green the inhabited localities, which implies to incentivize measures of support and improvement the status of trees and plants in residential areas of inhabited localities, to increase plants density in urban environment via creating of public and curtilage gardens, green roofs, and to plant different types of vegetation to enable sequestration and uptake of accumulated carbon;
- to enhance interagency coordination, in particular, among forestry, agriculture etc.

#### ***2 Improvement the practices of economic activities in LULUCF sector based on climate friendly methods of farming and forest management - Climate Smart Agriculture, Climate Smart Forestry***

*Policy and measures aim to:*

- implement and support best practices of farming and forest management, which take due account of climate change and aim to prevent carbon take out from soils in agrocoenosis, increase the level of forest productivity and resilience, to preserve and accumulate carbon in forest phytomass and soil;
- to improve conservation and protection of forests and conservation areas, green vegetation in the inhabited localities, conservation of field protection forest strips and other reclamative afforestation to store the accumulated (sequestered) carbon;
- to introduce economic incentives of land user (owner) to rationally use and protect agricultural lands;
- to combat degradation of agricultural lands and desertization, including via conservation of low productive and technologically polluted lands;
- to improve methods of agro technical regulation of carbon content in soil, which means promotion implementation of innovative agri-technologies, geared towards preservation and improvement of fertility, non-alkalic cultivation and rotation of crops; to lower mechanical impact on the soil;
- to support measures which aim to transform low productive agricultural lands into lands with permanent plantation cover, such as meadow/pasture, garden or forest where the carbon content in the soil and/or biomass will increase;
- to reduce the rate of agricultural lands transformation into build-up lands, as this will help to uptake carbon in the soil of such land and also keep their carbon sequestration potential.

### ***3 Development and implementation of national forestry development program with the engagement of the best international experience***

National Forestry development program will include the following components: policy and strategy (set of the national and regional forest policy, goals and ways to achieve them, assignment of responsibilities, connectivity with other sector policies in the sphere of land use and climate change); legislation (laws which will enable policy implementation, regulatory framework); institutions (organizations for decision making preparation and implementation – forest administrations, civic organizations, professional association and NGO, R&D institutions, educational institutions and media); information, communication and research (stock taking and monitoring of forests, forest information system, collection, exchange and dissemination of information on forests, including information on climate change and vulnerability; research of biophysical, social and political aspects related to forest problems and climate change; reports to national and international organizations; communication and awareness raising work for interested groups and general public); competence (knowledge and experience, which make it possible to efficiently respond to climate change produced challenges in forestry and ability to

efficiently resolve the tasks related to planning, management and economic activities); financial mechanisms (mechanisms which are used to finance forestry, mechanisms for attraction, management and allocation of financial resources; and control mechanisms).

#### **4 *Promotion of replacement of energy intense products made of metal, concrete, plastic etc. With products made of wood grown under sustainable (balanced) forestry.***

Implementation of such policy promotes the use of wood in which the absorbed carbon is conserved for such wood usage period. In addition to that, the policy will also contribute to reduction of GHG emissions in other sectors in consequence to energy intense products being replaced with products made of metal, concrete, plastic with wooden products.

To efficiently implement forestry potential as regards low carbon development applied shall forestry methods which factor in the climate change in accordance to Climate Smart Forestry.

Key elements to this concept of forestry include the following:

- application of «triune» approach - absorption (sink), sequestration (deposing) and replacement;
- establishment of new political incentives;
- due account of regional (local) specific features of forests in the process of climate prevention measures implementation and adaptation thereto;
- interaction in solving the climate change problems and other challenges (such as development of bio economics, food safety, rural areas, recreation, tourism, biodiversity );
- synergy in climate change prevention and adaptation thereto.

#### **6.3 Projections of GHG emissions absorption dynamics under different scenarios of Ukraine's forestry sector development**

Projections of GHG emissions absorption dynamics under different scenario of Ukraine's forestry sector development are based on the outcomes of international project SCEFORMA «Scenario analysis of forestry management in Czech Republic, Hungary, Poland and Ukraine».

Analysis of Ukraine's forestry sector development scenarios was performed with the help of the model of European Forest Institute EFISCEN based on processing information for each forest plot, which is included in the database of the State Forest Agency of Ukraine «Forest Fund of Ukraine». General modelling scheme included assessments of the following:

- Natural growth in forest stand;

- Natural growth in forest stand;
- Scope of wood substance, harvested in course of cutting (main use, care felling and forest sanitation felling);
- Losses of wood substance due to adverse factors such (fires, pests, diseases etc...);
- Forest regeneration (forest restoration and afforestation);

The scope of GHG absorption in the forests is projected based on two main scenarios of Ukraine's midcentury forestry development - «business as usual, » scenario developed on the basis of expert modification of previous and modern trends in economic and social development, and «forward looking scenario,» which envisions achievement of forestry and natures protection activities targets in accordance to government strategies defined priorities and programs. The third, additional scenario, made it possible to estimate the scope of GHG absorption in the process of forest cultivation (afforestation) in the area of million 1.4 hectare, which, given the "forward looking" scenario implementation shall by 2050 ensure increase in Ukraine's forest cover up to 19.4% and approximate it to optimum level. The State Forest Service of Ukraine set up the above presented scope of forest cultivation and forest cover targets in the course of drafting «Ukraine forests 2010-2015 State program. »

