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POTENTIAL FOR IMPROVING INDUSTRIAL ENERGY EFFICIENCY IN KAZAKHSTAN AND UKRAINE

UNECE

Study cut-off date: 31 December 2021

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Abbreviations

BAT - Best Available Technologies

BF-BOF - Blast Furnace-Basic Oxygen Furnace

BREF - Best Available Techniques Reference Documents

CO_2 - Carbon Dioxide

DRI-EAF - Direct Reduced Iron-Electric Arc Furnace

EAP - Energy Audit Programme

EED - Energy Efficiency Directive

EMS – Energy Management System

EnPI - Energy Performance Indicator

EPC - Energy Performance Contracts

ESCO - Energy Service Companies

ETP – Energy Technologies Perspective

GDP – Gross Domestic Product

GES – Groningen Environmental Service

GHG – Greenhouse Gas

GVA - Gross Value Added

IEA – International Energy Agency

ISIC - International Standard Industrial Classification

ISO - International Standards Organization

LIEN - Large Industry Energy Network

PPP - Purchasing Power Parity

RPTC - Regular Programme of Technical Cooperation

SME – Small and Medium Enterprises

TFC – Total Final Energy Consumption

TRL - Technology Readiness Level

UNECE – United Nations Economic Commission for Europe

UNFCCC – United Nations Framework Convention on Climate Change

UNIDO - United Nations Industrial Development Organisation

EXECUTIVE SUMMARY

Kazakhstan and Ukraine both have relatively high final energy consumption, of which about one third is used by the industry sector. This sector in both countries is primarily powered by coal and electricity, and driven primarily by the production of iron and steel.

To assess industrial energy productivity, a set of indicators for the sector have been assessed and defined, and are presented in detail in this report. Based on this approach, the required data was collected from a series of free, accessible databases. Because of this, the analysis is limited to the available data. Within the available datasets, the definitions of the sector industry and its associated sub-sectors differ. Therefore, the availability of outcomes from this analysis may differ across sub-sectors, including for the highly energy-intensive "iron and steel" sub-sector. As a result, the significance derived from the outputs vary, and consideration of context and applicability should be taken into account when assessing the conclusions.

There are many potential strategies for addressing energy use and emissions reduction within the industrial sector of Kazakhstan and Ukraine. As the energy sources within the industry sector are mainly coal and electricity, one impactful strategy for reducing greenhouse gas emissions is to increase the use of renewables within the electricity generation mix. Among cross-cutting technologies, district heating is also recognized, as the share of heat used by the industrial sector in both countries is quite high. Various other technological options are also described.

The case studies presented in the study are primarily focused on enablers of energy efficiency, such as energy management systems and energy audits. Therefore, as part of an overall strategy, actions enabling improvement of energy productivity and reduction of carbon intensity should be considered in addition to technological options (e.g., deployment of advanced production technologies, process optimization, deployment of innovative and cross-cutting technologies, fuel switching, etc.).

The study identifies two main categories of business models, which were found to be suitable for implementation in Kazakhstan and Ukraine. First, models to accelerate technological change could be used, in which specific legislation and regulations are developed and implemented. These support swift modernisation of existing industrial facilities, as well as the utilisation of advanced technologies for newly designed facilities. Examples include mandatory and voluntary energy audits, energy management systems, use of best available technologies, and standards for industrial equipment. Second, governments should consider models that mobilise and scale-up industrial actions, in which various stakeholders initiate collaborative action to increase implementation of state-of-the-art technologies and share best practices. Examples include voluntary agreements, industrial networks, financial mechanisms, and incentives.

While some legislative measures related to industrial energy efficiency have already been adopted in Kazakhstan and Ukraine, more tailored policies are needed to address special needs and local contexts in both countries as well as to accelerate industrial actions to improve energy productivity and efficiency. Following consultations and interviews with various national stakeholders, the study identifies a number of policy options suitable for implementation in Kazakhstan and Ukraine, which are presented in the form of an Outline of a National Policy roadmaps.

INTRODUCTION

Background

The United Nations Economic Commission for Europe (UNECE) provides member states with clear and understandable overviews of non-governmental and intergovernmental energy efficiency initiatives. These overviews support the states in deciding which initiatives and policies are best suited for accelerating the adoption of energy efficiency measures by industrial sector companies. Governments in the UNECE region see value in improving energy efficiency within their industry sector, particularly in the most energy intensive industries. This is viewed as one way to progress in decarbonizing both within the industry sectors themselves and to achieve higher-level commitments under the Paris Agreement.

The Ministry of Industry and Infrastructure Development of Kazakhstan and the State Agency on Energy Efficiency and Energy Saving of Ukraine requested UNECE to provide technical assistance for improving industrial energy efficiency through a set of analysis and recommendations specific to their industrial contexts.

Objective

The objective of the study is to explore the energy intensity of the industry sector and sub-sectors, analyse energy productivity, identify technological options for improving energy productivity and reducing carbon intensity across the sector, identify successful business models to implement technological options, and identify policy options to support improved energy productivity and decarbonization of industry.

Furthermore, the study provides policymakers in Kazakhstan and Ukraine with information on practical steps that they can undertake to promote industrial energy efficiency among companies operating in these countries, thus helping achieve national targets in this area. All work in this study is based on data and context collected prior to 31 December 2021.

This study aims to support the countries as they work to attain the objectives of the 2030 Agenda for Sustainable Development and to meet their commitments under the Paris Agreement in the contemporary context.

Methodology

While the study focuses on Kazakhstan and Ukraine, the employed methodology is designed to be replicable. The four core approaches are:

- Relevant data: To explore energy and emissions of the industry sector, relevant data on energy use in the sub-sectors have been collected and analysed. Important points to consider, especially when comparing with other countries, are described. Data for the industry sector are available for individual sub-sectors and for sections (aggregated sub-sectors) like ‘manufacturing’ or ‘construction’.
- Use of indicators: A short introduction to energy indicators provides basic knowledge of how indicators make energy productivity and carbon intensity visible. Different kinds of indicators can be used, and notes on the requirements for data are provided. Interpretation and analysis of available indicators output suggestions for policy measures, from which further steps can be taken.
- Application of a survey: With the help of a survey, it is possible to collect first-hand information on actual barriers and drivers that complements data analysis at the

individual company level to develop more suitable measures for the industry. The questionnaire developed for this work can generally be re-used in other countries.

- Expert interviews: Experienced experts offer relevant insights and feedback.

Content

The study is divided into four chapters:

Chapter 1: Provides the introduction of data and indicators and the analysis of energy productivity in the industrial sector in Kazakhstan and Ukraine.

Chapter 2: Identifies technological options for improving energy productivity and reducing carbon intensity in the industrial sector.

Chapter 3: Provides an overview of the most applicable business models to implement technological and non-technological measures to improve energy efficiency and energy productivity of industrial facilities, including a menu of best practice case studies suitable for adaptation in Kazakhstan and Ukraine.

Chapter 4: Identifies policy options to support improved energy productivity and decarbonization of industry, presented in an Outline of a National Policy Roadmaps.

The study concludes with a set of recommendations and an Annex, which includes the data used as basis in the figures and copies of the surveys used in the course of this work.

CHAPTER 1: ANALYSIS OF THE INDUSTRY OF KAZAKHSTAN AND UKRAINE

Summary:

Among the countries benefitting from the UNECE Regular Programme of Technical Cooperation (RPTC)[1], Kazakhstan and Ukraine both have relatively high final energy consumption (second and third largest final energy consumers after Turkey) and high use of natural gas and oil products. The industry sector within both countries uses roughly one-third of the nation's energy (Kazakhstan's industry consumes 36 per cent (629 PJ), Ukraine's industry consumes 32 per cent (690 PJ)). Carbon dioxide (CO_2) emissions of industry are quite high, due in part to the large direct consumption of fossil fuels as well as the limited share of renewables within each country's electricity generation mix.

In Kazakhstan, coal and electricity are the two dominating energy sources for industry. Both are mainly used in the "iron and steel" and "non-ferrous metals" sub-sectors, which consume 43 per cent (269 PJ) of the overall final energy consumption of the entire industry sector. The sub-sector "iron and steel" is the largest consumer with 34 per cent (213 PJ) of overall final energy consumption of the industry sector.

The dominating role of "iron and steel" is even more extreme in Ukraine at 53 per cent (360 PJ) of overall final energy consumption of the industry sector. This sub-sector is mainly using coal (181 PJ), as well as electricity, heat, and natural gas (each around 60 PJ).

The following Figures 1 and 2 show relative change of energy intensities as an index comparing MJ/USD PPP 2015 of the three sections (which are aggregated sub-sectors) of Kazakhstan and Ukraine of 2018 in comparison with the basis year 2015 (index value of 2015 = 100).

