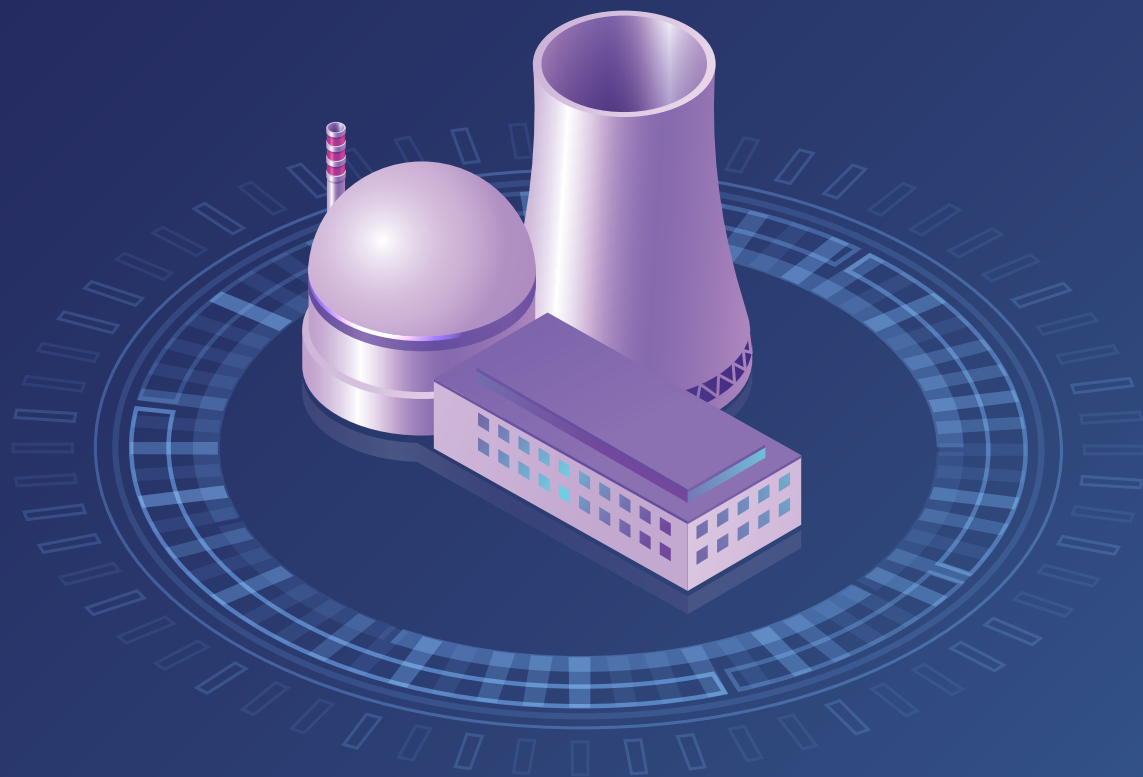
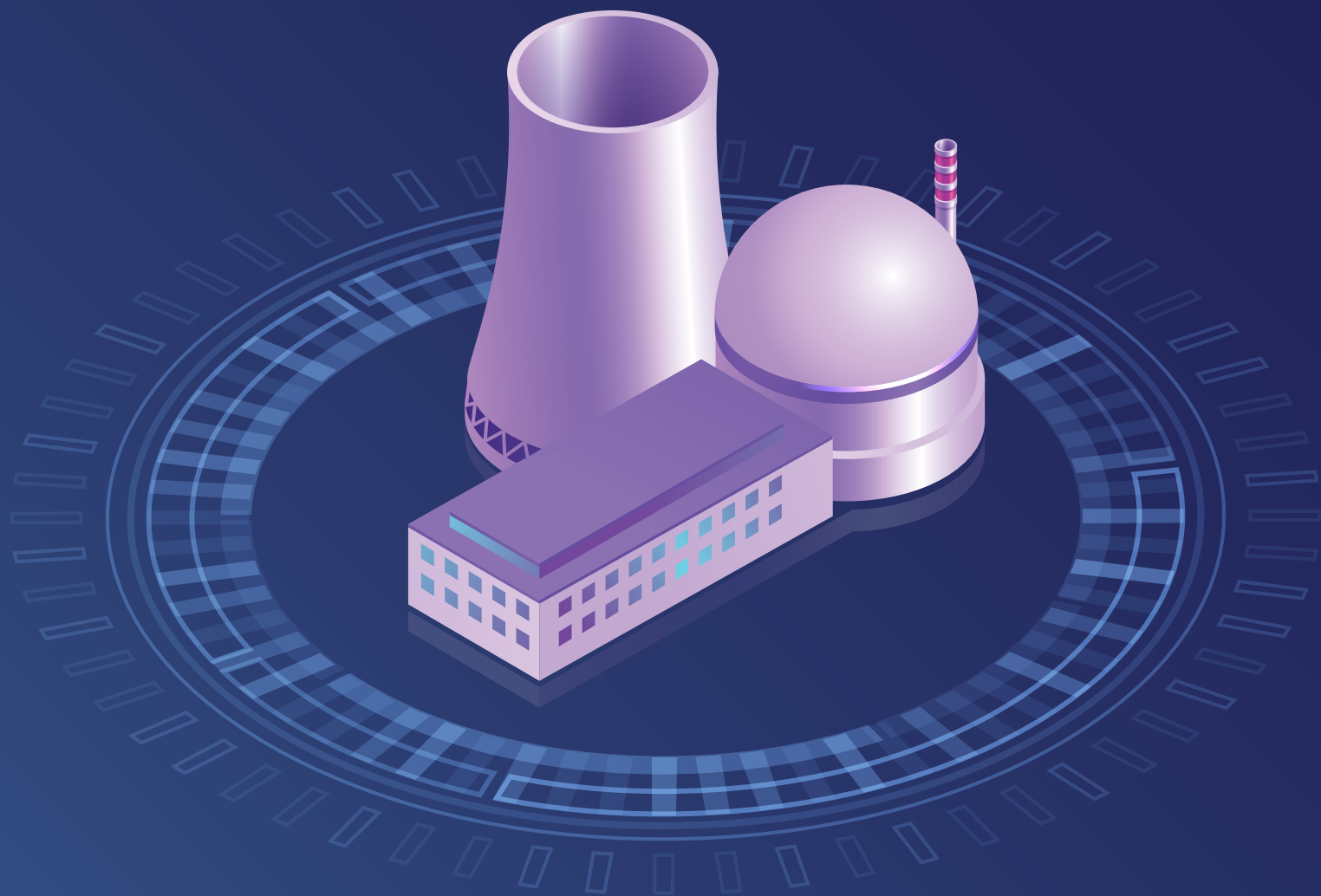


ANALYTICAL REPORT

2020

# IMPACT OF NUCLEAR INDUSTRY ON THE DEVELOPMENT OF UKRAINE





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# INTRODUCTION

Ukrainian Nuclear Society, one of the largest entities in the Ukrainian nuclear industry, has conducted a study on the impact of the nuclear power complex on the development of Ukraine. The purpose of the study was to perform a comprehensive assessment of the activities of the companies involved in the Ukrainian nuclear industry and their overall impact on economic development, social area and the environment of our country. The first report was prepared jointly with Ukrainian Nuclear Forum Association and presented in 2019. The methodology for the research was developed by UNF Association with the support of UkrNS.

In January 2020, the Ministry of Energy and Environmental Protection of Ukraine presented the Concept of «Green» Energy Transition of Ukraine until 2050, which should become the basis for

development a new energy strategy of Ukraine. The primary goal is to decrease the amount of greenhouse gas (GG) emissions so as to ensure the transition to a climate neutral economy of Ukraine in 2070 in a socially acceptable way.

To achieve this goal in the power generation sector it is proposed to decommission all coal-fired power plants by 2050, increase the share of renewables up to 70%, and decrease the nuclear share, the largest source of low-carbon cheap energy in Ukraine, down to 20% to 25%. It should be noted that the current amount of greenhouse gases emitted in Ukraine is lower than that specified under the Paris Agreement. This is primarily due to a large share of nuclear generation that does not release harmful emissions into the atmosphere (for further details see Chapter 5 Environmental Indicators of Nuclear Industry).

Keeping the current share of nuclear generation combined with a gradual deployment of renewable energy sources is the most optimal and balanced solution. It will facilitate the fastest transition to a low-carbon economy, which will help not only to mitigate climate changes but also to achieve other sustainable development goals, providing access for all consumers to affordable, reliable, sustainable and modern energy sources, decent work, jobs and economic growth, innovations and infrastructure development, sustainable development of cities and communities.

In fact, nuclear power and nuclear power complex are the most important components of economic, energy and environmental security of our country. During the last 5 years the share of nuclear

generation exceeded 50% in the country's energy mix and achieved even 65% in certain periods. In 2019, National Nuclear Energy Generating Company (NNEGC) «Energoatom» generated 83 billion kWh of electricity that was more than half of its total consumption in Ukraine. Secure performance of the nuclear industry became the primary factor for stable operation of the unified Ukrainian power system and the absence of mass blackouts. Besides, execution of its social function by Energoatom, operator of Ukrainian nuclear power plants, by supplying electricity at low fixed price 57 kopecks/kWh to meet people's demand (Public Special Duties) allowed Ukrainian consumers not to suffer from significant growth of the electricity bills.



It should be noted that a discriminatory low tariff for generated electricity was valid for Ukrainian NPPs for many years until July 1, 2019, when a new power market started operating. The tariff was established by the National Energy and Utilities Regulatory Commission and barely covered the required production expenses of the NPP operator. It also caused lack of funds to implement investment projects targeted to enhance safety and replace obsolete equipment that decreases NPP performance. Despite this situation, Ukrainian NPPs continue ensuring one of the highest records of operational safety performance in the world, which has been repeatedly confirmed by international peer reviews of the WANO and IAEA experts. In particular, the first-ever cross-centre review was carried out by the WANO Paris Centre at RNPP and proved high safety of Ukrainian nuclear power plants. Besides, to ensure the highest safety of NPP operation, Energoatom became the first power-generating company in Ukraine, which certified the management system by three international standards EN ISO 9001:2008; EN ISO 14001:2004; BS OHSAS 18001:2007.

