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CURRENT TOOLS TO CONTROL DECARBONIZATION IN UKRAINE BOTH GOVERNMENTALLY AND LOCALLY

Purpose. To develop tools as well as specific measures controlling decarbonization processes both governmentally and locally which will favour economic stability during martial law.

Methodology. The study involved the following approaches: deduction; induction; case study; system analysis; and modelling.

Findings. Subsidies, grants, and tax benefits for businesses, investing in decarbonization projects, are the most effective governmental tools. Specific measures have been developed at the level of business entities; the measures correspond to regulatory requirements as for decarbonization at the state level. Moreover, they will become the efficient propagation of tools controlling decarbonization. They apply to the whole activity by the business entity and should involve the following tendencies: strategic management aimed at a zero-level achievement; development and implementation of environmental behaviour; adaptation of a business model with a focus on ESG standards; organization of climatic/environmental audit; and ensuring for the reliable traceability to enable efficient control.

Originality. Implementation of internal system to control decarbonization has been further developed. Its periodicity has been formed in such a way to satisfy information needs of both internal and external consumers. Consequently, the system is concerned in dynamics with further establishment of job performance standards. Methodological foundations to control decarbonization system locally have been improved while developing indicators for achievement of low-carbon practices as well as zero carbon emission. An algorithm measuring both quantitative and qualitative indicators to achieve low-carbon practice and zero carbon emission has been proposed for local decarbonization control.

Practical value. The findings may be applied by the state administration bodies to develop and implement decarbonization strategies and generate tools for clean technology stimulation. In addition, business entities may also use them while implementing clean production technologies.

Keywords: *decarbonization, management, stable development, environmental behaviour, transformation of the economy*

Introduction. Decarbonization of economic sectors means reduction of greenhouse gas emissions and limiting the human activity impact on the change. The abovementioned is becoming a more and more important problem in view of the increased consciousness as for the climate change, and the necessity to limit the global warming.

Martial law may complicate decarbonization process since full-scale invasion makes it difficult for our state to focus on the environmental problems as well as on the sustainable growth implementation. However, it should be mentioned that wartime posture decreases both stability and safety which may result in the intensified attention to climatic and resource problems. Despite the difficulties, some decarbonization aspects can be currently important and even necessary for our country. Under the martial law, rational use of resources may become the key issue since it can favour both saving and mitigation of impact on the environment. Decrease in the use of such traditional energy sources as fuel and petroleum products, and transition to renewable ones will help provide greater independence from the external resources and reduce energy infrastructure vulnerability. Preservation and renewal of natural ecosystems may be important to provide local people with vital resources during the military conflict.

A report by Intergovernmental Panel on climate change “AR6 Synthesis Report: Climate Change 2023” emphasizes 1.1 °C temperature increase compared with the 1850–1900ss industrial period. At the same time, the number of intensive extreme weather phenomena, impacting negatively human health, biodiversity, and global ecosystems, also increased. It is expected that the world will cross 1.5 °C temperature limit during the 2030s (in terms of the current gas emissions, creating greenhouse effect, and their annual increase). Climate change consequences are not of a linear nature anymore; further temperature increase will result in faster growth of negative natural phenomena intensifying thermal waves, floods, and fires [1].

The European Union (EU) strives to become a climate-neutral continent in 2050. The abovementioned involves decarbonization of various sectors and transformation of economy into a system being free of greenhouse gas emissions. The important goal is the basis of the European Green Deal (EGD), and corresponds to the EU commitments as part of the global climate change measures set out in the Paris Agreement [2, 3].

Transition to the economy with a neutral climate impact, resulting from decarbonization implementation, is a challenge. At the same time, it provides an opportunity to shape a better future. Within the process, such various sectors of economy as industrial energy, transport, construction, building and renovation, land management, waste treatment, agriculture and forestry, will play proper role together with the whole society. The first step towards a climate neutral economy is coming into force of the Law of Ukraine No. 377-IX “On the principles of monitoring, reporting and verification of greenhouse gas emissions” (MRV) since 01.01.2021 [4]. The Law is aimed at harmonization of Ukrainian legislation with the European Union Law Standards, and implementation of provisions of the “Directive on the establishment of a scheme for trading emissions permits” No. 2003/87/EU [5].

Even in the context of the national challenges, connected with the military conflict, Ukraine takes measures to achieve the defined goals. In 2023, the State Fund of Decarbonization and Energy-Efficient Transformation was established. The Fund will be financed partially at the expense of CO_2 emission taxation. Mainly, the tax is paid by large industrial enterprises. Before the Fund establishment, the carbon duty was directed to the total budget since it had no specific purpose.