Figure 1: Indices showing change in energy intensities of the three sections within the industry sector in Kazakhstan, 2015 versus 2018 (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015)

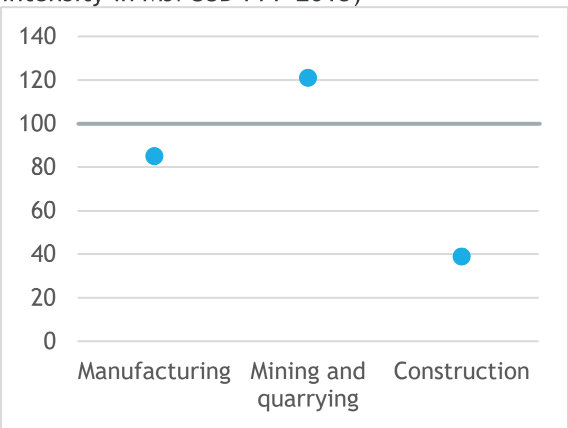
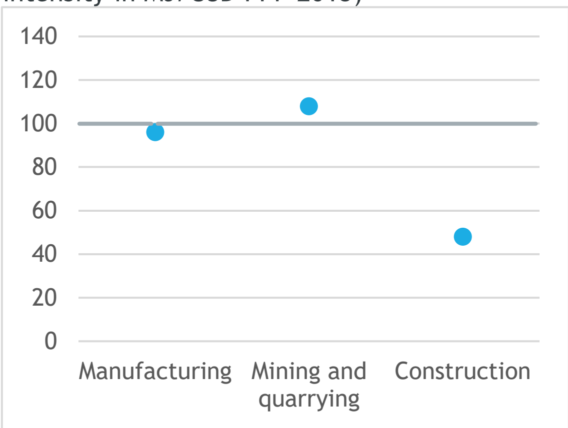


Figure 2: Indices showing change in energy intensities of the three sections within the industry sector in Ukraine, 2015 versus 2018 (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015)

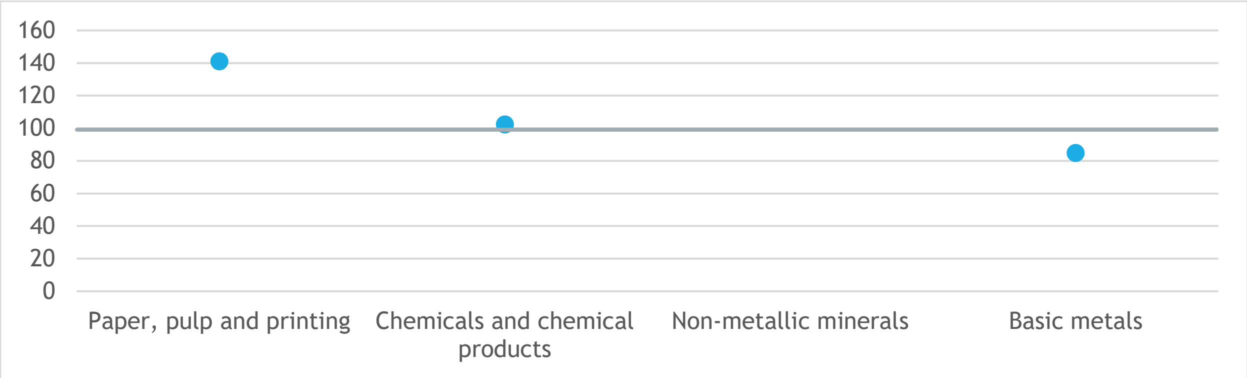


Source for Figure 1 and 2: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) – Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021).

[1] RPTC countries include: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Montenegro, Republic of Moldova, Republic of North Macedonia, Serbia, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan

For some sub-sectors of the 'manufacturing' section, data for the relative change of energy intensities (measured in MJ/USD PPP 2015, reported as index of change over time) are available. Figures 3 and 4 show the index of 2018 for Kazakhstan and Ukraine in comparison with the basis year 2015 (index value of 2015 = 100). The figures show that for both countries the energy intensity for "Basic metals" decreased and "Paper, pulp and printing" increased. In Kazakhstan "Chemicals and chemical products" increased slightly over the period while the same sub-sector increased far more in Ukraine. And for "Non-metallic minerals" the sub-sector energy intensity decreased for Ukraine and is not available for Kazakhstan.

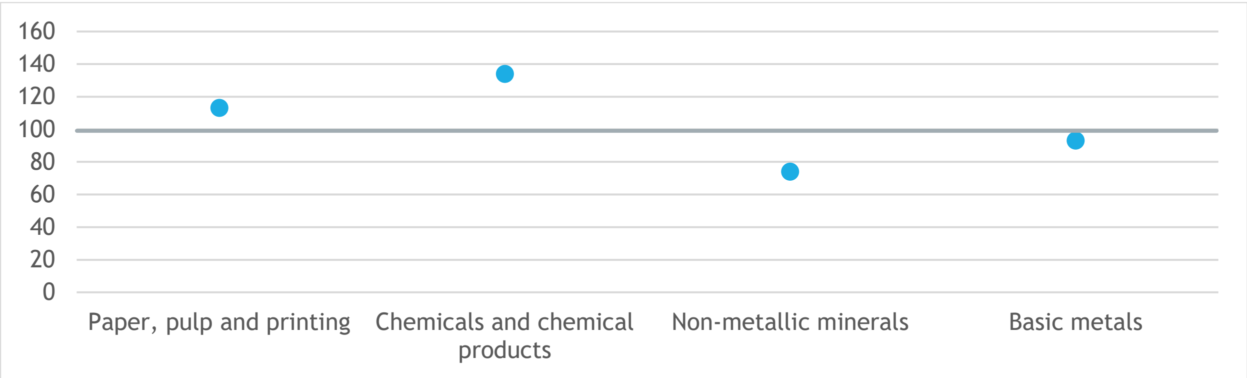
Figure 3: Indices of energy intensities of the sub-sectors in Kazakhstan within the section manufacturing, 2018 (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015)



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) – Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021).

Note: for Kazakhstan, no values for "non-metallic minerals" (per value added energy intensity)

Figure 4: Indices of energy intensities of the sub-sectors in Ukraine within the section manufacturing, 2018 (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015)



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) – Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021).

1.a Methodology for assessment of industrial energy productivity

The goal of this assessment is primarily to assess the 'status-quo' situation in the industry sector. This serves as a basis for comparison with other countries and basis for development of measures to improve energy productivity.

Indicators

In order to enable consistent and useful comparison, it is important to establish indicators for both the overall industry sector and disaggregated by sub-sectors. These indicators are necessary to enable a more detailed analysis and for generating more significant results.

In the following Table 1, indicators are divided into three aggregation levels.

Table 1: Sector and sub-sector indicators

ID	Level	Indicator	Ratio calculation	Usage for analysis
1.0	Level 1: industry sector	final energy consumption	---	comparison across countries
1.1		share of energy sources	= energy source / total	distribution of energy sources → further statements derivable
1.2		energy intensity (monetary value)	= energy input / activity output	express, how much energy is needed to generate value (e. g. one unit GDP) → reflects efficiency
1.3		energy productivity (monetary value)	= activity output / energy input	express, how much value (e.eg. one unit GDP) can be generated by using one unit energy → reflects efficiency
2.0	Level 2: industry sub-sectors	final energy consumption for each sub-sector	---	comparison across sub-sectors → shows relevant sub-sectors
2.1		share of energy sources for each sub-sector	for each sub-sector see 1.1	comparison across sub-sectors; see 1.1
2.2		energy intensity (monetary value) for each sub-sector	for each sub-sector see 1.2	comparison across sub-sectors; see 1.2
2.3		energy productivity (monetary value) for each sub-sector	for each sub-sector see 1.3	comparison across sub-sectors; see 1.3
3.1	Level 3: process/product type industry sub-sectors	energy intensity (physical value) for each process/ product type	for each process/ product type: = energy input / physical output	comparison across same/similar processes/ products
3.2		energy productivity (physical value) for each process/ product type	for each process/ product type: = physical output / energy input	comparison across different processes/ products

Source: The levels follow the pyramid structure of the publication OECD/IEA (2014): Energy Efficiency Indicators: Fundamentals on Statistics. Paris.

Depending on the needs of the analysis, the listed indicators can be modified. They can also apply to the case studies presented later in this paper. The same indicators can also be adapted for emissions, using CO_2 in place of energy to calculate emissions intensity and emissions productivity, as presented throughout this study.

Elements of indicators

In the following Table 2, the elements of the indicators are described in more detail.

Table 2: Elements of indicators

Energy input	Energy always refers to final energy consumption because this is the relevant factor in this approach. This can also be substituted with total emissions for parallel emissions indicators.
Activity output	Activity is monetary value created through production. This can be the gross domestic product (GDP) or the gross value added (GVA). The difference between GVA and GDP are taxes and subsidies. For international comparison the value should be adjusted in purchasing power parity (PPP). If comparing activity output over time, then constant prices should be used.
Physical output	Physical output is the quantity of goods produced. The unit depends on the product.