At the same time, the study shows that the highest contribution of Ukrainian nuclear power is made in the economy. Moreover, the financial stability of the operator of all NPPs ensures continued activities and development of companies supplying goods and services to the nuclear industry saving dozens of thousands of jobs and paying billions UAH as taxes.

This research was carried out to assess the above-mentioned indicators of total contribution of nuclear power in the development of the country, its impact on Ukrainian economy, social aspects and the environment. The impact of the nuclear industry was, in particular, assessed by direct and indirect economic indicators, such as the number of jobs, volume of commodity output, paid taxes, gross domestic product (GDP), investments, labour costs, social contributions.

The total economic contribution of nuclear power complex was calculated using the Total Value methodology and a modern methodology on «Measuring Employment Generated by the

Nuclear Power Sector» developed jointly by the Nuclear Energy Agency at Organization for Economic Cooperation and Development (OECD/NEA) and International Atomic Energy Agency.

According to the study, nuclear power sector and nuclear industry provide 136 thousand jobs at average. The whole production cycle, from construction of NPP to its decommissioning and radioactive waste treatment throughout its entire operating lifecycle, creates about half a million jobs.

In 2019 the industry's total net profit was UAH 162 billion; UAH 64 billion taxes were paid in different budgets; labour costs were about UAH 40 billion; capital investments amounted to UAH 70 billion. Nuclear companies allocate almost UAH 9 billion for social actions, including unified social security tax, insurance payments and costs for rehabilitation treatment of Energoatom's employees and members of their families.

When comparing these data with the corresponding items of the Ukraine national budget, it can be claimed that that nuclear industry makes significant contribution to the national economy. For example, the net profit of the nuclear industry in 2019 was about 4.4 % of the Ukraine real GDP<sup>1</sup>.

**The amount of paid taxes was almost 6 % of all national budget revenues<sup>2</sup>. To compare, the 2020 budget assigns UAH 64.6 billion to combat COVID-19 acute respiratory disease caused by SARS-CoV-2 coronavirus and its after-effects. This amount is comparable with the amount of taxes paid by the nuclear industry in 2019 (UAH 64.3 billion).**

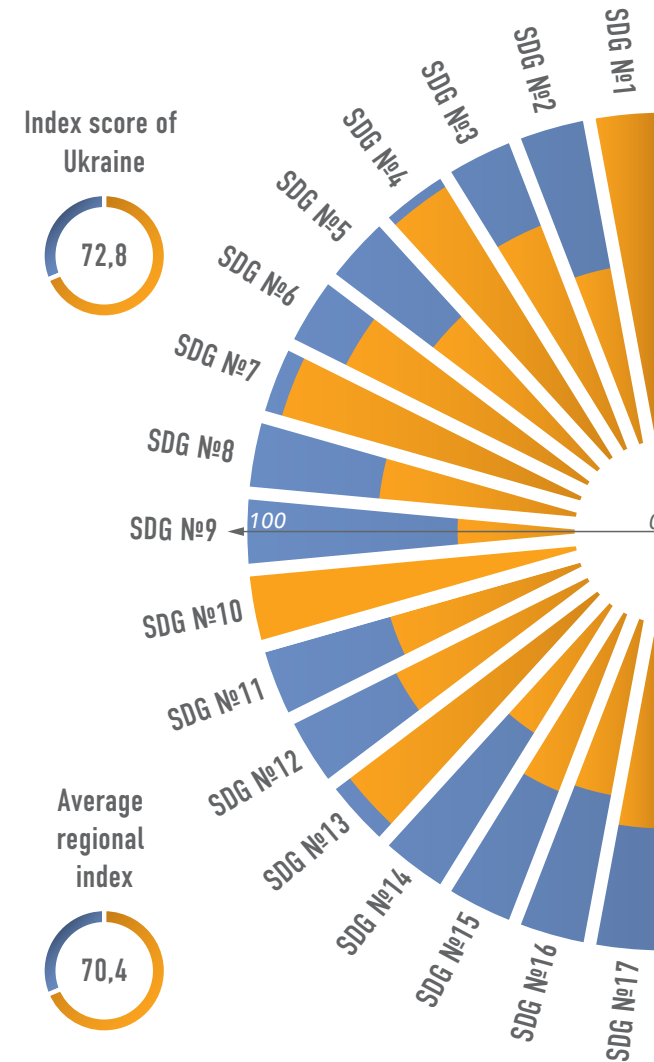
<sup>1</sup> State Statistics Service of Ukraine - <http://www.ukrstat.gov.ua/>

<sup>2</sup> State Treasury Service of Ukraine - <https://www.treasury.gov.ua/ua/file-storage/richnij-zvit-pro-vikonannya-derzhavnogo-byudzhetu-ukrayini-za-2019-rik>



The nuclear industry is not only among the most important components of the Ukrainian economy, it promotes sustainable development of the society in the long run in its all social and environmental aspects that form the basis for UN Sustainable Development Goals (SDG). By Decree of the President of Ukraine On the Sustainable Development Goals of Ukraine until 2030, Ref. No. 722 as of 30.09.2019<sup>3</sup>, our country accepted Global Sustainable Development Goals proclaimed by the UN General Assembly. The aim of achieving the above goals is ensuring the balanced economic, social and environmental sustainable development of Ukraine. The research results prove that the contribution made by the nuclear industry to the SDG achievement is significant and important.

In particular, nuclear power features low emissions of contaminants, greenhouse gases, emissions into natural water bodies as compared with thermal power plants, especially coal-fired TPP. That is why Ukraine features high performance indicators in attaining the Sustainable Development Goal



**Ukraine SDGs implementation score**

<sup>3</sup> <https://www.president.gov.ua/documents/7222019-29825>

No. 7 (Clean and Affordable Energy) and No.13 (Combating Climate Change). High results achieved by Ukraine in attaining these goals are confirmed by the Sustainable Development Report updated and published annually<sup>4</sup>.

Implementation of the best global NPP operating experience and application of state-of-the-art and environmentally-friendly technologies yields positive results, which makes operating Ukrainian NPPs a model of safe, high-tech, and reliable power generation.

Ukrainian NPPs over the entire period of their operation allowed to avoid releasing more than 3 billion tons of CO<sub>2</sub> into the environment (taking into account the lifetime extension for 10 NPP units). Additionally, 70 million tons of CO<sub>2</sub> would have been emitted annually in case of NPP shutdown. More than USD 100 billion would have been additionally spent if 3 billion tons of emissions were prevented using Carbon Capture

and Storage (CCS) technologies at thermal and combined heat and power plants. Owing to low greenhouse gas emissions and large share in the national power generation, nuclear power dominates Ukrainian power sector in terms of prevention of man-induced impact on climate change. In 2019, NNEGC «Energoatom», the Ukrainian NPP operator, entered the top five of the rating «Top Green Power Generators: Carbon-Free Generation Capacity». The rating of 20 largest power-generating companies in the world was prepared by international information-analytical agency Energy Intelligence Group<sup>5</sup> under EI New Energy project. The EI New Energy report used the amount of direct CO<sub>2</sub> emissions per 1 MWh of generated power as a major assessment criterion for each company. This is another evidence that there is no need to significantly decrease nuclear share in the total energy mix or to replace it with renewable energy to decrease the amount of greenhouse gas release.

<sup>4</sup> Sustainable Development Report 2019 - <https://www.sdindex.org/>

<sup>5</sup> <https://www.energyintel.com/>

Therefore, to strengthen economic, energy and environmental security of the country, which is significantly contributed by the nuclear power complex, a state policy need to be established facilitating sustainable development of nuclear power sector, supporting its developmental projects, attracting investment in new nuclear builds and ensuring scientific-technical support of new reactor technologies. A number of European countries such as the United Kingdom, France, Hungary, Finland, the Czech Republic, and others have already taken this path. According to the analytical study performed by S&P Global<sup>6</sup>, nuclear energy develops in those countries, where government wants to develop it and understands all its benefits both for consumers and the economy and for combating climate change. The United Kingdom is an illustrative example of such support. In 2018, its government adopted the strategic document Nuclear Sector Deal<sup>7</sup> aimed at state support of the nuclear industry development, in particular, seeking funding for the construction of new NPPs.

We hope that the Verkhovna Rada of Ukraine, the Government and other stakeholders, when they get familiar with this research, will put additional efforts to create appropriate conditions in support and development of a national strategic industry, a leader of Ukrainian power sector today, which is utmost important for the energy security, economic development and climate change prevention.

Nuclear power complex of Ukraine must keep developing and strengthening for the development of the Ukrainian state!



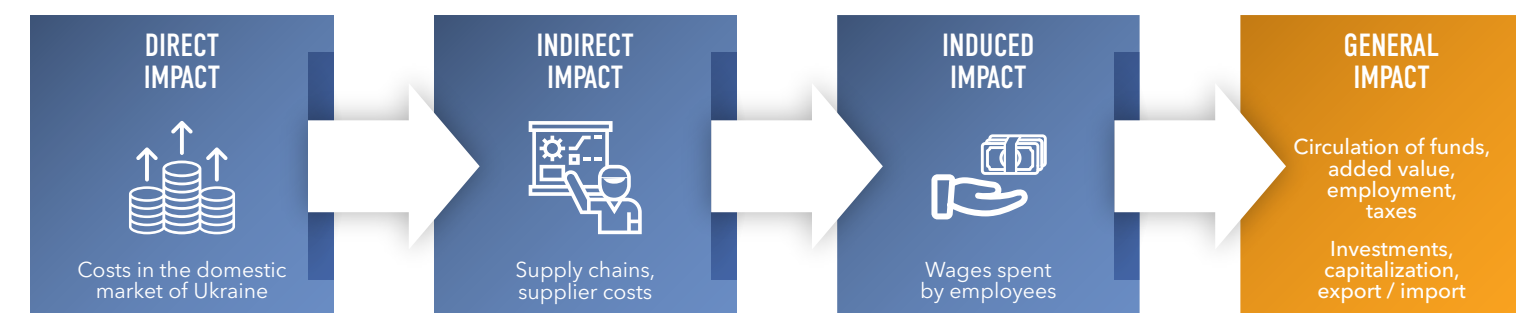
<sup>6</sup> <https://www.spglobal.com/ratings/en/research/articles/191111-the-energy-transition-nuclear-dead-and-alive-11222402>

<sup>7</sup> <https://www.gov.uk/government/publications/nuclear-sector-deal>

## RESEARCH METHODOLOGY

Assessment of the industry impact on total economy is a classic task in the interindustry balance theory and the model «input-output», «cost-output». The impact assessment starts with the description of direct and indirect economic indicators, including the amount of electricity generated, the number of jobs, commodity output, paid taxes, GDP, investment amounts, etc.

