



An Institutional Approach to the Decarbonization of the Economy and the Transition to Clean Energy Based on EnergyTech

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INTRODUCTION

Decarbonization of the economy is an important step towards the practical implementation of SDG 7, that is, the transition to clean energy. Among the large-scale national programs for decarbonization of the economy in international practice, we can single out the initiative of the European Union (representing developed countries), Russia and China as developing countries (Popkova, 2022). In the mentioned successful examples, firstly, the state plays a key role in the decarbonization of the economy and the transition to clean energy. Secondly, this transition is carried out based on progressive digital economies and developed Industry 4.0. Therefore, the tool for monitoring, control, and practical implementation of programs for the decarbonization of the economy is high technology in the energy sector—EnergyTech.

This article intends to systematize, analyze and present the successful international experience of the decarbonization of the economy and the transition to clean energy and identify the contribution of the institutions of state regulation and EnergyTech to this transition. To achieve this goal, this article consistently solves a set of the following tasks:

- The patterns of “Market failure” on the way of decarbonization of the economy and transition to clean energy are revealed;
- The international experience of decarbonization of the economy and the transition to clean energy, as well as the contribution of state regulatory institutions to this process, is studied;
- Recommendations are being developed to overcome the “market failure” of decarbonization of the economy and transition to clean energy through an institutional approach to managing the development of EnergyTech.

The work is completed by a combined discussion and conclusion section, where the contribution of the article to the literature is noted, the results of the study are summarized, its limitations are indicated and prospects for further scientific research are outlined.

“Market failure” on the Way to Decarbonization of the Economy and Transition to Clean Energy

This article is based on the Theory of Sustainable Energy, the fundamental provisions of which are the following:

- Sustainable energy is the energy that ensures the practical implementation of SDG 7 (Klemm and Wiese, 2022; Saheb et al., 2022; Wang et al., 2022).
- Decarbonization of the economy is carried out on the basis of the development of sustainable energy (Balaras, 2022; Kany et al., 2022).

The existing literature Awawdeh et al. (2021), Latapí et al. (2021), Ngo et al. (2021), Ren et al. (2022), Taghizadeh-Hesary et al. (2022), Yang et al. (2022) notes that sustainable energy is developing on the basis of corporate social responsibility. The argument put forward is that private business actively supports the UN initiative and consolidates support for the implementation of SDG 7 in its corporate strategies, makes ESG investments in energy. In this regard, in the available literature, sustainable energy is also often called responsible energy (Rehman et al., 2021; Skjølvold and Coenen, 2021; Adamik et al., 2022; Lu et al., 2022).

Since the basis of corporate social responsibility is market freedom, today there is a market approach to the decarbonization of the economy. In accordance with this approach, for the implementation of SDG 7, it is assumed to reduce the energy intensity of production and consumption in the economy, as well as the transition to “clean” (wind, solar) energy (Carbajo and Cabeza, 2022; Huang et al., 2022; Li et al., 2022; Liu et al., 2022; Safarianzengir et al., 2022; Zhang et al., 2022).

The problem is that corporate social responsibility is unstable, difficult to control, predict and manage at the macroeconomic level. Its contribution to the decarbonization of the economy is insufficiently studied at the empirical level of science. There is a gap in the literature due to insufficient elaboration of the causal relationships of decarbonization of the economy.

Practical experience shows that a high level of market freedom does not guarantee sustainable energy development. For example, Qatar is classified by The Heritage Foundation (2022) as a mostly free economy and is ranked 44th in the world in terms of economic freedom, but its carbon emissions in 2020 increased by 16.52 million tons/18.31% compared to 2015 (Our World in Data, 2022). Similarly, Albania is classified by The Heritage Foundation (2022) as a mostly free economy and is ranked 50th in the world in terms of economic freedom, but its carbon emissions increased by 38.945 million tons/0.66% in 2020 compared to 2015 (Our World in Data, 2022). The Philippines is classified by The Heritage Foundation (2022) as a mostly free economy and is ranked 80th in the world in terms of economic freedom, but their carbon emissions in 2020 increased by 23.88 million tons/21.29% compared to 2015 (Our World in Data, 2022).