Decarbonization process management remains an important problem even during a martial law since negative environmental impact by the military conflict may be a significant threat to sustainable development.

The abovementioned means that it is required to develop the current modern tools for decarbonization management under martial law.

Literature review. Numerous scientific papers concern problems of the development and implementation of decarbonization strategies, policies, and approaches. M. O. Kuznetsova analysed functioning features of energy enterprises in the context of implementation by Ukraine international decarbonization initiatives [6]. M. L. Vasylyshyna studied practices of the European Union as for decarbonization process favouring inclusive of financial support through various tools (namely, provision of loans, grants, and compensation payments to cover environmental investments as well as introduction of tax holiday) [7], K. Yu. Gura & V. G. Petruk analysed the current decarbonization tendencies, progress, and processes as well as ecomodernization of energy and industry in Ukraine and in the world in the context of the global climate change [8]. B. I. Basok & O. F. Butkevych were engaged in issues of studies involving solution of the problems of electric power system decarbonization to achieve zero greenhouse gas emission. A mathematical model of balancing process of active power of electricity system has been proposed where generating capacities are renewable energy sources and nuclear power stations [9]. Difficulties and prospects of processes to decarbonize economy as a mandatory prerequisite for climate neutral future were considered by K. Gnedina & A. Soroka too. They also analysed such current decarbonization-focused strategies and measures as use of renewable energy sources; implementation of introduction of green technologies in industry; projects for energy efficiency; development of electromobility, etc. [10]. E. Papadis & G. Tsatsaronis have identified that obstacles to decarbonize energy sector are defined concerning environmental stability; security of energy supply; economic stability; and social aspects. In addition, the global carbon tax is the most promising tool accelerating decarbonization process [11]. Road map for rapid decarbonization were developed by J. Rockstrom, O. Gaffney, J. Rogelj, & M. Meinshausen [12]. Ways of solving issues of environmental and profit-making efficiency were developed by J. Meckling, T. Sterner, & G. Wagner [13]. Critical review of global decarbonization scenarios were done by P. Loftus, A. Cohen, & J. Long. They also modelled their implementation [14].

In general, the review of scientific sources has shown that the management of decarbonization processes is the key task to provide sustainable development and reduce human impact on a climate change. Decarbonization strategies should be formulated both governmentally and locally. Moreover, they have to be coordinated and take into consideration national contexts.

Purpose. Governmental and local development of tools as well as specific measures to manage decarbonization processes will favour economic stability and growth during the martial law while helping the country use resources effectively and mitigating economic impact by the conflict.

Methods. The study has applied different approaches of scientific knowledge. Among other things, induction method was used to analyse specific decarbonization examples; deduction method helped formulate certain conclusions concerning decarbonization efficiency relying upon general principles and laws; and abstraction method made it possible to single out the basic ideas and concepts characterizing decarbonization and ignoring details. Empiric studies were applied to separate the basic regularities and tendencies being relevant for decarbonization process analysis in the European countries and for determination of the most efficient strategies and practices. Case study was used to analyse specific decarbonization situations in different countries inclusive of their strategies, problems, and successes. System analysis was required to consider decarbonization as a system, and study interaction between various parts of the system as well as their influence on the result. A modelling method helped study decarbonization performance indicators at the business entity level and forecast their results.

Results. Decarbonization, involving transition to low-emission technologies and sustainable energy sources, may face high costs. Hence, it is important to develop mechanisms stimulating its financial support from various sources. The financial support provision for decarbonization projects is the key element to implement successfully green initiatives.

The EU practices prove that subsidies, grants, and tax incentives for businesses, investing in decarbonization projects, are the most efficient governmental tools.

Since the first of January 2024, the law has entered into force in Ukraine providing for the establishment of the State Fund for Decarbonization and Energy Efficient Transformation [14]. Owing to the State Energy Efficiency Agency, acting as the main energy manager of the country, the governmental policy will be implemented concerning introduction of efficient tools. It is planned to adopt various mechanisms that have proven themselves in other countries, i.e. "green" bonds; ESCO projects; "green" lending; factoring; and leasing. The basic objective of the Fund are as follows:

- support of governmental programs in the field of energy efficiency, use of alternative energy and decarbonization sources;
- attraction of international credit funds and grants to implement the investment projects;
- ensuring reliable payback and reimbursement of foreign investments and financial liabilities.