The following methodologies were used in the research: Measuring Employment Generated by the Nuclear Power Sector (2018)<sup>8</sup> developed by OECD/NEA in cooperation with IAEA, and Total Value methodology. These methodologies allow assessing the common impact of the nuclear industry on the country economy with high accuracy.



**Conceptual representation of direct, indirect, induced and general economic impact**

<sup>8</sup> Measuring Employment Generated by the Nuclear Power Sector, NEA/OECD, 2018



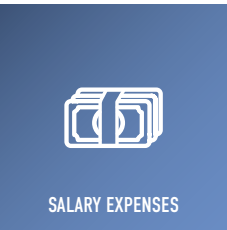
NUMBER OF STAFF  
AT ENTERPRISES



NET PROFIT  
FROM THE SALE OF PRODUCTS



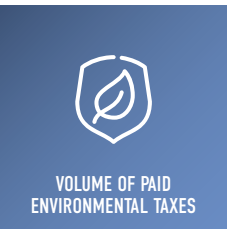
DEDUCTIONS  
ON SOCIAL MEASURES



SALARY EXPENSES



THE TOTAL AMOUNT OF  
PAID TAXES



VOLUME OF PAID  
ENVIRONMENTAL TAXES



COSTS OF ACQUISITION OF  
NON-CURRENT ASSETS



VOLUME OF CAPITAL  
INVESTMENTS

### Indicators used in the research

By using these methodologies the overall impact of nuclear power sector was assessed within the study over 2017 to 2019 with the following indicators:

- number of personnel involved in industrial facilities (employment);
- net operating income;
- salaries expense;
- social security contributions;
- total amount of paid taxes;
- total amount of paid environmental taxes;
- non-current assets expenditure;
- capital investments.

Different types of multipliers may be used to simulate and assess indirect and induced impact of nuclear power on the development of Ukraine according to the proposed methodology. The methodology used in this research is built on a detailed analysis of economic indicators applied in nuclear power sector of USA, France and the Republic of Korea and on generalization of these data.

Indirect and induced indicators were calculated using the following ratios:

### BI

a basic indicator for simulation  
(actual data)

Basic indicator in the nuclear power sector features the contribution made directly by nuclear industry facilities, including permanent subcontractors.

### IDI

an indirect indicator calculated  
by the formula  
 $IDI = 1,25 \cdot BI$

Indirect indicator covers the contribution made by facilities fully involved in the supply chain, and business entities providing goods, works and services for this supply chain.

### II

an induced indicator calculated  
by the formula  
 $IDI = 0,41 \cdot (BI + IDI)$

Induced indicator features the contribution made by all entities to the corresponding industry.

### TI

a total indicator that equals  
to the sum  
 $TI = BI + IDI + II$

The report evaluated the information from financial statements and other reporting documents submitted by 6 basic facilities of the Ukrainian nuclear power complex, specifically:

- State Enterprise «National Nuclear Energy Generating Company «Energoatom» – operator of all operating NPPs in Ukraine. [www.energoatom.com.ua](http://www.energoatom.com.ua)

– State Enterprise «State Scientific and Technical Centre for Nuclear and Radiation Safety» – an expert entity providing scientific and technical support for the state regulator of nuclear and radiation safety. [www.sstc.ua](http://www.sstc.ua)

– State Specialized Enterprise «Chornobyl Nuclear Power Plant» – the entity in charge of decommissioning of Chornobyl NPP and transforming the Shelter facility into environmentally safe system. [www.chnpp.gov.ua](http://www.chnpp.gov.ua)

– State Enterprise «Eastern Ore Dressing Complex» – the only Ukrainian company that mines natural uranium and produces uranium oxide concentrate. [www.vostgok.com.ua](http://www.vostgok.com.ua)

– State Specialized Enterprise «Radon Association» – the main entity in Ukraine involved in collection, transportation, conditioning, and temporary storage of radioactive wastes. [www.radon.net.ua](http://www.radon.net.ua)

– State R&D Entity «Chornobyl Centre for Nuclear Safety, Radioactive Waste and Radioecology» – renders expert, engineering, scientific and technical services to ensure safety of nuclear power complex facilities through all phases of their operating lifecycle, conducts scientific researches in the Chornobyl Exclusion Zone. [www.chornobyl.net](http://www.chornobyl.net)

All information was officially collected directly from the nuclear industry facilities and verified.

Considering high unemployment rate in Ukraine included into the National Budget – 2020<sup>9</sup>, evaluation of the number of jobs that exist or could be created potentially was among the main tasks of this study. The employment assessment in the nuclear industry is well studied including general approaches<sup>10</sup> and methods<sup>11</sup>. The assessment itself was somewhat more complicated than a simple survey of how many people have been employed during construction and operation of a particular NPP or a facility.

<sup>9</sup> On amending the Law of Ukraine About the State Budget of Ukraine for 2020 - <https://zakon.rada.gov.ua/laws/show/553-20>

<sup>10</sup> Robert Bacon, Masami Kojima «Issues in estimating the employment generated by energy sector activities», The World Bank, Sustainable Energy Department, June 2011

<sup>11</sup> David Solan «Employment estimates in the energy sector: concepts, methods, and results», Center for Advanced Energy Studies' Energy Policy Institute, March 2013

That is why all jobs were conditionally divided into three large categories to calculate the total number of jobs in the industry: direct, indirect and induced jobs. The number of indirect and induced jobs is evaluated using corresponding factors due to the lack of exact statistical information.

**DIRECT JOBS (DJ)** – are employees working at power plants and other nuclear industry facilities, including permanent subcontractors, such as physical protection and security service staff, full-time personnel involved in emergency and repair activities.

**INDIRECT JOBS (IDJ)** – are full-time employees involved in the supply chain and in industries that render goods, works and services for this chain, i.e. there are first-level contractors that supply equipment, render services and perform works for nuclear industry facilities.

**INDUCED JOBS (IJ)** – are ones provided when payments to direct and indirect employees are spent in a broader economy when purchasing goods and services.

Evaluation of indirect and induced jobs is called the macroeconomic effect of the increasing demand multiplier. These multipliers make it possible to assess the macroeconomic impact on a particular economy caused by the change in demand. There are two multiplier types. I Type multipliers help to take into account industrial connections; they are calculated by dividing the sum of direct and indirect employment by direct jobs.

**I TYPE MULTIPLIERS** help to account for industrial linkages and are calculated by dividing the sum of direct and indirect employment by direct jobs.

$$\text{I Type multipliers} = (DJ + IDJ) / DJ$$



**II TYPE MULTIPLIERS** help to take into account connections between the economy as a whole and the industry; it is calculated by dividing the sum of all three employment categories by direct employment.

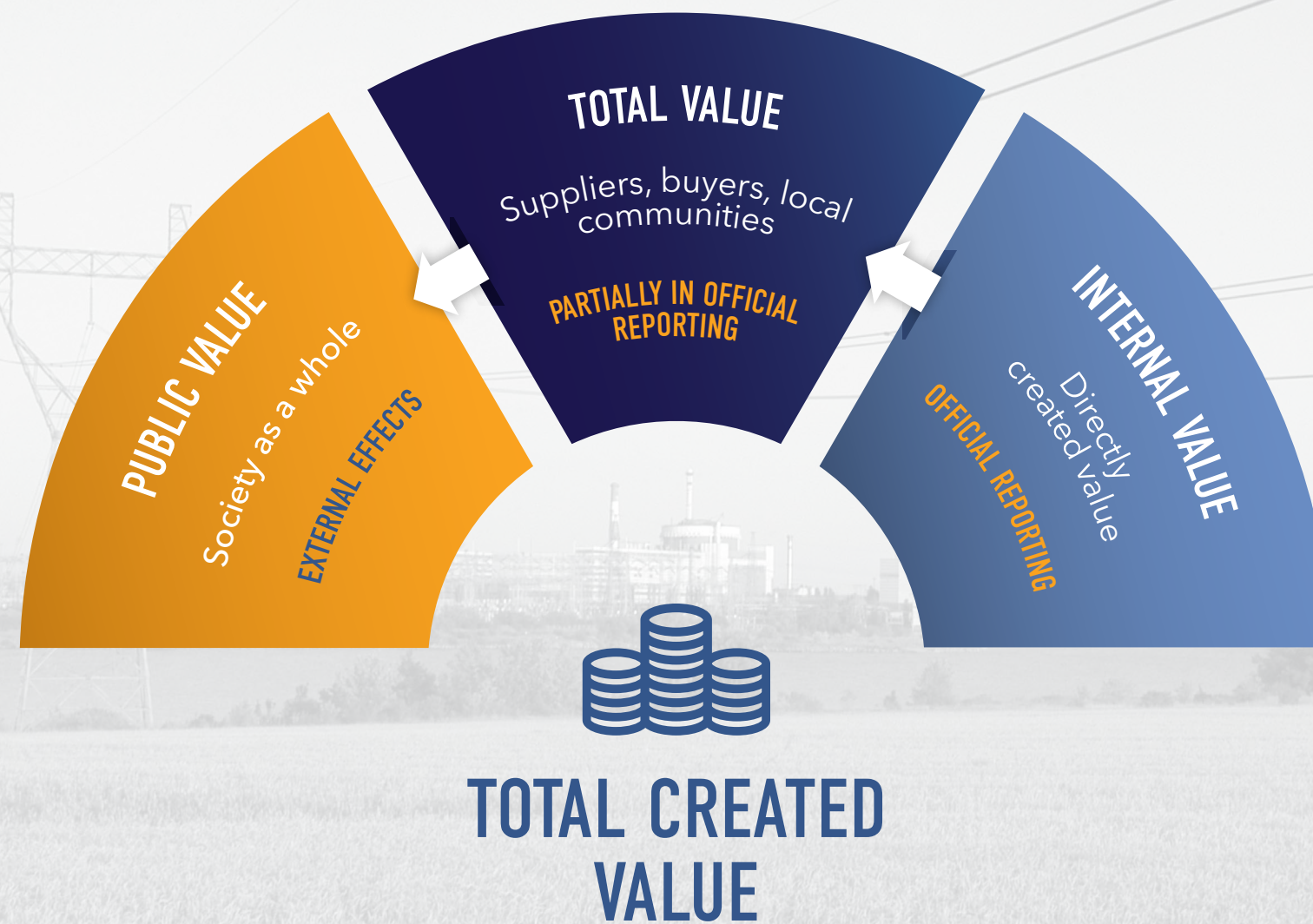
$$\text{II Type multipliers} = \frac{(DJ + IDJ + IJ)}{DJ}$$