In contrast, Venezuela is classified by The Heritage Foundation (2022) as a repressed economy and is ranked 176th in the world in terms of economic freedom, but its carbon emissions in 2020 decreased by 95.51 million tons/53.02% compared to 2015 (Our World in Data, 2022). These examples demonstrated the “failure of the market” on the path of decarbonization of the economy and the transition to clean energy. This raises a research question (RQ) about how to overcome the identified “market failure” on the way to

decarbonization of the economy. In this article, the hypothesis is put forward that the institutions of state regulation and EnergyTech can solve the problem posed and ensure the decarbonization of the modern economy.

International Experience of Decarbonization of the Economy and Transition to Clean Energy and the Contribution of State Regulatory Institutions To it

To test the hypothesis and determine the role of state regulatory institutions in the decarbonization of the economy, it is necessary to consider the available statistics and analyze it. One of the most reliable and relevant indicators of the level of development of institutions of state regulation of the economy, determined by The Heritage Foundation (2022), is to ensure public institutions embed strong governance principles, build a long-term vision and establish trust by serving their citizens.

Based on the rating for 2020, a sample of the top 10 developed and top 10 developing countries was formed by the level of development of institutions of state regulation of the economy. For this sample, data were collected on annual CO₂ emissions in 2015 (the period of the adoption of the SDGs under the auspices of the UN) and in 2020 (the beginning of the “Decade of Action”) on the assessment of (Our World in Data, 2022). These data are summarized in **Table 1**, where their system analysis is also performed.

Using the variation analysis method, the homogeneity of the sample is estimated. The trend analysis method is used to determine the increase in annual carbon emissions in 2020 compared to 2015. The correlation analysis method is used to determine the relationship of institutions with carbon emissions. Using the method of comparative analysis, the results in developed countries are compared with the results in developing countries.

The results obtained in **Table 1** indicate that the level of development of institutions in developed countries is very high (on average it is estimated at 72.50 points in 2020) and homogeneous (variation is 5%). The decarbonization rate is very high: Annual CO₂ emissions decreased by an average of 13.57% in 2020 compared to 2015. Institutions play an important role in achieving decarbonization—their correlation with carbon emissions in 2015–2020 is estimated at 56.23% (the negative value of the correlation coefficient indicates that the higher the level of development of institutions, the lower the amount of carbon emissions).

In developing countries, the level of development of institutions is lower (on average, it is estimated at 53.03 points in 2020) but also homogeneous (the variation is 15%). Due to large differences in the amount of carbon emissions (their variation in 2015 was 119.99%, and in 2020—116.86%), despite the achievements of individual countries (for example, in Argentina decarbonization was 18.41%, in Chile—0.79%, in Russia—2.47%), the amount of carbon emissions in 2020 increased by an average of 0.54% compared to 2015. Institutions play a slightly less important role (compared to

TABLE 1 | State regulatory institutions in 2020 and decarbonization of the economy in 2015–2020 in developed and developing countries.

Category of countries by the development of institutions	Country	Ensure public institutions embed strong governance principles, build a long-term vision and establish trust by serving their citizens, score 1–100	Annual CO ₂ emissions, million tonnes		
			2015	2020	Growth, %
Developed countries	Finland	78.5	44.13	39.29	-10.97
	Switzerland	76.8	38.73	32.30	-16.60
	New Zealand	73.0	36.07	33.48	-7.18
	Denmark	72.0	35.20	26.19	-25.60
	Netherlands	72.0	164.20	138.10	-15.90
	Sweden	70.3	43.60	38.63	-11.40
	Austria	69.9	66.35	60.63	-8.62
	United States	67.5	5,370.00	4,710.00	-12.29
	Arithmetic mean	72.50	724.79	634.83	-13.57
	Variation, %	5.00	259.04	259.44	-42.94
	Correlation with institutions, %	-	-56.23	-56.23	-
Developing countries	China	64.3	9.85	10.67	8.32
	Chile	61.9	81.82	81.17	-0.79
	Indonesia	58.8	551.48	589.50	6.89
	South Africa	53.9	450.57	451.96	0.31
	India	49.4	2,270.00	2,440.00	7.49
	Turkey	47.7	381.33	392.79	3.01
	Argentina	45.4	192.41	156.98	-18.41
	Russia	42.8	1,620.00	1,580.00	-2.47
	Arithmetic mean	53.03	694.68	712.88	0.54
	Variation, %	15.02	116.86	119.99	1,595.46
	Correlation with institutions, %	-	-52.74	-49.58	-

Source: Calculated and compiled by the authors on the basis of materials.

developed countries) in achieving decarbonization—their correlation with carbon emissions in 2015 was estimated at 49.58%, and in 2020—at 52.74% (negative values of correlation coefficients indicate that the higher the level of development of institutions, the lower the amount of carbon emissions).