Environmental tax on CO_2 emission will become the key financing source of the Fund. In turn, the assets will be applied exclusively to finance energy efficiency programmes and operations. Currently, environmental tax rate on CO_2 emission in Ukraine is UAH 30/t [15]; in general, the Law on the State Budget of Ukraine for 2024 foresees UAH 2.175 billion of the environmental tax revenues. In Ukraine, the tax on CO_2 emission was introduced in 2011. It is a part of environmental tax. Fig. 1 shows the tendency of changes in tax rates and the amount of tax revenues to the state budget in 2018–2022 [15].

Since 2019, CO_2 emission tax rate in Ukraine has experienced its 24-fold increase (i. e. up to UAH 10 per ton) and the funds raised are 18 times more, i. e. UAH 951 million. Nevertheless, the money was transferred to a general fund of the state budget without any certain target orientation. Starting from 2024, all revenues of the CO_2 tax will be distributed in the following way: 50 % will get to a general fund of the state budget and other 50 % – to the State Fund for Decarbonization and Energy Efficient Transformation.

The Ukrainian CO_2 tax uniqueness is as follows. It is levied on the basis of the filled-up declarations; is calculated when emission arises; and applies complex calculation algorithm.

The approach results in the fact that enterprises, using biomass in their activities, are taxed even when the fuel type is considered as a carbon neutral being tax free in the majority of countries.

Ukraine needs harmonization of its laws in accordance with EU Directive 2003/96/EU concerning restructurization of electric energy taxation. The abovementioned means fossil

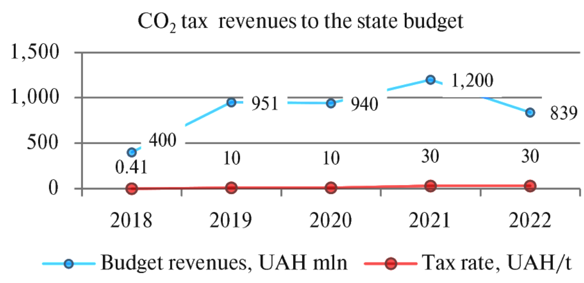

Fig. 1. CO_2 *tax revenues to the state budget*

fuel taxing instead of CO_2 emission. It helps involve in taxing all potential CO_2 emissions and stimulate transition to renewable energy sources being tax free.

However, establishment of the State Energy Efficiency Agency Fund will favour reduction in CO_2 emissions at the enterprises using the Fund tools. Financing by the Fund will concern only projects supporting decrease in CO_2 emissions, and having energy efficient, environmental, and social benefits.

Tax incentives for businesses, investing in decarbonization projects, may attract private sector to participate in environmentally friendly initiatives. During the crisis, increase in tax burden and unprofitability of domestic businesses in Ukraine has extremely negative consequences. First of all, the tax burden intensification at the expense of CO_2 emission tax hike will result in further decrease in profitability; erosion of competitiveness; and reduction of exports and manufacture. In the face of lower production and lack of internal financing combined with high tax burden, domestic manufacturers cannot fulfil decarbonization plans. It is the reason why enterprises may be closed, and Ukrainian industry will be totally lost. The negative consequences will heavily influence the growth of the country's economy. Decline in industrial output, i. e. decrease in budget revenues and foreign exchange earnings; job cuts, i. e. increase in the number of insolvent population; and reduction of the general standard of living and welfare of the population are worth mentioning. In the EU countries, governments stimulate industries in two ways: 1) through a scheme of the scheduled energy efficiency commitments; 2) through support programme in terms of tax benefits or the reduced rates on loans for energy efficiency measures. For example, Italy an energy efficiency process started in 2001. In 2004, all the available decarbonization tools began operating actively. As of 2021, industrial sector of the country reduced electric energy consumption by 60–70 %. France implemented the plan of decarbonization process gradually. At the terminal stage of energy efficiency development, government guarantees small and medium business green loans at a reduced rate. Funds are issued to purchase energy efficient equipment. Austria introduced environmental support program in the form of subsidies from a grant at the rate of up to 30 %; however, it denied tax benefits to enterprises.

The EU prepares to submit a proper plan in response to the US Inflation Reduction Act (IRA) which provides for tax incentives of $400 billion (€369 billion) and an investment package for the USA economy decarbonization (Table 1) [16]. The law has become an alarm signal for European politicians. Making production ecologically modernized takes a long path since initially, 'green economy' is not profitable; hence, financial support by government is required.

The EU notes that the businesses, implementing decarbonization projects, pay high environmental tax; nevertheless, the government provides them with simultaneous reduction or tax holiday for other taxes.

In such a way, taxes on wages, property taxes and VAT are reduced to maintain the overall level of fiscal burden and competitiveness of national enterprises. Consequently, preferential tax rates and tax incentives can also be differentiated depending upon the real environmental effect of the investments.