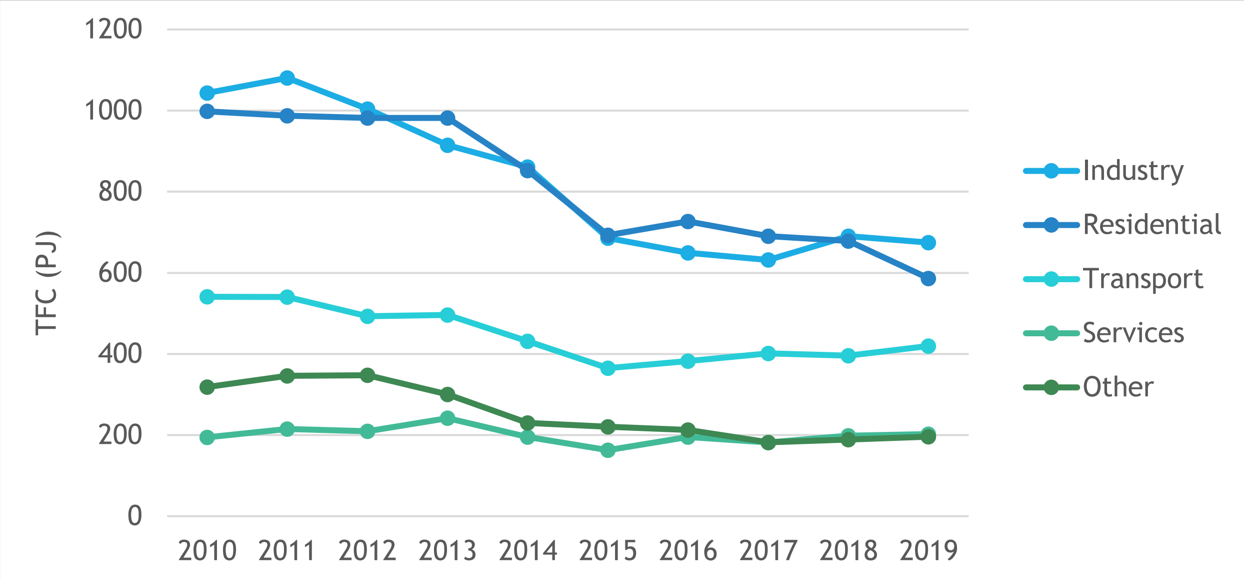
Developments over time

The indicators of Table 1 should not be seen as an exhaustive list. According to the needs of a given analysis, time series or new indicators can be used. This is the case if the development over time is part of the analysis. A time series can be built using the indicators of absolute value to reflect the trend.

As an example, Figure 5 below shows the development of the total final energy consumption (TFC) by sector in Ukraine. It shows a significant decline in energy consumption in the industry sector during the last decade.

Sometimes it is most useful to track change over time as compared to a single basis year in order to assess progress. In this case, indices are used. All indicators in Table 1 can be easily converted into indices by setting a designated basis year. Indices are especially useful if changes from a predetermined starting point must be tracked, for example if a goal is defined such as "reduction of X per cent by year Y". The basis would be the year of setting such a goal or the basis year defined within the goal itself.

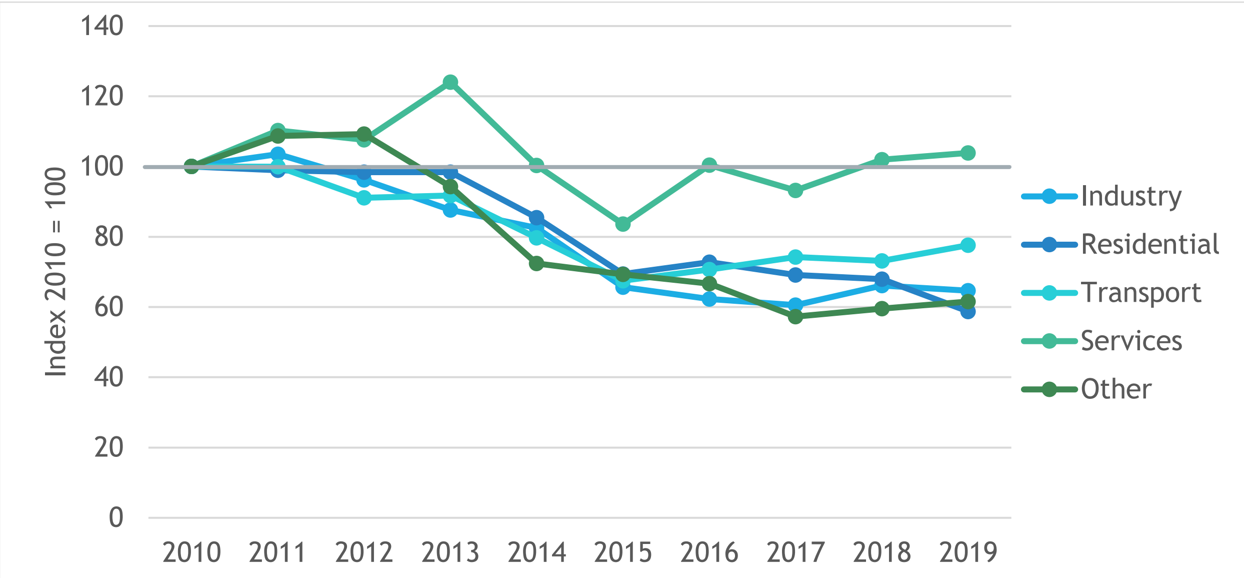
Figure 5: Trends in TFC by sector, 2010-2019 in Ukraine



Source: Based on data of IEA: Ukraine trends in total final energy consumption by sector, 2010-2019. Paris. https://www.iea.org/data-and-statistics/charts/ukraine-trends-in-total-final-energy-consumption-by-sector-2010-2019 (accessed 25.11.2021).

Figure 6 is based on the same data as in Figure 5, but transformed into an index using 2010 as a basis year. The changes since 2010 are clearly visible: the final energy consumption of industry has decreased by almost 40 per cent.

Figure 6: Relative change of TFC by sector in Ukraine, 2010-2019 (index of 2010=100)



Source: Based on data of IEA: Ukraine rate of change in total final energy consumption by sector, 2010 2019. Paris. https://www.iea.org/data-and-statistics/charts/ukraine-rate-of-change-in-total-final-energy-consumption-by-sector-2010-2019 (accessed 25.11.2021).