Total employment supported by an economic sector at a particular time is usually an indicator that highlights the importance of a certain industry for the national or regional economy. These are gross performance estimates that provide current value rather than future impact. Leading consulting companies perform a comprehensive evaluation of the activities for certain industries or large manufacturing companies taking into account their performance indicators in economic, social and environmental areas. The total value methodology<sup>12</sup> was used in our study.

This approach allows to estimate income and expenses in each activity area and define the total created value, which is a real contribution to the country economy. Such evaluation is a basis for making strategic decisions regarding the company or the entire industry development in the economic, social and environmental areas.

Within the research:

- the main stakeholders were interviewed regarding the issues of the nuclear industry performance, its effect on economic, environmental and social fields;
- all available information over 2017 to 2019 was acquired and assessed regarding the amount of electricity generated, its cost, lifecycle of generating facilities, cost and availability of energy resources, levels and scope of environmental impact;
- global and European policies were reviewed regarding de-carbonization and the place of nuclear power in the climate change mitigation strategies.



<sup>12</sup> Total Value. Impact valuation to support decision-making, Ernst & Young Accountants LLP, 2016



# ECONOMIC IMPACT OF THE NUCLEAR INDUSTRY ON THE DEVELOPMENT OF UKRAINE

It is difficult to overestimate the impact of the nuclear power industry on economic and energy security since nuclear power plants have been generating more than 50 % of all electricity in Ukraine for the last 6 years. By the share of nuclear generation in the total amount of energy production, our country ranks second in the world conceding to France only, where the share of nuclear power plants exceeds 70 %. Thus, environmentally-friendly and the cheapest nuclear energy is among key components of the national energy security and a powerful factor for increasing the competitiveness of the Ukrainian economy.

Besides, nuclear generation has started playing an important social function of limiting the increase of electricity price since new energy market started operating on July 1, 2019.

**NNEGC Energoatom has been 80 % of generated electricity at a low cost (0.57 UAH/kWh) for public needs under the Public Special Duties**

Renewables with the tariff exceeding almost 10 times the average electricity selling price from nuclear power plants are also donated at the expense of NPPs.

Nuclear power plays an important role in budget payments and creation of jobs. Over the last 3 years direct employment at the major studied nuclear industry companies has been at average 43,000 employees, and the amount of paid taxes in 2019 was UAH 20 billion.



The main enterprises of the nuclear-industrial complex of Ukraine

The impact of nuclear power on investment development is equally important since only direct financing of investment projects in the nuclear was approximately UAH 22 billion in 2019. Implementation of projects in nuclear facilitates not only the industry development and employment but allows Ukraine to stay among developed countries capable to create breakthrough technologies and export them.



Direct impact of the main enterprises of Ukrainian nuclear industry in 2019

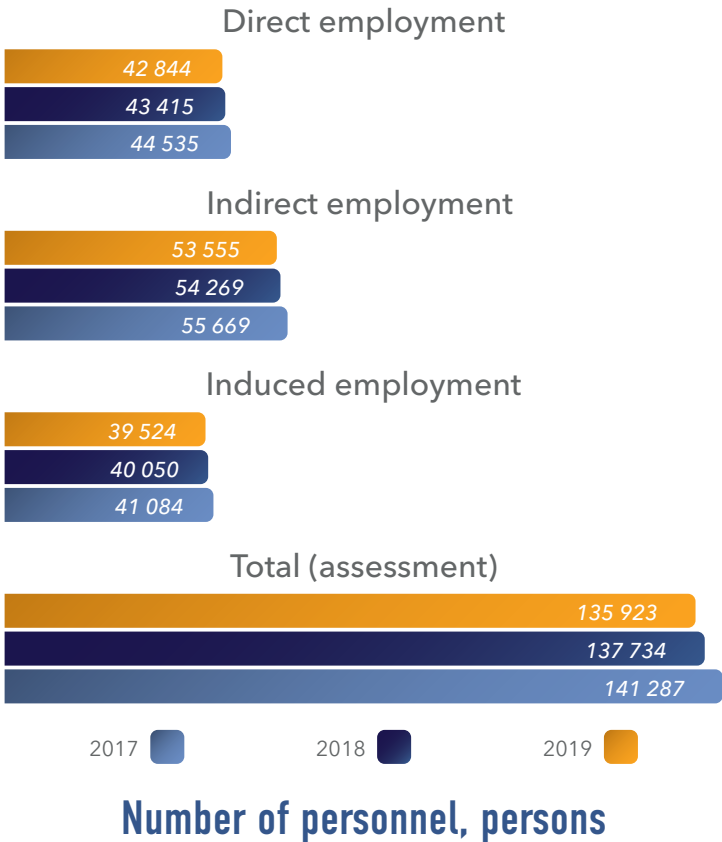
At the same time the impact of nuclear power sector is potentially bigger since performance characteristics of the industry facilities usually do not consider directly economic contribution of vendors and contractors, manufacturers of nuclear equipment, suppliers of support, engineering, design and other services.

In 2019, the number of employees at SE NNEGC Energoatom, the biggest company in the Ukrainian nuclear industry, was 34,736 persons. Employment assessment in the nuclear power industry takes also into account jobs in uranium mining (SE Eastern Ore Dressing Complex) and the companies involved in handling RAW/spent nuclear fuel (first of all, in the Exclusion zone) as well as R&D support of the regulator on nuclear and radiation safety (State Scientific and Technical Centre for Nuclear and Radiation Safety) – 8,108 employees. In total, 42,844 employees worked at the major companies of the nuclear industry in 2019.

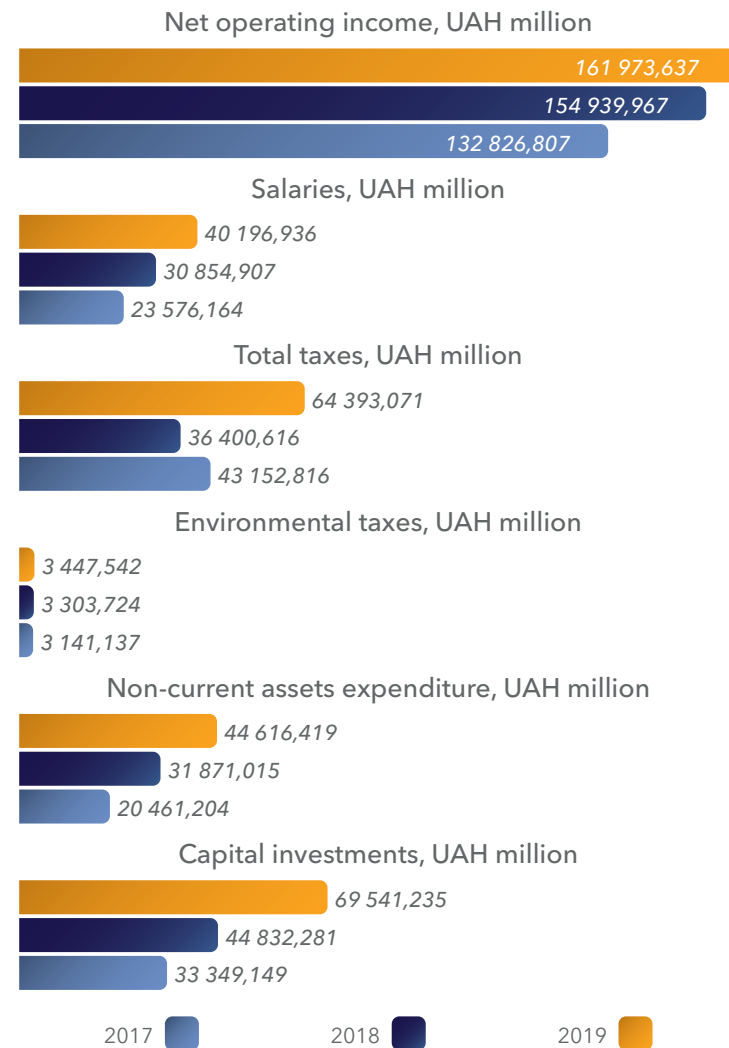
These figures feature direct employment (DE) that includes the staff working at generating facilities, including permanent subcontractors, such as physical protection and security service staff, full-time personnel involved in emergency and repair works.

Indirect employment (IDE) in turn covers additionally the full-time staff involved in the

supply chain (first-order indirect employment) and in the industry that provides goods and services for it (n-order indirect employees). Finally, induced employment (IE) covers all employees engaged in corresponding industry.