At the local level, business entities must meet the requirements of customers, regulators and investors; improve the quality of environmental and social risk management; and make management more transparent for effective reconstruction and post-war modernization. Hence, it is proposed at the level of economic entities to develop specific measures meeting the regulatory requirements for decarbonization at the state level, and which will become an effective continuation of decarbonization management tools (Fig. 2) [4, 17, 18].

In accordance with the decarbonization goal [17] and the statutory principles of management [4, 18], it is proposed to work out in more detail the specific steps which should be developed and implemented by an economic entity. They cover all activities of the economic entity, and should include the following:

Table 1

State aid in the EU countries

Country	Type of governmental support	Description
Great Britain	Soft loans	Reduced energy consumption and interest-free small business loans of up to £100.000
	Tax benefits	If resource efficient technologies are applied then ecology tax exemption takes place or its partial return
Denmark	Tax benefits	The increase in environmental tax rates was offset by a decrease in the tax burden on the payroll
Italy	Tax benefits	If innovative energy efficient technologies are applied, then hyper depreciation of assets is up to 270 % instead of 100 %
The Netherlands	Tax benefits	Reduction in the amount of new environmental technologies purchase through 20/80 or 30/70 the state-enterprise co-financing
Germany	Grants or special funds	Defraying up to 80 % costs of new technology implementation

1) strategic management aimed at a "zero level" achievement;

2) development and implementation of environmental behaviour;

3) business model adaptation with a focus on ESG standards;

4) organization of climate/environmental accounting;

5) reliable traceability for effective control.

Currently, there are neither indicators, measuring decarbonization effectiveness at the level of a business entity, nor a clear algorithm quantifying dynamics of the indicators. It is proposed to introduce an internal quality system for managing decarbonization at intervals which would satisfy the needs of both internal and external users of the information. This system should be considered in dynamics with further determination of the certain standards. The five proposed tendencies are not a complete list, which will be supplemented over time. However, they may become the basis to develop 'Indicators for achieving low-carbon practices and zero carbon emissions' within the framework of the decarbonization management system. The list of the indicators which can measure potentially achievements of low-carbon practices as well as zero carbon emissions (Table 2) has resulted from processing of normatively regulated information requests to business entities.

Decarbonization efficiency at the enterprise level is analysed after the data were obtained and systematized in terms of each indicator. Then, boundary values are identified and unified to determine a degree of the goal achievement. The sequence of decarbonization efficiency measuring using a mathematical apparatus and neuroprogramming should consist of following steps.

Step 1. A range of changes in quantitative indicators is defined depending upon the degree of the problem solving or the goal achievement. While measuring qualitative indicators, it is also important to identify boundaries of changes in the indica-