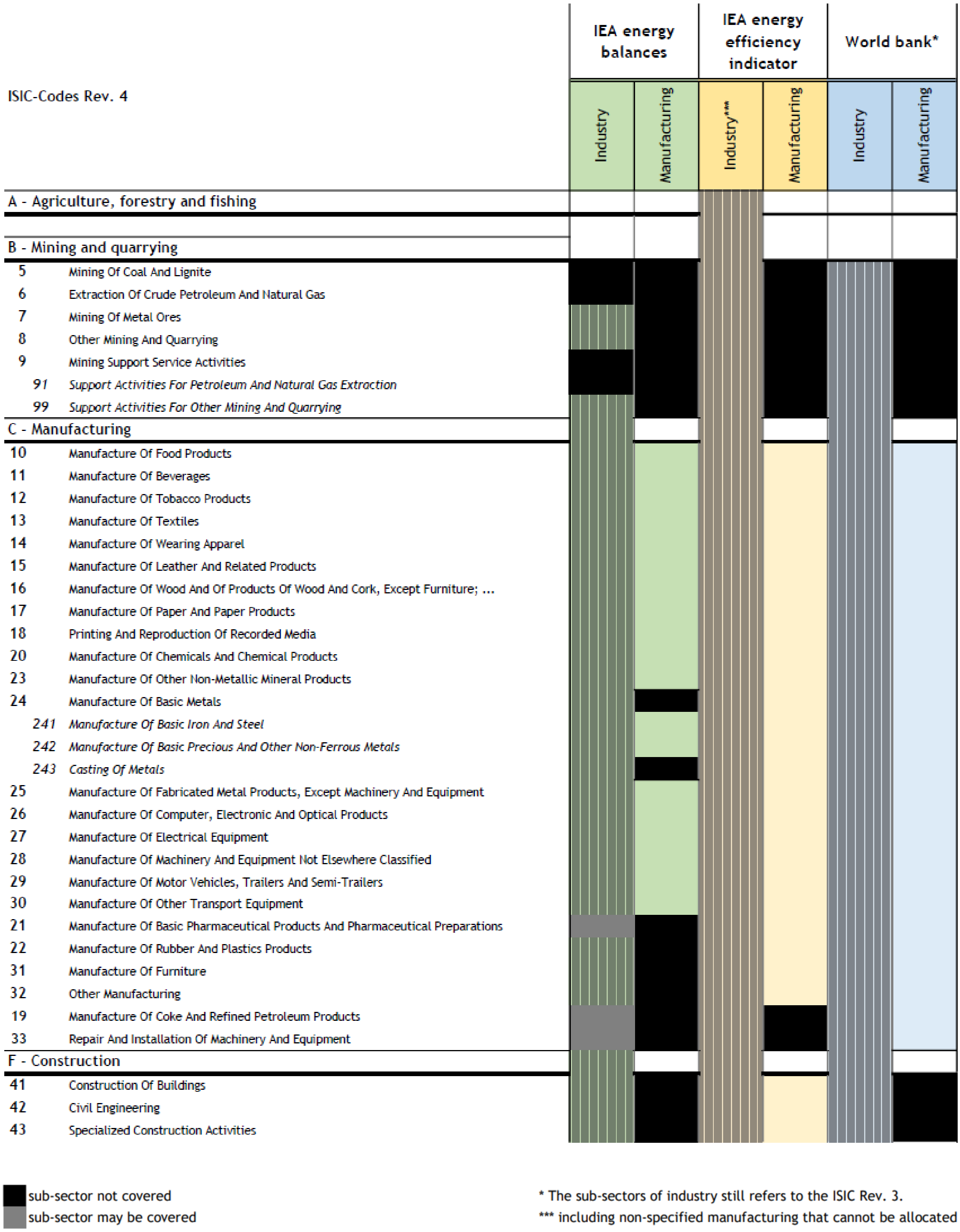
Definition of industry

As there is no agreed definition of industry, end users and sub-sectors within the industry sector designation can vary. As such, it is not always clear which sub-sectors of economic activity are part of statistical data for industry sector. In addition, it is important to note that an additional categorization layer between the industry sector and single sub-sectors is often used. It is an aggregation of single sub-sectors and is referred to as a “section” in this report. Some data sources use up to four sections: ‘agriculture, forestry and fishing’, ‘mining and quarrying’, ‘manufacturing’ and ‘construction’.

It is evident from the list of indicators above that ratio indicators (including indicators 1.2, 1.3, 2.2, 2.3, 3.1, 3.2) only make sense if data for both the denominator and numerator refer to the same industry definition. Otherwise, when calculating the energy intensity, a mismatch may occur (e.g., a ratio of final energy containing only manufacturing to an activity output containing both manufacturing and mining). This would lead to false statements and findings. It is the same when making comparisons, for example, with industry data of two countries from different statistical offices.

Consequently, it should be clear beforehand which sub-sectors are included in consideration. It is easier to compare sub-sectors following the terms of the International Standard Industrial Classification (ISIC). Figure 7 shows a comparison of definitions of industry sector and ‘manufacturing’ section for the three data sources: 1) the IEA energy balances, 2) the IEA energy efficiency indicators, and 3) the World Bank GDP. All three data sources include the ISIC section C (‘manufacturing’) and F (‘construction’) when referring to industry but vary with respect to ISIC section A (‘agriculture, forestry and fishing’) and B (‘mining and quarrying’). Differences also exist in the definition of the term ‘manufacturing’. The definition of ‘manufacturing’ according to ISIC is the section C, which coincides with that of the World Bank. IEA, however, does not include all sub-sectors of section C, and, in the case of the efficiency indicators, does include section F.

Figure 7: Comparison between definitions for industry and manufacturing



Source: Author-developed

1.b Energy consumption across RPTC countries in the UNECE region

Data for final energy consumption were chosen for 2018 because data for 2019, though not marked as provisional, have continued to change during the study phase and still seemed to not be final at the time of this submission.

The main takeaways for Kazakhstan and Ukraine are summarized in the boxes below.

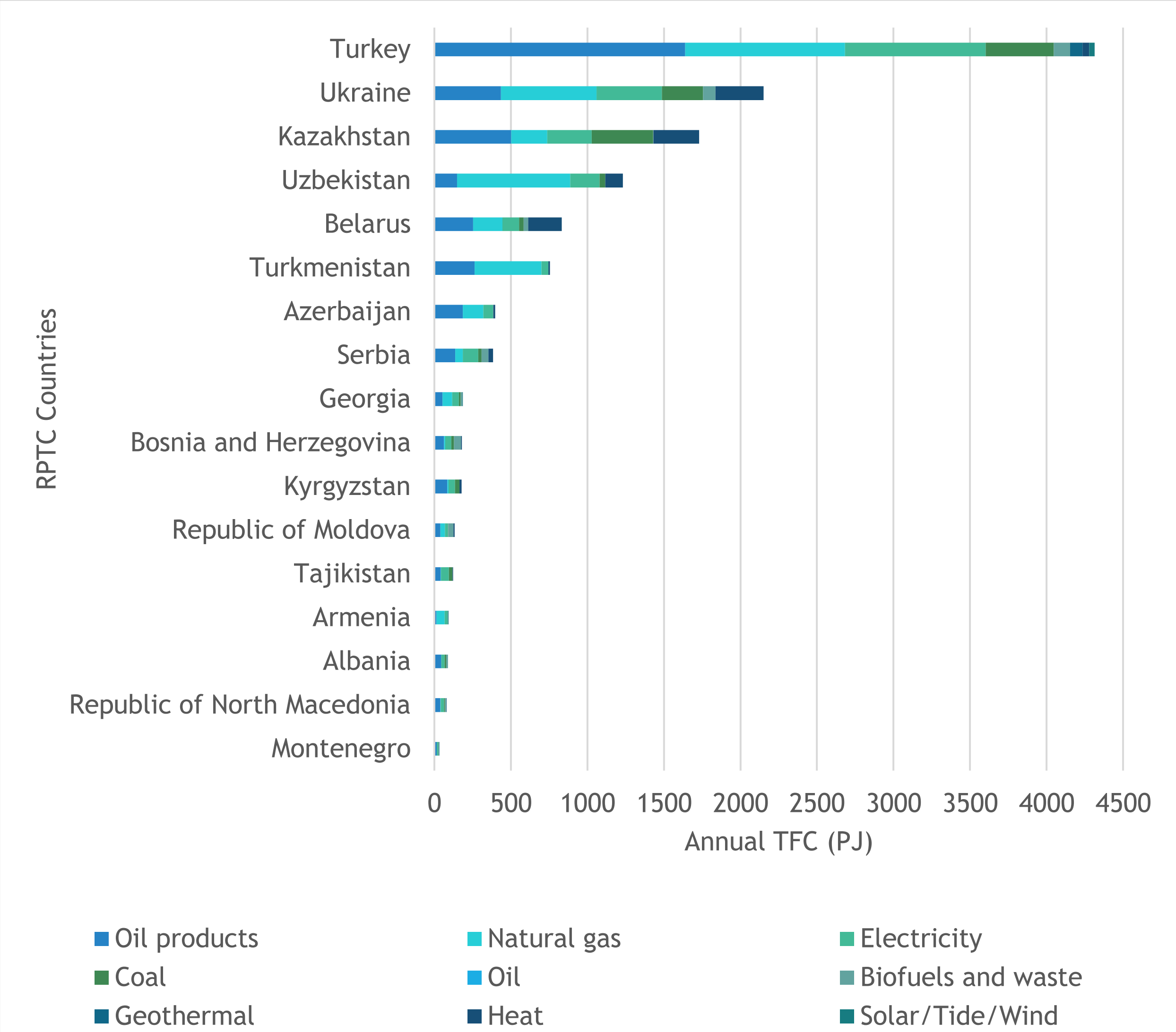
Final energy consumption by sources

Kazakhstan and Ukraine

The data shows that Kazakhstan and Ukraine are two of the top energy consumers among the RPTC countries; both are heavily dependent on fossil fuels including oil products and natural gas for end use consumption. Thus, for these two countries, as well as other RPTC countries with similar energy consumption mixes, there is a real opportunity to both reduce consumption (and resulting emissions) through improving energy efficiency, and to pursue fuel switching toward electrification and clean hydrogen to supplant direct use of fossil fuels.

Figure 8 shows final energy consumption of the RPTC countries in the UNECE region by sources of energy, sorted by the total consumption. Turkey is by far the country with the largest consumption of energy with 4315 PJ, which is around twice that of the second largest energy consuming country Ukraine (2152 PJ). Kazakhstan (1729 PJ) is the third largest energy consumer.