«Forward looking scenario, » envisioned support to protection, environment protection and recreations functions of forests, introduction of improved forest management regime (implementation of close to nature forestry, changes in the ages of final felling operations, roll out of target forest calculation etc...). According to «forward looking» scenario, the forest areas intended for nature protection, recreation and safeguard purposes is increased, yet they are not fully excluded from wood usage. Final felling operations (or forest restoration fellings) shall be restricted by higher felling age, conservation methods and technologies and reduced cutting areas. It should be underscored, that the felling areas increase gradually. Such a strategy is justified given additional benefits provided by protection, recreational and environmental functions of forests. If «forward looking» scenario is implemented, because of forest cultivation (afforestation) it is expected that the area of forest covered lands will gradually increase from 15.9% to 17%.

Dynamics in the GHG absorption scope in Ukrainian forests was calculated in accordance to above-mentioned scenarios. Calculations includes determination of carbon sequestration in forest phytomass, dead wood substance forest litter vegetation (without including carbon in forest soil, as it is assumed that under unchanged land use, the lands which are permanently covered with forest vegetation retain stable stock of carbon.)

According to «business as usual» scenario, by 2050 a gradual decrease in phytomass growth in the forests is expected mostly due to the age change in forest structure, which will bring about a gradual decrease in the GHG absorption level. It is expected that by 2050 the annual GHG absorption level will decrease by 26% compared to 2012, and will amount to about 44.4 million t CO<sub>2</sub> per year (Table 6.1).

Table 6.1

***GHG absorption projections in Ukrainian forests according to «business as usual» scenario***

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
«Business as usual» scenario	Million tons of CO <sub>2</sub> -equivalent	60	56,4	55,3	52,8	50,3	48,8	47,4	45,9	44,4
	% of 1990 level	95	89	87	83	79	77	78	72	70

Implementation of «forward looking» scenario will contribute to improvement in the forest age structure on account of new forests creation and optimization of forestry system (differentiation of felling ages, reduction in the area of clear felling operations and increase in the area of selective and gradual felling in final felling, improvement in forests security and protection from pests, diseases and fires). According to «forward looking» scenario forest cultivation will be performed at the area covering around 690 thousand hectare, which will enable to increase Ukraine's forest cover up to 17%, as per the Law of Ukraine dated 21 December 2010, № 2818-VI «On Foundations (Strategy) of the State Environmental Policy of Ukraine for the Period through 2020.»

Implementation of «forward looking» scenario will enable to gradually by 2030 adjust forest age structure even though it may take about 50 more years to reach the optimum age structure. According to this scenario biomass growth, as is the case of «business as usual» scenario, will also decrease due to objective reasons related to dynamics in the age structure of forests, yet the decrease will not be substantial. Decreased growth in phytomass will result in reduced annual GHG absorption levels in forest phytomass by 16% compared to 2012. In 2050, CO<sub>2</sub> absorption is projected to reach 50.4 million t per annum (Table 6.2).

Table 6.2

***GHG absorption projections in Ukrainian forests according to «business as usual» scenario***

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
«Forward looking» scenario	Million tons of CO <sub>2</sub> -equivalent	60,0	57,6	56,4	54,6	52,8	52,2	51,6	51,0	50,4
	% of 1990 level	95	91	89	86	83	82	81	80	79



*Additional estimates for GHG absorption level were made under the following assumptions:*

- Achievement of 19.4% of forest cover in Ukraine;
- Implementation of «forward looking» scenario (forest cultivation at the area of 690 thousand hectare) with parallel afforestation in the area of 1.45 million hectares, as per Forest Cultivation Strategy in Ukraine, drafted in 2015 as a part to FAO Project «Consolidation of Ukraine's Forest Policy.»

Additional forest cultivation will enable to increase GHG absorption level by 3.5 million t of CO<sub>2</sub>-equivalent, and further on the absorption level at forest cultivation lands will increase owing to phytomass growth in the newly created forests. Given that «forward looking scenario with optimum forest cover, » is implemented, the scope of GHG absorption will stabilize after 2035 at the level of 85% of 1990 (Table 6.3).

*Table 6.3*

***GHG absorption projections in Ukrainian forests according to «forward looking» scenario with approximation to optimum forest cover scenario in forest cultivation (afforestation) in Ukraine***

Scenario	Unit	2012*	2015*	2020	2025	2030	2035	2040	2045	2050
«Forward looking» scenario with optimum forest cover	Million tons of CO <sub>2</sub> -equivalent	60	57,6	57,0	55,6	54,3	54,1	54,1	54,0	53,9
	% of 1990 level	95	91	90	88	86	85	85	85	85

Given proper implementation of other policies and measures in LULUCF sector, with quantitative assessment of their impacts on GHG emissions dynamics being complicated due to uncertainty of input parameters, GHG emissions absorption balance will correspond 1990 level.



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