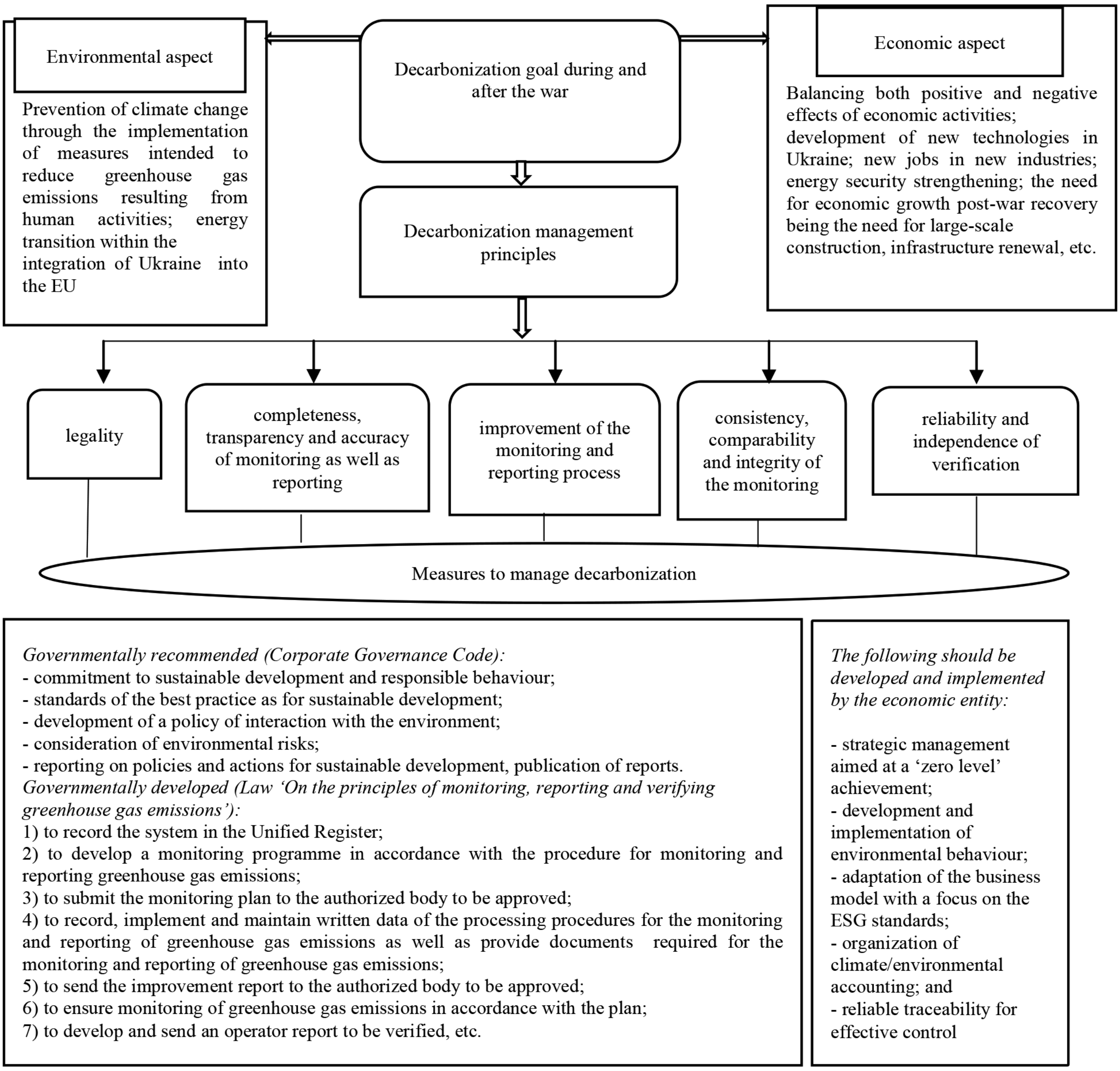

Fig. 2. Decarbonization management in Ukraine

tors (1 is performed; and 0 is not performed). Combination of business activity analysis and the specific functions of the indicator control becomes the basis for the development of analysis procedure as for boundaries of changes in the proposed indicators.

Step 2. Complex of the indicators is described through the interval system

$$LC_i^1 \le X_i \le LC_i^2,$$

where X_i is the i^{th} indicator; LC_i^1, LC_i^2 are boundaries of changes in X_i index (0–10 for quantitative; 0–1 for qualitative); $i = \overline{1,n}$ where n is the number of the considered indicators. In the context of component 1, 'Strategic management intended to achieve 'zero level' proposes n = 12 (Table 2). However, it is possible to add indicators taking into consideration both specific nature and activity types of the specific business entity or making response to information request by external and internal users.

If the resulting indicator measuring decarbonization efficiency at the level of a business entity during the period does not meet the minimum required level (determined by internal or external recommendations listed in Fig. 2), then it becomes a signal to the business entity management to make effective rapid changes. If there is neither response by the management to the business entity nor the situation correction, then sanctions from external levels of decarbonization control will be only intensified under the conditions of European integration.

Step 3. Use of low-carbon practice achievements as well as zero carbon emissions of the neural network for the efficient management and control as for weight determination of indicators in five synthetic components.

The neural network functioning to achieve the resulting indicator being 'low carbon practice and zero carbon emission achievement' is provided as follows:

1) input data concerning individual indicator measuring are supplied to the network input;

2) any neuron is represented as a single computation node receiving input signals from other neurons

$$A_j = \sum_{i=0}^{L^*} (y_i^{n-1} \cdot R_{ij}^n),$$

where L^* is the number of neurons within previous level; y_i^{n-1} is the i^{th} neuron yield within the previous level; R_{ij}^n is a weight factor to combine the i^{th} neuron from the previous level with the j^{th} neuron for which the input signal has been calculated;

Table 2

Indicators to achieve low-carbon practices and zero carbon emissions at the level of economic entity