Figure 8: TFC by sources of energy, sorted by total annual energy consumption, PJ, 2018

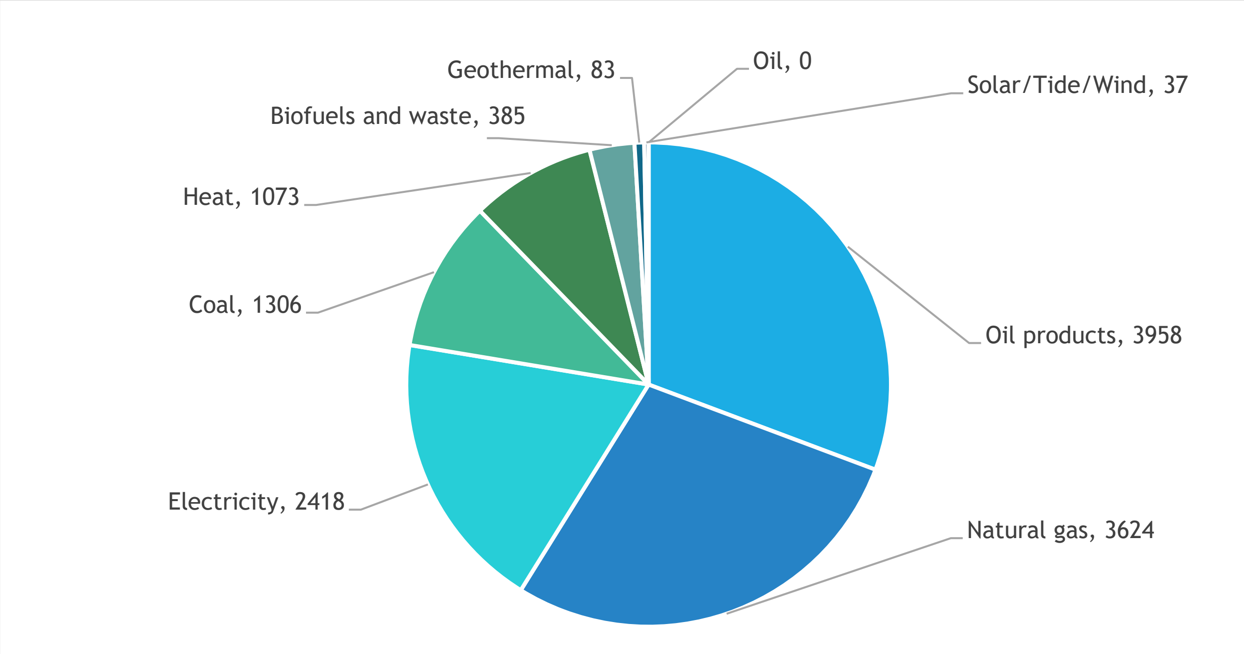


Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

The following analysis considers three aspects. The first two aspects are the absolute quantity (amount) of each energy source and the relative quantity (share) of the energy sources within a country. Figures for each energy source combining both aspects can be found in the Annex (Figure 30 - Figure 37). The last aspect is the distribution of energy sources for all RPTC countries in the UNECE region. The results can be a basis for comparison when reflecting on future steps concerning all RPTC countries in the UNECE region.

Figure 9 shows the TFC of all RPTC countries broken down by source. The largest share (31 per cent of overall consumption, 3958 PJ) is oil products, of which Turkey consumes 41 per cent (1639 PJ). The second largest source consumed is natural gas (28 per cent of overall consumption, 3624 PJ), which is driven by high amounts of consumption concentrated in Turkey (1045 PJ), Uzbekistan (739 PJ) and Ukraine (626 PJ). The third largest source of final energy consumption is electricity (2418 PJ), with Turkey again the dominant consumer responsible for 38 per cent (918 PJ). While Turkey (446 PJ) has the highest consumption within the share of coal (1306 PJ), Kazakhstan’s consumption in coal is also quite high (401 PJ). The fifth largest share is heat (1073 PJ) and here Ukraine (315 PJ) and Kazakhstan (299 PJ) are the two large consumers who are together responsible for 57 per cent of the heat consumption. The four smallest shares are biofuels and waste (385 PJ), geothermal (83 PJ), solar/tide/wind (37 PJ) and oil (0.1 TJ). While oil is only due to the consumption in Kazakhstan, 99 per cent of the renewable energy sources geothermal and solar/tide/wind are due to Turkey.

Figure 9: TFC by sources of energy for all RPTC countries in the UNECE region, PJ, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

When looking at the final energy consumption broken down by source for each country, most of the RPTC countries in the UNECE region have a focus on using natural gas or oil products. Figure 10 below illustrates the largest share of energy source of each country. Natural gas is the largest share in five countries, representing more than half of final energy consumption in Uzbekistan (60 per cent), Armenia (60 per cent) and Turkmenistan (58 per cent). The other eleven countries are mainly using oil products as a lead energy source, led by the Albania and North Macedonia (both 51 per cent). An exception is Tajikistan with 42 per cent use of electricity.

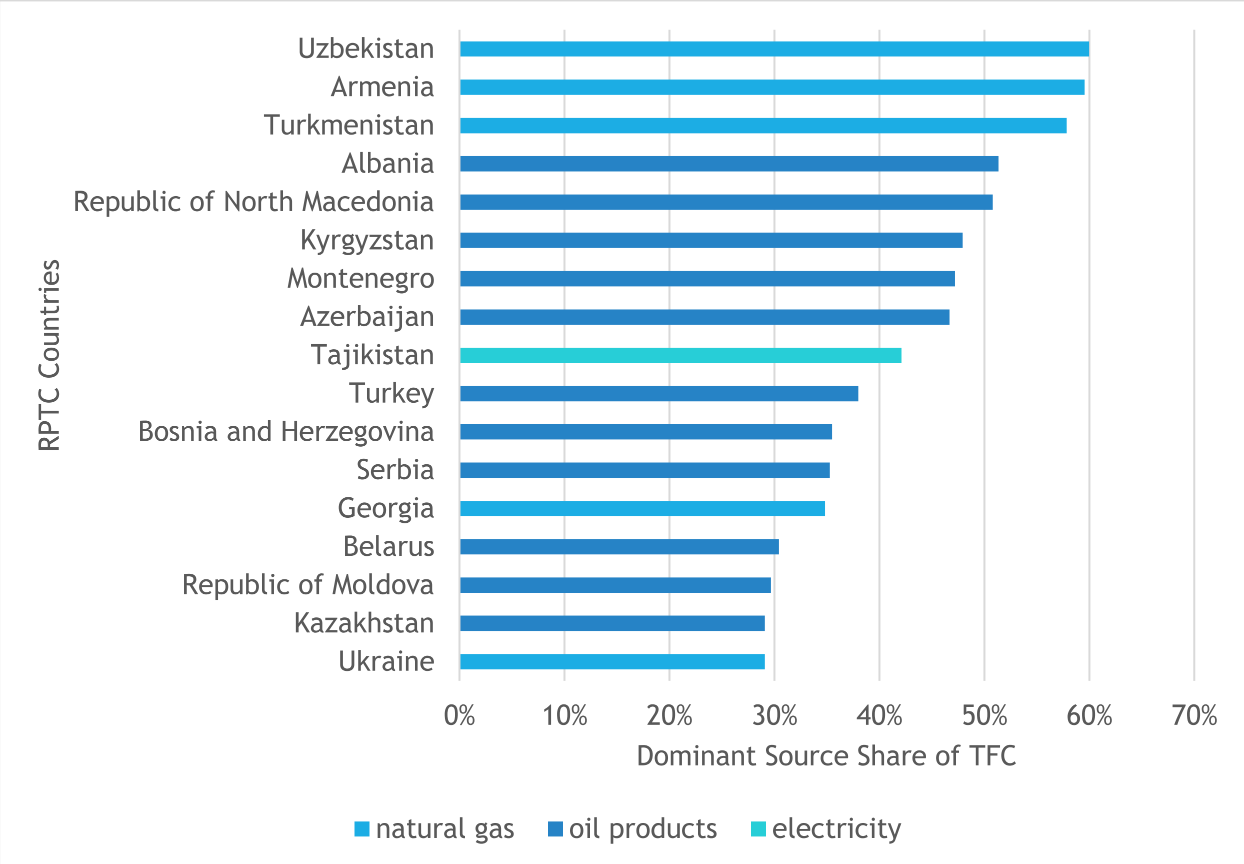
Oil products, natural gas and electricity are three energy sources which play a big role within the RPTC countries in the UNECE region: these three energy sources combined account for at least 60 per cent (Kazakhstan) and up to 99 per cent (Turkmenistan) of the final energy consumption. In eight countries, these three energy sources form the three largest shares of energy consumption.[2] In the other eight countries two of them are represented within the three largest shares. Only in Kazakhstan coal and heat are also dominating the energy consumption along with oil products.

[2] Oil products, natural gas and electricity account for Ukraine 69 per cent, Serbia 75 per cent, Turkey 84 per cent, Georgia 87 per cent, Uzbekistan 88 per cent, Armenia 95 per cent, Azerbaijan 97 per cent and Turkmenistan 99 per cent of the final energy consumption.