### Economic impact of the nuclear industry on Ukraine's economy

The nuclear industry of Ukraine provided totally about 136 thousand jobs in 2019. It is 0.9 % at average of the total employed population in the country.<sup>13</sup>

Within this study, the following economic indicators of the nuclear industry were calculated: amount of paid taxes, investment costs, salary allowances and others. The research results are given in the Table:

In 2019 the nuclear industry gained totally more than UAH 161 billion as net profit, paid UAH 40 billion of salary and more than UAH 64 billion of taxes to the national budget. At the same time total capital investments of the industry amounted to UAH 69 billion.



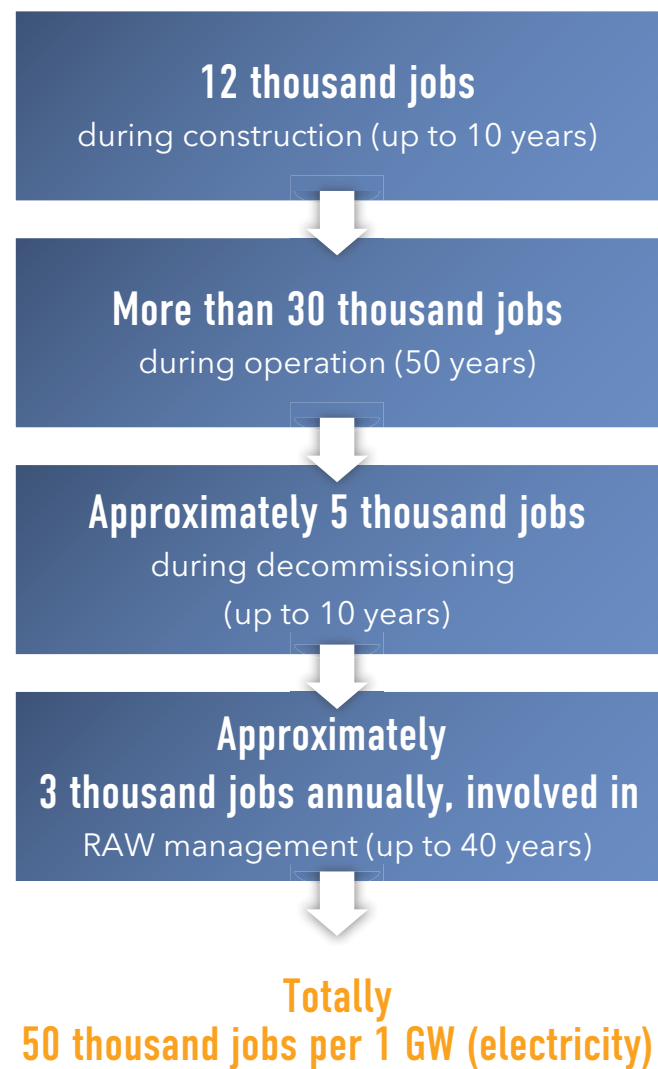
<sup>13</sup> State Statistics Service of Ukraine - <http://www.ukrstat.gov.ua/>

<sup>14</sup> <https://openbudget.gov.ua/>



The analysis of the above indicators highlights the significant impact of the nuclear industry on the country economic development and its contribution to the economy and population welfare. Therefore, Ukrainian nuclear power sector requires clear, transparent and easy-to-understand governmental policy concerning its support, stimulation and development.

Considering the importance of maintaining the existing capacities of Ukrainian nuclear energy and taking into account the provisions of the Energy Strategy of Ukraine until 2035, there is an issue on lifetime extension and new nuclear builds. In this context, the study proposed to assess created jobs in the nuclear industry during construction and further operation of one power unit. Employment throughout the entire lifecycle of a nuclear plant was considered in the study (from construction to decommissioning) for a typical power unit equipped with a 1,000 MW(electricity) reactor. According to the assessment, 1 nuclear power unit provides the following employment opportunities throughout the entire lifecycle:



Given that Ukrainian NPP sites house several power units, it is possible to decrease the above assessments by 25 to 30 % since the managing staff, repair, security, and RAW management departments operate simultaneously at several units. So, totally 35 to 37.5 thousand jobs are required annually to generate 1 GW(electricity). Taking into account the current installed capacities of Ukrainian NPPs 13,835 MW, the nuclear industry potentially creates 485 to 518 thousand jobs to ensure all phases of its lifecycle. It makes 3 % of all employed population in Ukraine.

**The nuclear industry provides about half a million jobs – 3 % of all employed population in Ukraine – during the entire generation cycle from NPP construction to its decommissioning and RAW reprocessing.**

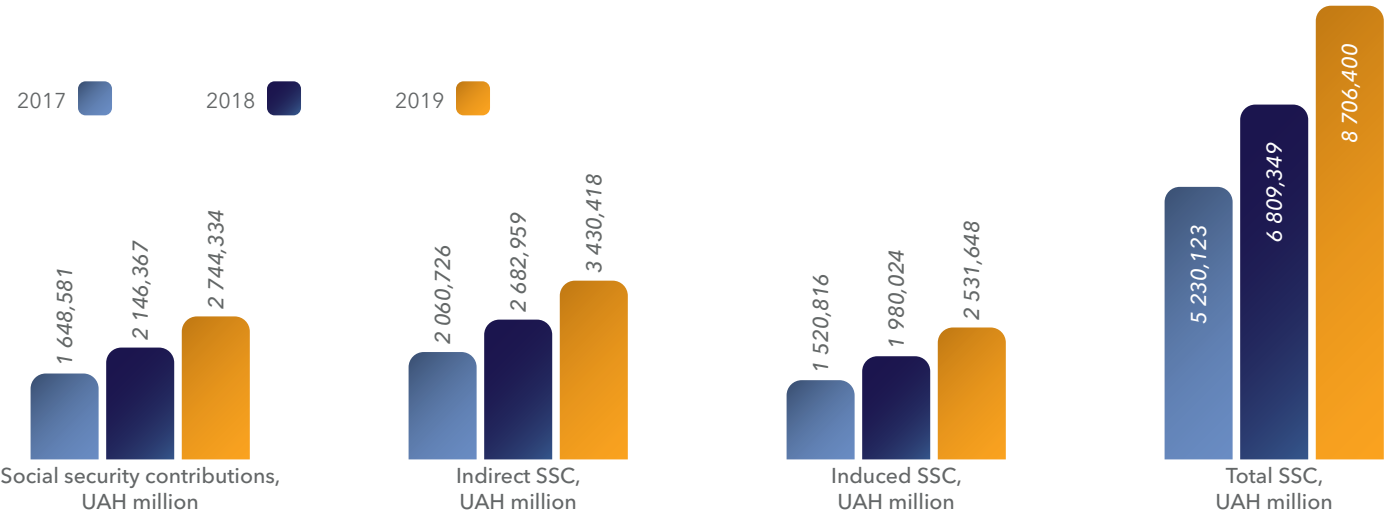


# SOCIAL IMPACT

In addition to the significant economic impact of the nuclear industry on the development of Ukraine, it is also very important in terms of social impact. Thy study analyzed an overall impact of the nuclear industry on employees, locations of industrial and generating facilities as well as the

support and employment of students and young professionals.

The total social security contributions of the nuclear industry are described below:



Social security contributions

Thus, nuclear companies allocate more than UAH 8.5 billion for social activities including unified social tax, insurance payments and costs for rehabilitation of Energoatom’s employees and members of their families.

Employment by occupation of university graduates in the technical fields is equally important from the viewpoint of social impact created by the nuclear industry.

In 2017 to 2019, 309 young professionals and graduates were employed at the nuclear industry facilities.

The nuclear industry also tightly cooperates with schoolchildren, students, secondary and higher education institutes to train future professionals that would work at nuclear industry companies. For this reason:

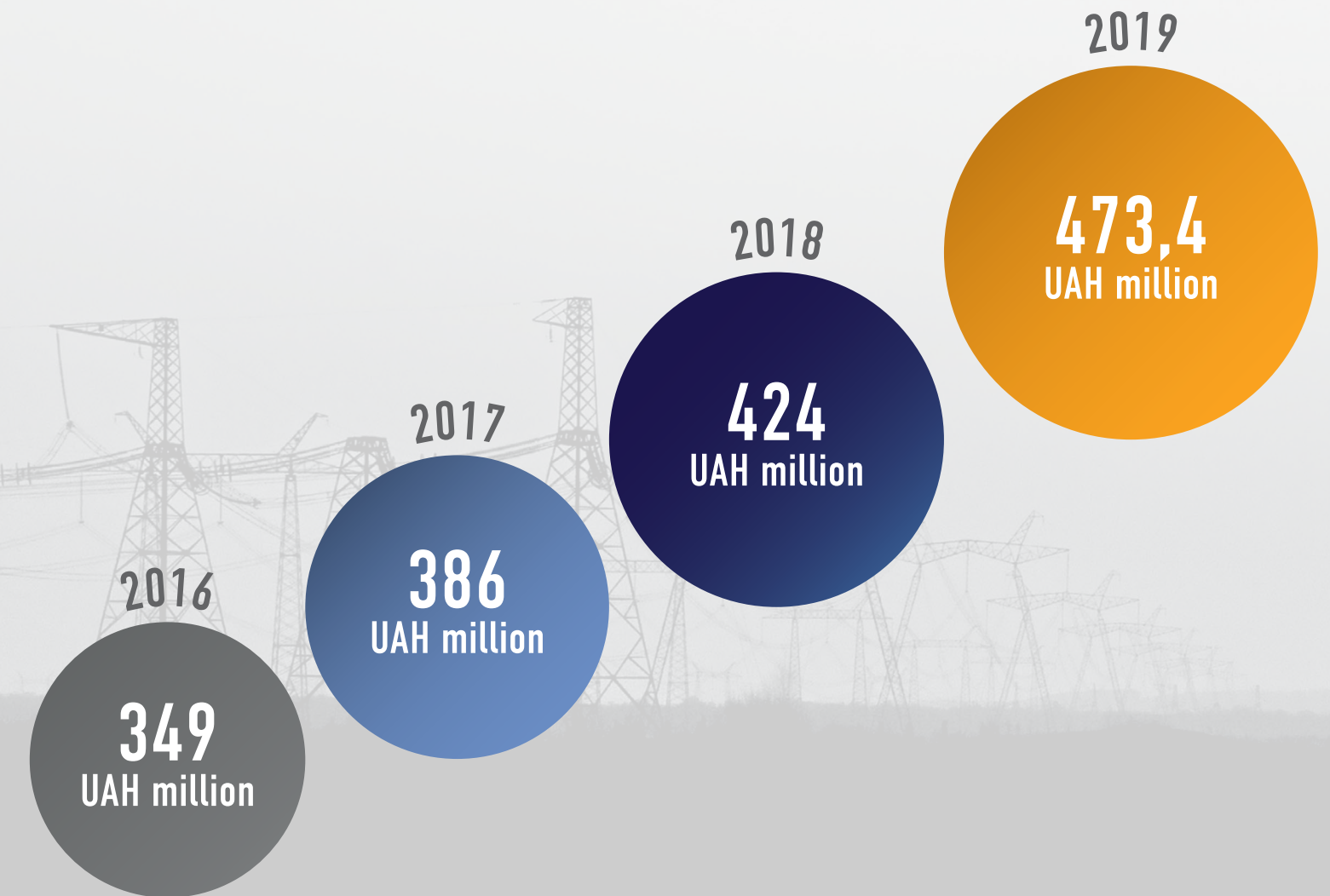
- companies provide opportunity for on-the-job trainings and pre-graduate internship;
- participation of nuclear industry professionals in educational process (lectureship for students and tutors, meetings in the «question-answer» format);
- participation of company representatives in state examination boards on graduate thesis defence;
- holding joint meetings, panels, projects;
- transfer of training aids and equipment to higher education institutions.