Synthetic indicators	Limits of change	Measuring indicators
1. Strategic management aimed at 'zero level' achievement (strategic level)	0–10	Decarbonization corresponds to your overall business strategy
	0–10	Staff have a general understanding of a climate change
	0–10	Bonus payments for managers depend upon environmental indicators
	0–10	Use of renewable energy sources
	0–10	Bonus payments for staff depend upon environmental indicators
	0/1	Reports on low-carbon practice achievement are drawn for internal stakeholders
	0/1	Reports on low-carbon practice achievement are drawn for external stakeholders
	0–10	Public information is provided on emission data
	0/1	Liability for violation of ESG principles
	0–10	Investing in sustainability managers
	0–10	Investing in energy managers
	0–10	Total wind and solar energy production costs are reduced
2. Development and implementation of environmental behaviour (administrative level)	0–10	Indicators of carbon emission amount are measured
	0–10	All initiatives are substantiated environmentally
	0/1	Understanding of climate risks and opportunities has become part of doing business at every level
	0/1	Increase in environmentally friendly activity funding
	0/1	Availability of savings from LED lighting updates
	0/1	Availability of savings from water conservation renewal
	0/1	Availability of savings from air conditioning modernization
	0/1	Availability of savings from ventilation system modernization
	0–10	Pressure by users as for ESG initiatives
	0–10	Pressure by investors as for ESG initiatives
	0–10	Competitors succeed in ESG initiatives
3. Adaptation of the business model with a focus on ESG standards (organizational level)	0–10	Intensification of internal ESG norms and standards
	0–10	Continuous monitoring of potential legislative changes
	0/1	Internal strategy has been developed to ensure adaptation to reporting requirements varying and widening constantly
	0/1	A measure of carbon social cost is calculated to show the quantitative economic impact by emissions
	0–10	Collection of consistent, reliable and suitable data has been organized for comparative analysis of information related to the climate
	0/1	Provision of information has been organized being consistent, reliable and suitable for comparative analysis of climate topics for users at all levels
4. Organization of climate/environmental accounting. (information and accounting level)	0/1	Reporting to regulatory authorities
	0/1	Cooperation has been established with independent third-party certifiers
	0/1	Enquirers by investors as for carbon emission level are answered
	0/1	Enquirers by users as for carbon emission level are answered
	0–10	Implementation of carbon off-set program
	0–10	Achievement of indicators of 'green financing' program implementation
	0–10	Level of tax credit use initiatives associated with zero emission
	0–10	Forming the history of impact by climate at the business entity level
5. Ensure reliable traceability (control/monitoring)	0–10	Obtaining accurate data as for emissions
	0/1	Sensors are applied to measure pollution
	0/1	Sensors are applied to measure energy consumption
	0/1	Machine learning reveals consumption and emission regularities
	0/1	Blockchain is the mechanism to obtain the required verification
	0–10	Tools in the form of reports and analytics, based upon the verified data, have been developed and are applied
	0–10	Real-time data are collected and integrated
	0/1	Data input is performed automatically
	0/1	Information on emissions is represented in publicly available reports where the data can be traced back to the primary source
	0–10	Problem areas as well as manual operations, connected with data gathering, are processed
	0/1	Decarbonization strategies are corrected

End of Table 2

3) the network is learned towards error function minimization

$$B^* = \sum_{jr} (y_{jr}^n - C_{jr})^2,$$

where y_{jr}^n is actual yield of j neuron of n network during supply of the r^{th} input image; C_{jr} is desired yield of such a neuron;

4) the function identifies correspondence of the actual network yield to the desired output value for the specified data set. Through change in the weight factors and shifts, the network adapts for the input data to minimize error between the actual and desired output value;

5) if difference between the actual and desired input exceeds the allowable one, then the weight factors for the nth level within Z iteration experience correction

$$R_{ij}^n = v_{ij}^n + \Delta R_{ij}^{n(Z)};$$

$$\Delta R_{ij}^{n(Z)} = (F-1)KL_j^n y_i^{n-1} + (1-Z)KF\Delta R_{ij}^{n(Z-1)};$$

$$L_j^n = \frac{dy_j}{dA_j} L_j^{n+1} \sum_i R_{ij}^{n+1};$$

$$L_j^{n^*} = \frac{dy_j}{dA_j}(y_j^{n^*} - C_j),$$

where L_j^n is calculated for internal layers; $L_j^{n^*}$ is calculated for the output layer; K is a weight change rate factor; F is inertia coefficient; $\frac{dy_j}{dA_j}$ is activation function derivative.

The learning process involves iterative optimization of the loss function through optimization methods (gradient descent). The objective is to search for such values of weight factors and shifts, which provide minimally possible error between network output values and the desired values. If the network learning error is minimized for the certain group of input data, then the following group is selected. The process is repeated iteratively until the error becomes acceptable for all available retrospective data or the predetermined number of iterations will be performed to learn the network.