Biofuels and waste play a larger role in five countries as it forms the second or third largest shares of the final energy consumption.[3] However this source is very low for Ukraine (3.8 per cent) and have almost no relevance for Kazakhstan (0.2 per cent).

With respect to the final energy consumption of heat, Belarus and Kazakhstan stand out: 26 per cent (representing the second largest share) is consumed in heat in Belarus and 17 per cent in Kazakhstan (representing the third largest share). Ukraine is forth in its share of heat consumption among the RPTC countries (15 per cent of the Ukraine's consumption). However, in absolute terms, Ukraine consumes more heat (315 PJ) than any other country in the group, followed by Kazakhstan (299 PJ).

Figure 10: Highest share of energy source (TFC) for each RPTC country in the UNECE region, sorted by the height of the share, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

[3] Biofuels and waste have the second largest share in Moldova 24 per cent and in Bosnia and Herzegovina 24 per cent. It forms the third largest share in Montenegro 20 per cent, Albania 13 per cent and North Macedonia 10 per cent of the final energy consumption.

Final energy consumption by sectors

Kazakhstan and Ukraine

This section shows evidence that both Ukraine and Kazakhstan, as well as many other RPTC countries, have an energy consumption driven by the industrial sector. This means that addressing energy efficiency and fuel switching to clean sources in this sector will have major benefits in reducing total energy consumption of the two countries (and resulting emissions).

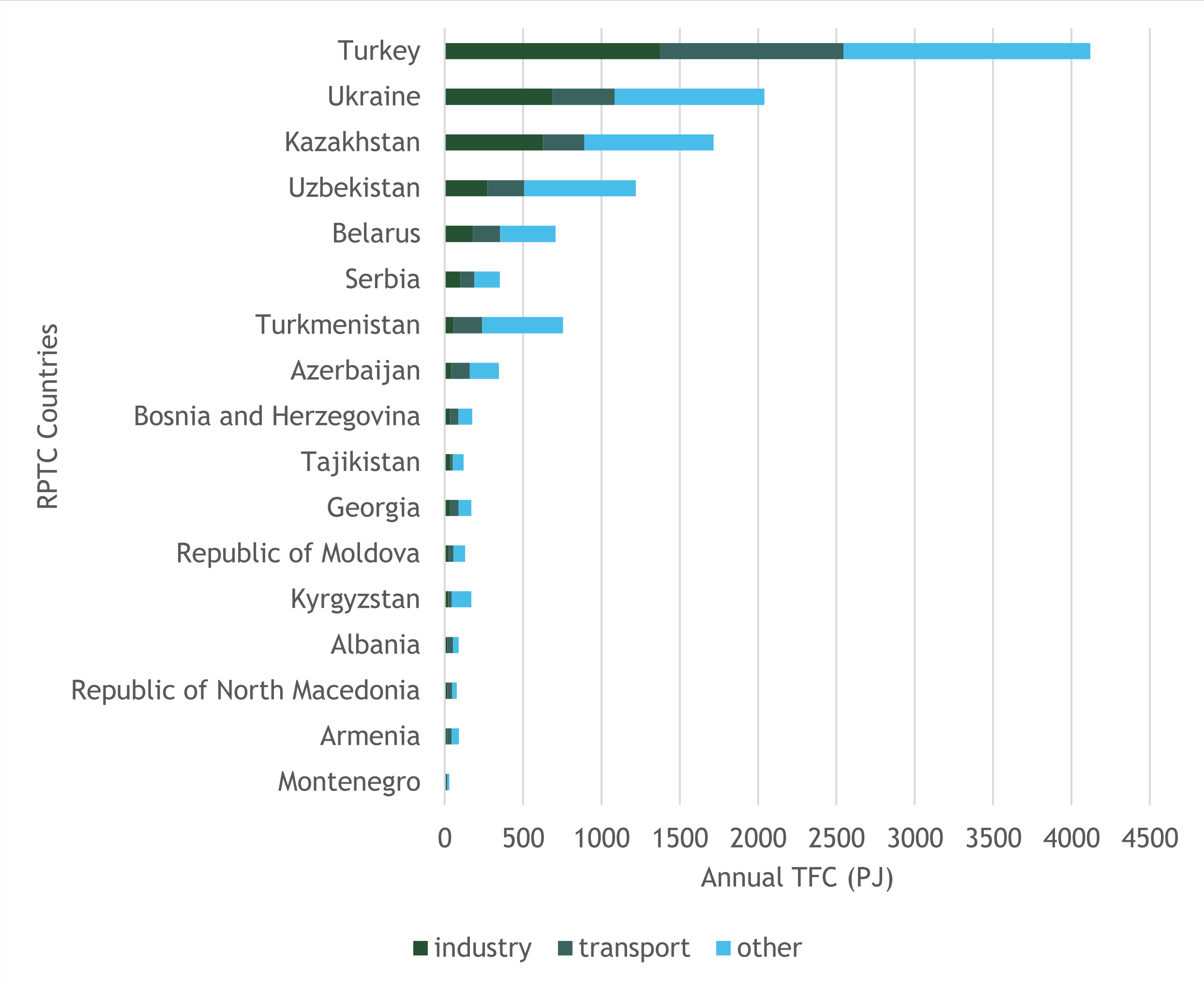
However, for the other RPTC countries where transport is a much larger share of TFC than industry, addressing industrial energy efficiency will have a smaller effect than other energy strategies.

The final energy consumption is divided amongst the industry, transport and other sectors. Figure 11 shows the TFC for each RPTC country split out by “Industry”, “Transportation”, and “Other” sectors.

The three largest final energy consuming countries are also the three with the largest share for industry among the RPTC countries. Kazakhstan’s industry sector consumed 36 per cent (629 PJ) of the nation’s energy use, along with 32 per cent (690 PJ) for Ukraine, and 32 per cent (1375 PJ) for Turkey. For the transport sector, the order is reversed: Turkey consumed 27 per cent (1171 PJ) in transport, Ukraine 18 per cent (396 PJ), and Kazakhstan 15 per cent (263 PJ).

For all three countries the share for industry is higher than that of transport. The same is true for Tajikistan, Uzbekistan, Serbia, Kyrgyzstan, and Belarus. The opposite is the case for the other countries. Among those where transportation out-consumes industry, it is notable that Azerbaijan and Turkmenistan use almost three times as much energy in transport as in industry (31 per cent versus 11 per cent, and 22 per cent versus 7 per cent, respectively).

Figure 11: TFC by sectors, sorted by Industry energy use, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021)

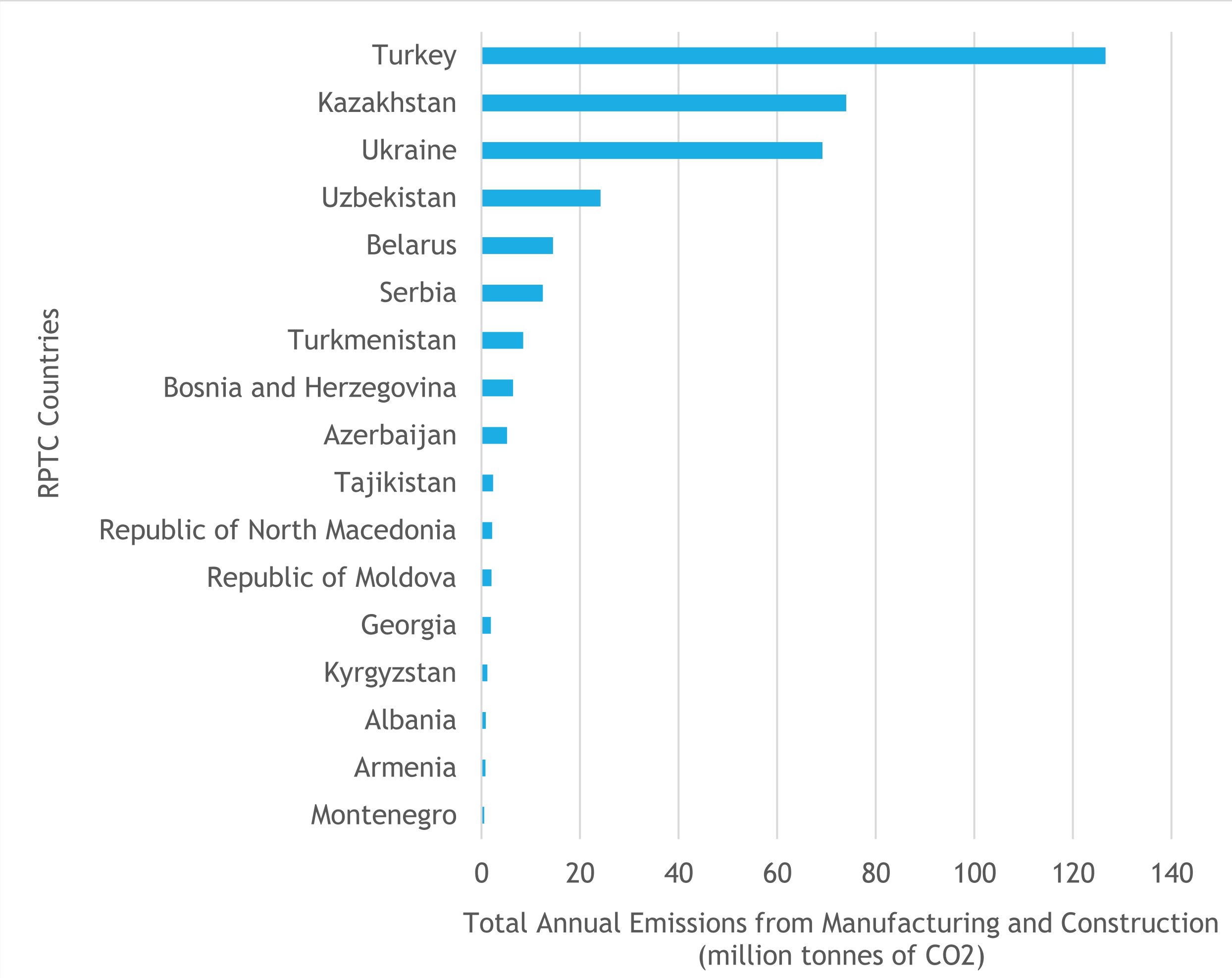
Six countries are using more than 30 per cent of the energy for transport: Albania (39 per cent), Republic of North Macedonia (37 per cent), Montenegro (33 per cent), Armenia (32 per cent), Georgia (31 per cent), and Azerbaijan (31 per cent).