To establish an efficient training system for the industry and to decrease the adaptation period for young professionals during employment, hundreds of students undergo practical training at nuclear industry companies. In 2017 to 2019, 4,110 students did practical training. In addition, companies permanently pay scholarships to the best students and their tutors at specialized higher educational institutions.

The nuclear industry has a significant effect on supporting local communities. Thus, NNEGC Energoatom, the operator of Ukrainian NPPs, pays annually a fee for socio-economic compensation of the risk for the population of the radiation control area in amount of 1 % of sold electricity generated during the corresponding period. This fee is set by the Law of Ukraine On the Use of Nuclear Energy and Radiation Safety as a socio-economic compensation to the communities that

live near nuclear power plants. Paid funds go into local funds as the national budget subventions and are used for construction, reconstruction, overhauls and running maintenance of social infrastructure, power, water, gas and heat supply networks and sewage systems, provision of the population with personal protective equipment and drugs.

Since nuclear power plants are mostly located in one-company towns, nuclear industry facilities also keep in their balance sheets and finance housing-and-utility and social-cultural infrastructures annually. The social infrastructure facilities include health care centres for the personnel rehabilitation and health improvement, sport complexes for industry employees and members of their families, social and business centres, particularly, for cultural events, facilities for children summer recreation and health improvement.



**Socio-economic compensation paid by NNEGC «Energoatom»  
to the national budget special fund**

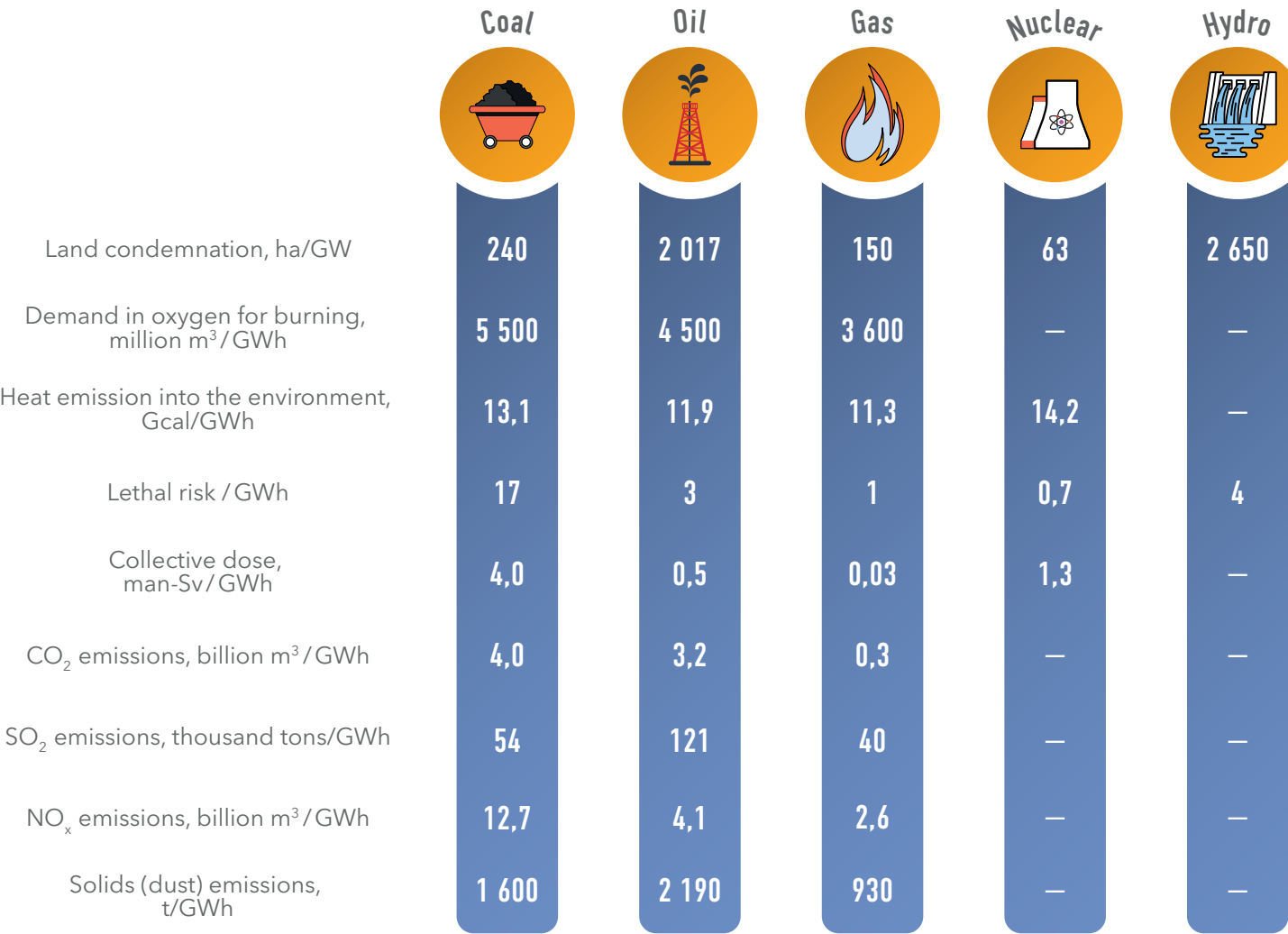


# ENVIRONMENTAL IMPACT OF NUCLEAR ENERGY

Nuclear power plants in Ukraine are the biggest source of low-carbon electricity among the conditional types of power generation. Importance of nuclear energy for preventing climate changes and attaining the Paris Agreement goals by Ukraine is emphasized by the Strategy of Low-Carbon Development of Ukraine until 2050. The climate targets of the Strategy Ukraine may be achieved by maintaining significant role of nuclear energy as a low-carbon energy source, namely – «license renewal, performance improvement, increasing efficiency of operating NPPs while strictly observing safety, establishing an efficient mechanism for accumulation of funds by nuclear plant operator to decommission power units».

The search for alternatives to carbon energy sources to cushion the environmental impact of power generation demonstrates that no generation type may compete with nuclear power in terms of both production output and minimum environmental and climate impact.

Nuclear energy features lower marginal expenditures as compared to conventional energy. At the same time, power generation does not result in the CO<sub>2</sub> emission increase and provides uninterrupted power supply. Today, nuclear energy remains the only alternative energy source with the lowest emissions of greenhouse gases.















International Energy Agency (IEA, 2016)