Overcoming the “Market Failure” of Decarbonization of the Economy and the Transition to Clean Energy Through an Institutional Approach to Managing the Development of EnergyTech

The obtained results revealed a significant potential of the institutions of state regulation of the economy in ensuring decarbonization. In this regard, to overcome the “market failure” of decarbonization of the economy and the transition to clean energy, this article suggests an alternative—an institutional approach to managing the development of EnergyTech. The essence of the proposed new approach is to develop institutions and tighten state regulation of EnergyTech. To determine the prospects for the practical implementation of the proposed approach, it is necessary to refer to the best practices of modern countries implementing decarbonization strategies.

The countries of the European Union have adopted the Global Climate Action: 2050 long-term strategy (European Commission,

2022). According to the calculations of the International Renewable Energy Agency (2022) in Denmark (as one of the leading countries in decarbonization in the EU) in 2020, onshore wind energy prevails (46.9%). The share of solid biofuels (18.7%), offshore wind energy (17.6%) and solar photovoltaic (13.4%) is also high.

Russia is implementing the Strategy of socio-economic development of Russia with a low level of emissions of greenhouse gases until 2050, approved by the decree of the Government of the Russian Federation (2022) dated 29 October 2021, No. 3052-R. According to the calculations of the International Renewable Energy Agency (2022) in Russia in 2020, the basis of renewable energy was renewable hydropower (90.8%). China has a strategy to achieve carbon neutrality by 2060 (UN, 2022). According to the calculations of the International Renewable Energy Agency (2022) in China in 2020, despite the predominance of renewable hydropower (36.7%), onshore wind energy (29.5%) and solar photovoltaic (27.4%) are highly developed.

The cited experience of Russia and China shows the wide possibilities of renewable hydropower, the advantage of which in comparison with wind and solar energy is high and stable performance. This makes it possible to move from saving energy to improving energy efficiency in energy production, that is, to manage sustainable energy not from the demand side, but from the supply side.

DISCUSSION AND CONCLUSION

Thus, the hypothesis is proved that the institutions of state regulation and EnergyTech can solve the problem and ensure the decarbonization of the modern economy. Unlike Awawdeh et al. (2021); Adamik et al. (2022); Latapi et al. (2021); Lu et al. (2022); Ngo et al. (2021); Rehman et al. (2021); Ren et al. (2022); Skjølsvold and Coenen (2021); Taghizadeh-Hesary et al. (2022); Yang et al. (2022) found that state intervention in market processes does not create barriers, but on the contrary, stimulates and accelerates sustainable energy development. The theoretical significance of this conclusion is that it allows the development of institutions of state regulation of the economy in support of sustainable energy.

In contrast to Carbajo and Cabeza (2022); Huang et al. (2022); Li et al. (2022), Liu et al. (2022), Safarianzengir et al. (2022); Zhang et al. (2022), it was revealed that the “clean” energy sector does not necessarily have to be unstable and unproductive. The analysis of case studies on Russia and China shown that sustainable energy can be based on reliable and highly efficient hydroelectricity. The conclusions obtained in this study allow us to recommend an institutional approach to the decarbonization

of the economy and the transition to clean energy based on EnergyTech, which is the contribution of the article to the literature. The practical significance of the article is that the proposed new approach improves the practice of SDG 7 implementation.

However, the results of the study are limited by the recommendation to develop institutions in support of EnergyTech and SDG 7, while the process of evolution and increasing the effectiveness of institutions remained outside the scope of the study. Thus, the reduced effectiveness of institutions in supporting decarbonization in developing countries deserves closer study. In further research, it is also advisable to develop concrete and applied measures for the development of EnergyTech institutions in support of decarbonization, taking into account the characteristics of developing countries.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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