There are also six countries using more than 50 per cent of energy for “Other”, which includes, for example, residential or commerce and public services: Kyrgyzstan (70 per cent), followed by Turkmenistan (62 per cent), Uzbekistan (58 per cent), Republic of North Macedonia (57 per cent), Tajikistan (57 per cent), and Armenia (51 per cent).

CO_2 emissions of industry (manufacturing industries and construction)

Data on CO_2 emissions from industry is only available for 2019. The industry sector CO_2 emission numbers shown in Figure 12 include manufacturing and construction for each RPTC country.

Figure 12: CO_2 emissions from fuel combustion with electricity and heat allocated to manufacturing industries and construction, sorted by total emissions, 2019



Source: Based on data of IEA (2021): Greenhouse Gas Emissions from Energy Highlights (26.10.2021). Paris. XLS-File. https://www.iea.org/product/download/009631-000284-009359 (downloaded 21.11.2021).

Turkey has the highest emissions with 127 million tonnes, followed by Kazakhstan (74 million tonnes) and Ukraine (69 million tonnes), and more distantly by Uzbekistan (24 million tonnes), Belarus (15 million tonnes) and Serbia (12 million tonnes). The remaining eleven countries are emitting less than nine million tonnes each. The lowest emissions are from Montenegro, Armenia, and Albania, all less than one million tonnes of CO_2. Combining the numbers in Figure 11 (final energy consumption for industry) and in Figure 12 (CO_2 emissions for industry), it is evident that the emission numbers are somewhat proportional to the energy consumption. For example, Montenegro has the lowest energy consumption as well as the low emissions. But this does not necessarily mean that Montenegro is performing better, for example, than Turkey. Consequently, it may lead to the conclusion that using a ratio in order to make the emission data comparable between countries is more appropriate. This cannot be done, however, due to fact that the data sources for these two figures are using different definitions for industry (see Figure 7). Therefore, a separate analysis is needed.

1.c Analysis of industry sector and sub-sector energy intensities within Kazakhstan and Ukraine

All data used in this sub-chapter are for the year 2018 and can be found in the Annex. While not marked as provisional, 2019 data have changed during the study phase and at the time of this submission still seemed to not be final.

Data needed

To calculate the first and second level indicators as presented in Table 1, the following data are needed (at both the industry sector and sub-sector levels):

- final energy consumption total
- final energy consumption by energy sources
- GDP or value-added PPP (constant year)
- GHG emissions

The third level indicators are not calculated within the scope of this study but could be assessed as a possible next step.

Availability of data

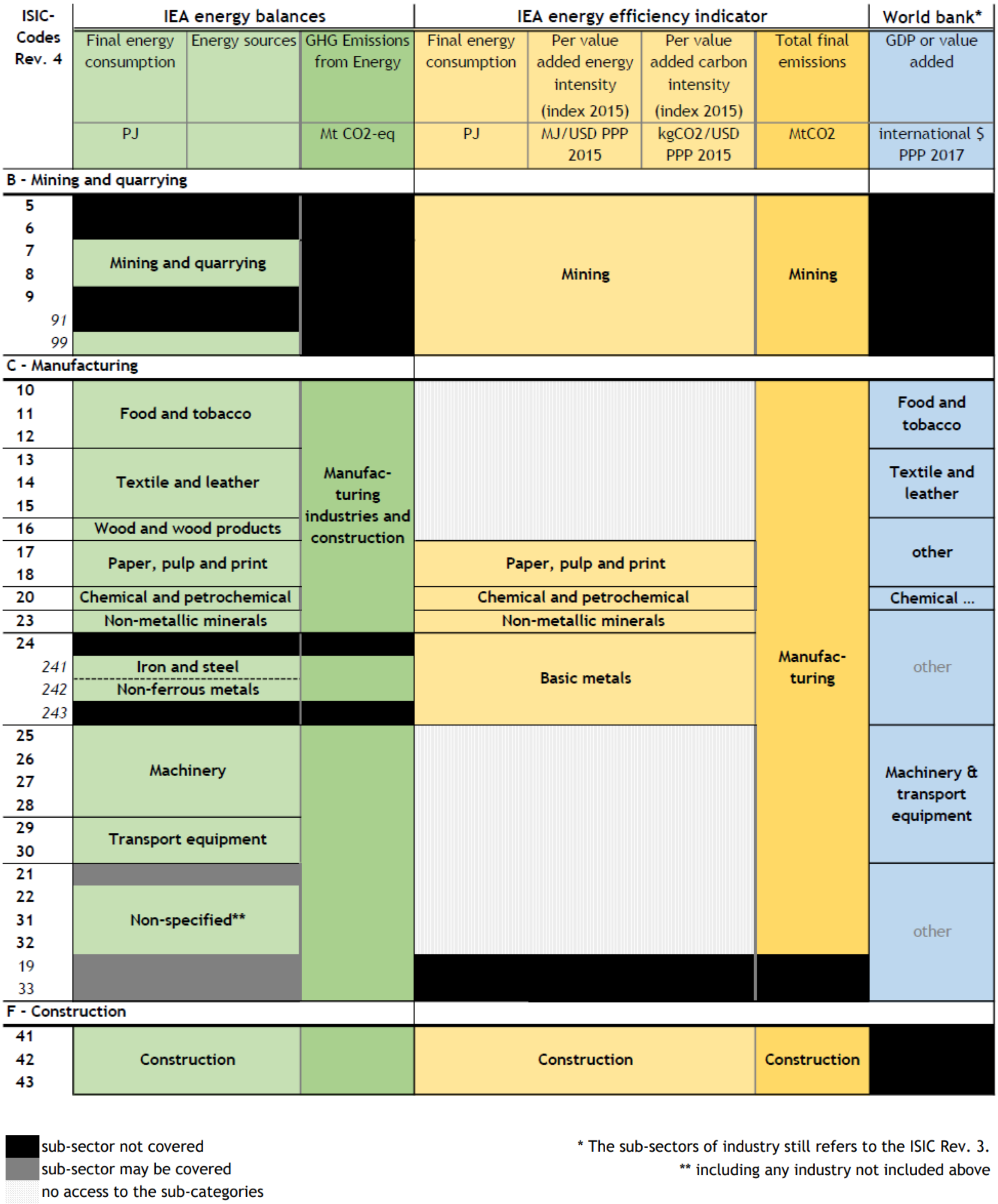
The biggest challenge is to collect or get access to disaggregated data on the level of sub-sectors. The next step is to assess whether the data are corresponding and can be used for the calculation of ratios. For example, there are data for GHG emissions from UNFCCC[4], but they are not suitable for this analysis as the set of sub-sectors differs from the data sources for energy consumption (as provided by IEA) as it is based on products and does not refer to ISIC.

Available open access data sources that reference sub-sectors are summarized in Figure 13 below. It illustrates the differences in included sub-sectors across the various data sources. The data for the final energy consumption and the energy sources from IEA are available for many sub-sectors. For the analysis, corresponding data for GHG emissions and value added for the identical set of sub-sectors are needed. As shown in Figure 13, other columns are far more aggregated, except for GDP or value added. However, manufacturing sub-sectors by World Bank are not referring to the current ISIC Rev.4 but rather to its previous version, Rev.3.