Hence, the input signals (i. e. calculated qualitative and quantitative indicators) shape a vector, which is the argu-

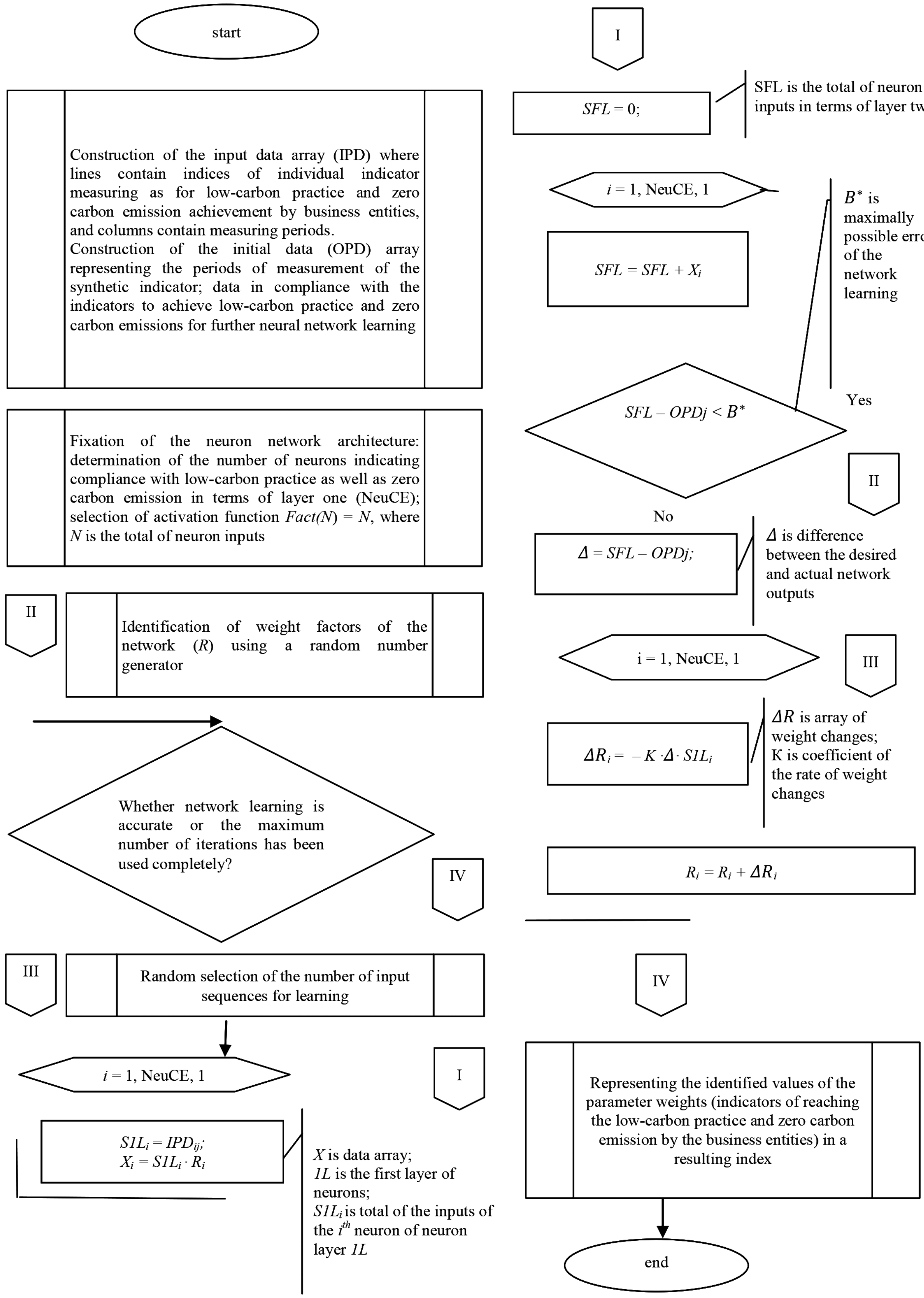

Fig. 3. Measuring procedure of indicators as for low-carbon practice as well as zero carbon emissions at the level of business entity

ment for neuron function activation. Connections between neurons of two layers of the network (i.e. weight coefficients) define the importance degree for each information connected by means of the relation. When the signals are passing through the connections, each signal is multiplied by a relevant weight coefficient; the total of all products, inclusive of a shift, creates input for activation function of the neuron. Such an operation helps neuron network identify non-obvious dependencies and forecast complex dynamic processes.

Fig. 3 demonstrates the algorithm for searching components of the indicators in terms of the specified 'Achievement of low-carbon practice as well as zero emissions of an enterprise' based upon apparatus of neuron networks [19].