Environmental impact indicators for different energy sources



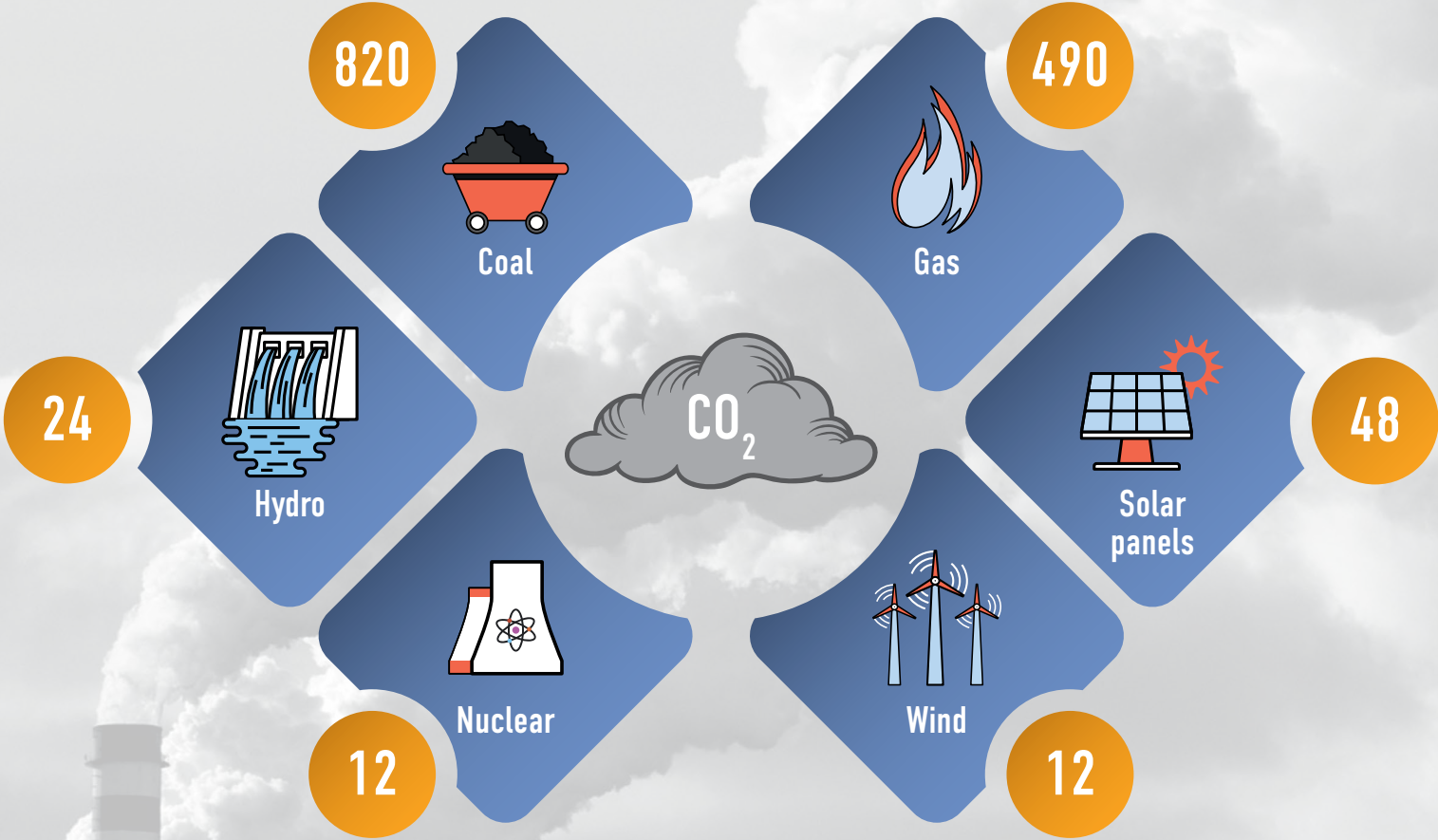
The Intergovernmental Panel on Climate Change (IPCC) performed the most illustrative study regarding the amount of CO<sub>2</sub> emissions per kWh of electricity. The study reported amounts of CO<sub>2</sub> emissions within the entire lifecycle of each generation.

Among all energy generation types, nuclear energy emits CO<sub>2</sub> almost 80 times less than coal generation, 4 times less than solar one, and 2 times less than hydrogeneration<sup>15</sup>.

	Coal	740 / 820 / 910		Geothermal energy	6 / 38 / 79
	Gas-combined cycle	410 / 490 / 650		Concentrated solar	8,8 / 27 / 63
	Biomass – co-incineration	620 / 740 / 890		Hydrogeneration	1 / 24 / 2200
	Biomass – direct incineration	130 / 230 / 420		Offshore wind energy	8 / 12 / 35
	Solar energy – solar power plants	18 / 48 / 180		Nuclear energy	3,7 / 12 / 110
	Solar energy on house roofs	26 / 41 / 60		On-shore wind energy	7 / 11 / 56

Lifecycle emissions, g CO<sub>2</sub>-eq / kWh, Min/Median/Max

<sup>15</sup> The Intergovernmental Panel on Climate Change - <https://www.ipcc.ch/>  
<sup>16</sup> Technology-specific Cost and Performance Parameters[https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc\\_wg3\\_ar5\\_annex-iii.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf)



Comparison of greenhouse gas emissions by power generation type (g CO<sub>2</sub>-eq / kWh)

Recognizing significant contribution of nuclear energy to combating climate change, the Intergovernmental Panel on Climate Change (IPCC) defined four basic scenarios of global decarbonization. These scenarios foresee the need to increase nuclear capacities by 60% to 100% yet until 2030 and by 100% to 500% until 2050 depending on the scenario. It is nuclear energy, in fact, that allows ensuring stable and sustainable operation of the energy system and avoiding significant increase in electricity prices in addition to generating clean and low-carbon energy.

Ukrainian NPPs over the entire period of their operation allowed to avoid releasing more than 3 billion tons of CO<sub>2</sub> into the environment (taking into account the lifetime extension for 10 NPP units). Additionally, 70 million tons of CO<sub>2</sub> would have been emitted annually in case of NPP shutdown.

Implementation of the best global NPP operating experience and application of state-of-the-art and environmentally-friendly technologies yields its results, which makes operating Ukrainian NPPs a model of safe, high-tech, and reliable power generation.

Germany is an illustrative example of obvious advantages typical for nuclear energy as compared with other sources of the baseload generation. Following Fukushima disaster in March 2011, German government decided to immediately decommission 8 of 17 nuclear power plants with further shutdown of all other nuclear power plants. At present, 11 power units are yet stopped, the other 6 units should be shutdown by 2022. After the Fukushima disaster, similar processes of nuclear shutdowns started in other countries; however, global after-effects of such phase-out were not simulated at the scientific level. This problem was solved by researchers of Carnegie Mellon and California universities in Berkeley and Santa-Barbara (USA). They simulated economic and social consequences

<sup>17</sup> THE PRIVATE AND EXTERNAL COSTS OF GERMANY'S NUCLEAR PHASE-OUT - <https://www.nber.org/papers/w26598.pdf>

CO<sub>2</sub> emissions in 2019

	Power generation, million kWh, 2019 <sup>17</sup>		CO <sub>2</sub> specific emissions, g/kWh	CO <sub>2</sub> emissions in 2019, thousand tons	
TPP	44 915,1		820	36 830,382	
CHPP	10 869,9		820	8 913,318	
NPP	83 002,7		12	996,032	
HPP	6 521,8		24	156,523	
Pumped storage plants	1 346,8		24	32,323	
Renewables <sup>18</sup>	5 542,2	Biofuel	167,22	230	38,461
		Wind	1 202,811	11	13,231
		Solar	4 172,169	48	200,264

of closing half of German NPPs after 2011. In December 2019, the USA National Bureau of Economic Research published the report on their research. Using computer-assisted learning, economists processed statistical data gained

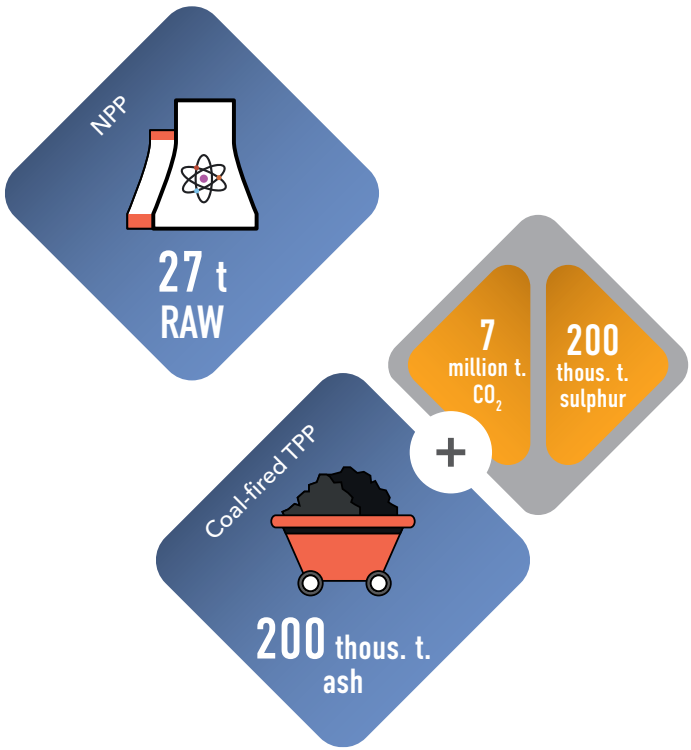
during 2011-2017 and concluded that nuclear generation in Germany was almost completely replaced with coal combustion, which resulted in additional emissions of 36 million tons of CO<sub>2</sub> into the atmosphere (emissions increased by 5 %).

<sup>18</sup> Information about operation of power-generating complex over 12 months of 2019 - <https://mineco.gov.ua/news/34531.html>  
<sup>19</sup> Installed capacity of the Ukraine power system - <https://ua.energy/vstanovlena-potuzhnist-energosystemy-ukrayiny/>

Even worse, increased coal combustion has resulted in higher atmosphere pollution with particles and sulphur dioxide resulting in an additional 1,100 deaths annually because of respiratory and cardiovascular diseases. The researches have defined the increase of harmful emissions into the atmosphere; and the resulting premature deaths cost USD 12 billion annually for German society. The study has shown that the expenses incurred by the government are not comparable with the costs of keeping NPPs in operation even considering the risks of man-induced accidents and the cost of spent fuel disposal. Moreover, refusal of NPP operation resulted in higher electricity prices that benefited its manufacturers but forced population to pay more.

Germany has already acknowledged that the decision to phaseout nuclear energy made impossible to achieve claimed targets on CO<sub>2</sub> emissions by 2020. Yves Desbazeille, Director General of FORATOM, European Association for the Nuclear Energy Industry, supposed that

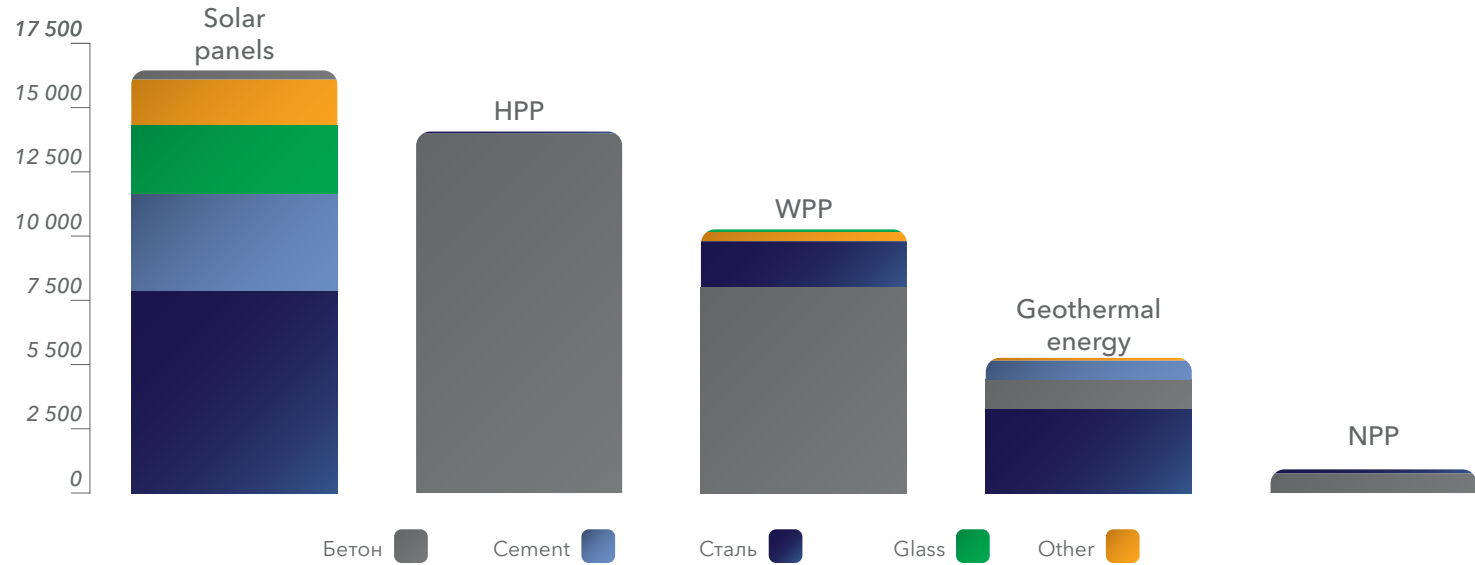
Germany would have achieved its climate targets and become a leader in combating climate changes in Europe if it decommissioned its 20 GW total capacities of coal-fired power plants rather than nuclear power plants in 2011.



TPP and NPP waste (t/GW·year)

Accumulation of wastes formed throughout power generation lifecycle is not the least important aspect of environmental impact. Although the operation of nuclear power plants and other facilities using ionization radiation sources results in the radioactive waste formation, their amounts are incomparable with the waste formed during operation of other power generation types.

Amounts of materials and natural resources needed to build a generating facility and its further operation are also important. Energy resources are also used to produce steel, cast iron, glass, concrete, and cement. 1 TWh of electricity generated at NPP requires dozens of times fewer resources than for RES generation. It is an additional argument in favour of nuclear industry development.



Mass of materials, tonnes/TWh



# NUCLEAR INDUSTRY IMPACT ON THE SUSTAINABLE DEVELOPMENT GOALS

At the UN Summit on Sustainable Development held in September 2015 country leaders and government heads adopted the 2030 Agenda and defined 17 sustainable development goals (SDG).

By Decree of the President of Ukraine On the Sustainable Development Goals of Ukraine until 2030, Ref. No. 722 as of 30.09.2019<sup>20</sup>, our country supported Global Sustainable Development Goals proclaimed by the UN General Assembly. The purpose of the above goals is ensuring the balanced economic, social and environmental sustainable development of Ukraine. Implementation of Sustainable Development Goals at national and global levels requires global partnership and active involvement of

all stakeholders: government and business officials, representatives of international and non-governmental organization and public.

Being a reliable, safe and clean energy source, as well as a strategic industry of the economy development both in terms of economic performance and ensuring national energy security and independence, nuclear power in Ukraine also contributes to achievement of the Sustainable Development Goals.

Yet due to the specifics of its operation as opposed to other industries nuclear power makes a significant contribution to the Sustainable Development Goals and the goals of the UN Framework Convention on Climate Change.

This specifics features:

- high level of safety, safety culture and labour protection at industrial facilities;
- high output at a relatively low electricity generation cost;
- low greenhouse emissions per 1 kWh and insignificant environmental impact in normal operation;
- support of innovations and implementation of new technologies at industry facilities;
- ensuring competitive salary for employees in the industry;
- infrastructure development and supporting the regions of its operation.



<sup>20</sup> <https://www.president.gov.ua/documents/7222019-29825>





Employees of the nuclear industry are provided with a decent salary and a wide package of social benefits. Besides, nuclear industry companies are among the biggest payers of taxes and social security contributions; they are investing in social and economic development of the regions of their location.



The specifics of nuclear power envisages high social security standards for all employee categories. These include the provision of social benefits and safety nets provided for by the Ukrainian laws and Collective Labour Agreement, concerns for the safety and health of employees, different kinds of material assistance, housing provision, etc.



To ensure continuous improvement of operational safety, Ukrainian nuclear companies created all necessary conditions for training, professional and career growth. The staff training system in Ukraine is based on the Systematic Training Approach recommended by the IAEA. The staff is trained so that each employee can implement own professional and creative potential. The industry has a strong training system for all levels of employees because only qualified personnel can ensure safe operation of nuclear power plants.



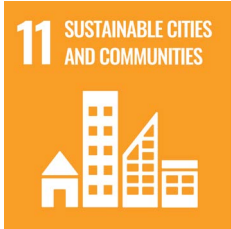
The fundamental concepts of the nuclear facility operation are safety and environmental impact minimization, including reasonable water consumption and ensuring the whole environmental safety during operation. Amounts of water resources consumed by Ukrainian NPPs virtually did not change over the last decade and are almost twice less than set limits.



The nuclear industry creates decent labour conditions for employees and pays a competitive salary. In 2019, the total amount of salaries paid to employees in the nuclear industry and related companies amounted to more than UAH 40 billion.



Nuclear power in Ukraine is a strategically important component to ensure national energy independence and security, as well as one of the most developed and high-tech economy sectors. Innovative solutions are being regularly implemented to ensure continuous safety improvement in the nuclear industry. These solutions have been developed by industry experts together with Ukrainian and international research and development institutions, science and technical and industrial partners. Investment projects are being implemented jointly by all industry companies to develop the nuclear power complex, decrease the dependence on external suppliers, ensure modernization and safety enhancement of nuclear facilities.



Nuclear power is low-carbon and safe under normal operation and therefore friendly to cities and ecosystems, where NPPs are located. In addition, nuclear facilities contribute significantly to the economic development of neighbour areas, the infrastructure and support local communities by paying taxes and other fees.



No harmful CO<sub>2</sub> emissions is one of the advantages of nuclear power, and, therefore, it is clean and safe for the environment. Operation of NPP does not result in emission of greenhouse gases affecting the climate change. The Paris Climate Change Conference recognized nuclear power as such that positively contributes to the environmental well-being, in particular, as a producer of a low-carbon energy.



In normal operation nuclear power does not result in land contamination; nuclear power plants occupy relatively low areas at high electric and thermal installed capacity.



To ensure continuous safety enhancement and considering the specifics of nuclear power, all nuclear companies tightly cooperate all over the world, in particular, within global international entities such as the International Atomic Energy Agency (IAEA), World Association of Nuclear Operators, World Nuclear Association and others.

# APPENDICES

## Occupancy level in the nuclear industry

	2017	2018	2019
Number of employees at the facility (direct employment), persons	44 535	43 415	42 844
Indirect employment, persons	55 669	54 269	53 555
Induced employment, persons	41 084	40 050	39 524
Total employment, persons	141 287	137 734	135 923

## Operating income

	2017	2018	2019
Net operating income (2000), UAH thous.	41 868 182	48 838 445	51 055 520
Indirect income, UAH thous.	52 335 228	61 048 056	63 819 400
Induced income, UAH thous.	38 623 398	45 053 466	47 098 717
Total income, UAH thous.	132 826 807	154 939 967	161 973 637

Salary expenses

	2017	2018	2019
Salary expenses (2505), UAH thous.	7 431 415	9 725 739	12 670 429
Indirect salary expenses, UAH thous.	9 289 269	12 157 174	15 838 036
Induced salary expenses, UAH thous.	6 855 480	8 971 994	11 688 471
Total salary expenses, UAH thous.	23 576 164	30 854 907	40 196 936

Social security contributions

	2017	2018	2019
Social security contributions (2510), UAH thous.	1 648 581	2 146 367	2 744 334
Indirect social security contributions, UAH thous.	2 060 726	2 682 959	3 430 418
Induced social security contributions, UAH thous.	1 520 816	1 980 024	2 531 648
Total social security contributions, UAH thous.	5 230 123	6 809 349	8 706 400

Taxes

	2017	2018	2019
Total amount of paid taxes, UAH thous.	13 602 149	11 473 796	20 297 264
Indirect taxes, UAH thous.	17 002 686	14 342 244	25 371 580
Induced taxes, UAH thous.	12 547 982	10 584 576	18 724 226
Total taxes, UAH thous.	43 152 816	36 400 616	64 393 071

Environmental taxes

	2017	2018	2019
Environmental taxes, UAH thous.	990 114	1 041 363	1 086 696
Indirect environmental taxes, UAH thous.	1 237 643	1 301 704	1 358 370
Induced environmental taxes, UAH thous.	913 380	960 657	1 002 477
Total environmental taxes, UAH thous.	3 141 137	3 303 724	3 447 542

## Intangible assets purchase

	2017	2018	2019
Costs for intangible assets purchase (3260), UAH thous.	6 449 552	10 046 025	14 063 489
Indirect costs for intangible assets purchase, UAH thous.	8 061 940	12 557 532	17 579 361
Induced costs for intangible assets purchase, UAH thous.	5 949 712	9 267 458	12 973 569
Total costs for intangible assets purchase, UAH thous.	20 461 204	31 871 015	44 616 419

## Capital investments

	2017	2018	2019
Capital investments, UAH thous.	10 511 946	14 131 531	21 920 011
Indirect capital investments, UAH thous.	13 139 933	17 664 414	27 400 014
Induced capital investments, UAH thous.	9 697 270	13 036 337	20 221 210
Total capital investments, UAH thous.	33 349 149	44 832 281	69 541 235

# FOR NOTES





**PUBLIC ORGANIZATION  
«UKRAINIAN NUCLEAR SOCIETY»**

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