Consequently, evaluation of decarbonization efficiency at the level of a business entity should take into consideration complexity of the process as well as nonavailability of the developed universal measurement indicators. The current analytical tools make it possible to trace the process operationally and supply the generalized information for external reporting. As a result of the measures, the results will be obtained at the management level of a business entity as for decarbonization:

a) the documented ESG policies and procedures as for following the decarbonization course;

b) the documented ESG principles as part of a development strategy by the enterprise;

c) consideration of the ESG factors while proper strategy planning;

d) procedures of monitoring effort in the field of the sustainable development;

e) indicators of implementation of sustainable development projects, and its approaches into proper business model;

f) digitalization of the data and processes to increase confidence, and verify the results;

g) continuous monitoring of compliance with the ESG policy.

Conclusions. As the study of decarbonization processes at the governmental level has shown, subsidies, grants, and tax benefits for businesses, investing in decarbonization projects, are the most effective tools. At the local level, business entities must meet the requirements of customers, regulators and investors; improve the quality of environmental and social risk management; and make management more transparent for effective reconstruction and post-war modernization. Hence, it is proposed at the level of economic entities to develop specific measures meeting the regulatory requirements for decarbonization at the state level, which will become an effective continuation of decarbonization management tools. They cover the whole activity types of a business entity; moreover, they should involve the following tendencies: strategic management aimed at a 'zero level' achievement; development and implementation of environmental behaviour; the business model adaptation with a focus on ESG standards; organization of climate/environmental accounting; and reliable traceability for effective control. To solve the problems of nonavailability of indicators to measure decarbonization efficiency at the level of a business entity as well as clear algorithm for quantitative determination of dynamics of the indicators, it is proposed to introduce internal system of decarbonization management quality with periodicity, and with further establishment of the certain standards. Based upon the management system, a list of indicators has been developed which can measure potentially the achievements of low-carbon practice as well as zero carbon emissions. Consequently, the tools and specific measures, managing decarbonization processes at the governmental and local control are intended to favour economic stability, and development during the martial law. The measures will help the country use resources efficiently and mitigate economic impact by the conflict.

Further vector of the study is the construction of a factor model of decarbonization efficiency at the level of economic entity being the important tool for research and analysis. The model construction will make it possible to consider various factors influencing the decarbonization process and determine their importance while forming the efficiency.

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Сучасні інструменти управління декарбонізацією України на державному й локальному рівнях

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Мета. Розробка інструментарію та конкретних заходів управління процесами декарбонізації на державному й локальному рівнях, що будуть сприяти економічній стійкості та розвитку під час воєнного стану.

Методика. У процесі дослідження використані методи: дедукції, індукції, кейс-стаді метод, системного аналізу й моделювання.

Результати. На державному рівні, найдієвішими інструментами управління процесами декарбонізації є субсидії та гранти, встановлення податкових пільг для підприємств, які інвестують у проєкти декарбонізації. На рівні суб'єктів господарювання розроблені конкретні заходи, що відповідають і нормативним вимогам у частині декарбонізації на рівні держави, і стануть дієвим продовженням інструментів управління декарбонізацією. Вони поширюються на всю діяльність суб'єкта господарювання та мають включати наступні напрями: стратегічне управління, спрямоване на досягнення «нульового рівня», розробка й реалізація екологічної поведінки, адаптація бізнес-моделі з фокусом на стандарти ESG, організація кліматичного/екологічного обліку, забезпечення надійної відстежуваності для ефективного контролю.

Наукова новизна. Набуло подальшого розвитку введення внутрішньої системи якості управління декарбонізацією з періодичністю, яка б задовольняла потреби і внутрішніх, і зовнішніх користувачів інформації, та розглядається в динаміці із подальшим встановленням певних нормативів. Удосконалені методичні засади системи управління декарбонізацією на локальному рівні шляхом розробки індикаторів досягнення низьковуглецевої практики й нульових викидів вуглецю. Запропоновано алгоритм визначення ваги індикаторів додержання етичних принципів у синтетичних компонентах і результуючому показнику щодо досягнення низьковуглецевої практики й нульових викидів вуглецю.

Практична значимість. Отримані результати можуть бути використані органами державної влади при розробці та впровадженні стратегій декарбонізації, розробці економічних інструментів для стимулювання чистих технологій, а також суб'єктами господарювання при впровадженні чистих технологій виробництва.

Ключові слова: *декарбонізація, управління, сталий розвиток, екологічна поведінка, перетворення економіки*

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