Consequently, ratios like energy intensity and productivity can be calculated on the sector level and only for selected sub-sectors with available data. As not all values of sub-sectors concerning industry structure and energy sources are corresponding perfectly, results of such calculations should be interpreted with caution and cannot always be compared like-for-like. Therefore, it is better to use the ratios presented by IEA which are limited to certain sub-sectors. Data on emissions, in turn, is aggregated and is available only on sub-sector level (mining, manufacturing and construction), similar to energy.

[4] If not combining the analysis with energy consumption this source can be used. GDP at market prices (constant 2010 USD) is available so that the indicator carbon intensity can be calculated.
Link to data source: https://di.unfccc.int/indicators_annex1.

Figure 13: Comparison between data for industry on the basis of ISIC-Codes



Source: Author-developed

Using institution-supplied data such as this helps ensure a certain degree of comparability. Research has already been done using this publicly available data from the statistical services of both countries. While the data allows for an internal analysis of development over time for each country, the ability to compare results across countries is difficult due to this lack of alignment in sub-sector definitions.

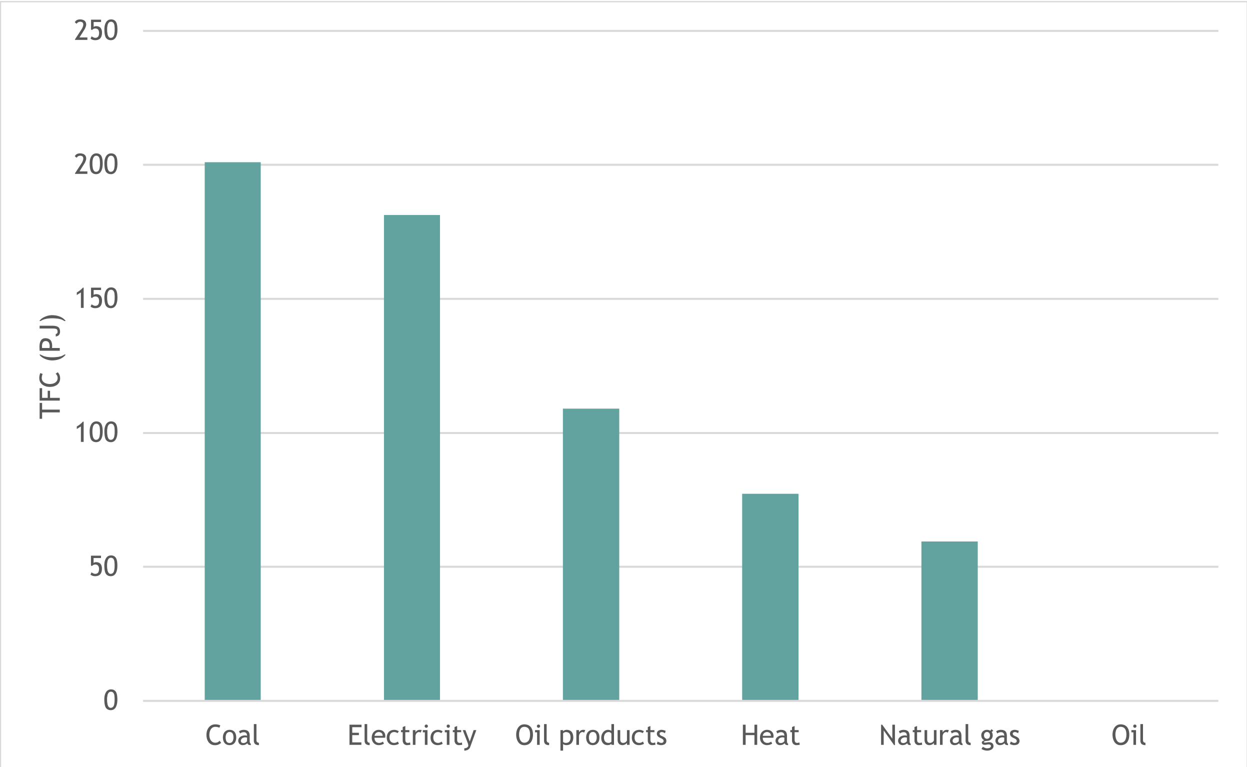
Industry structure

In order to analyse the structure of the industry sector, the final energy consumption and energy sources are combined in three different types of figures presented below for both Kazakhstan and Ukraine. This includes TFC split out by energy source, by industry sub-sector, and a 3-dimensional chart enabling the combined view of sub-sector and energy source.

Kazakhstan:

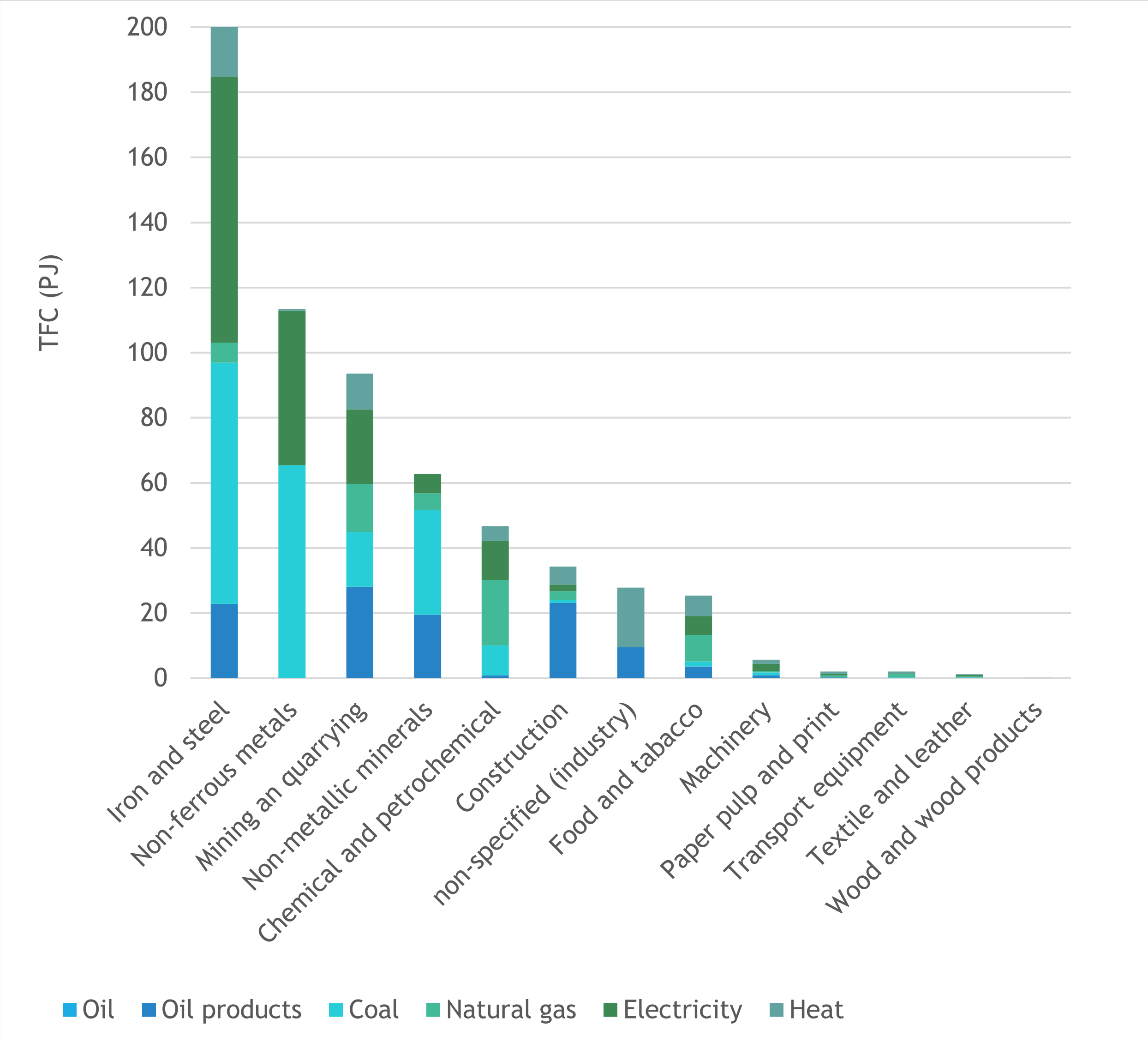
For energy consumption in the industry sector, coal is the largest energy source (201 PJ) followed by electricity (181 PJ) (Figure 14). These two sources comprise almost two thirds of industry sector's total consumption of 628 PJ. TFC disaggregated by sub-sectors is presented in Figure 15.

Figure 14: TFC of Kazakhstan's industry by energy source, with sub-sectors, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

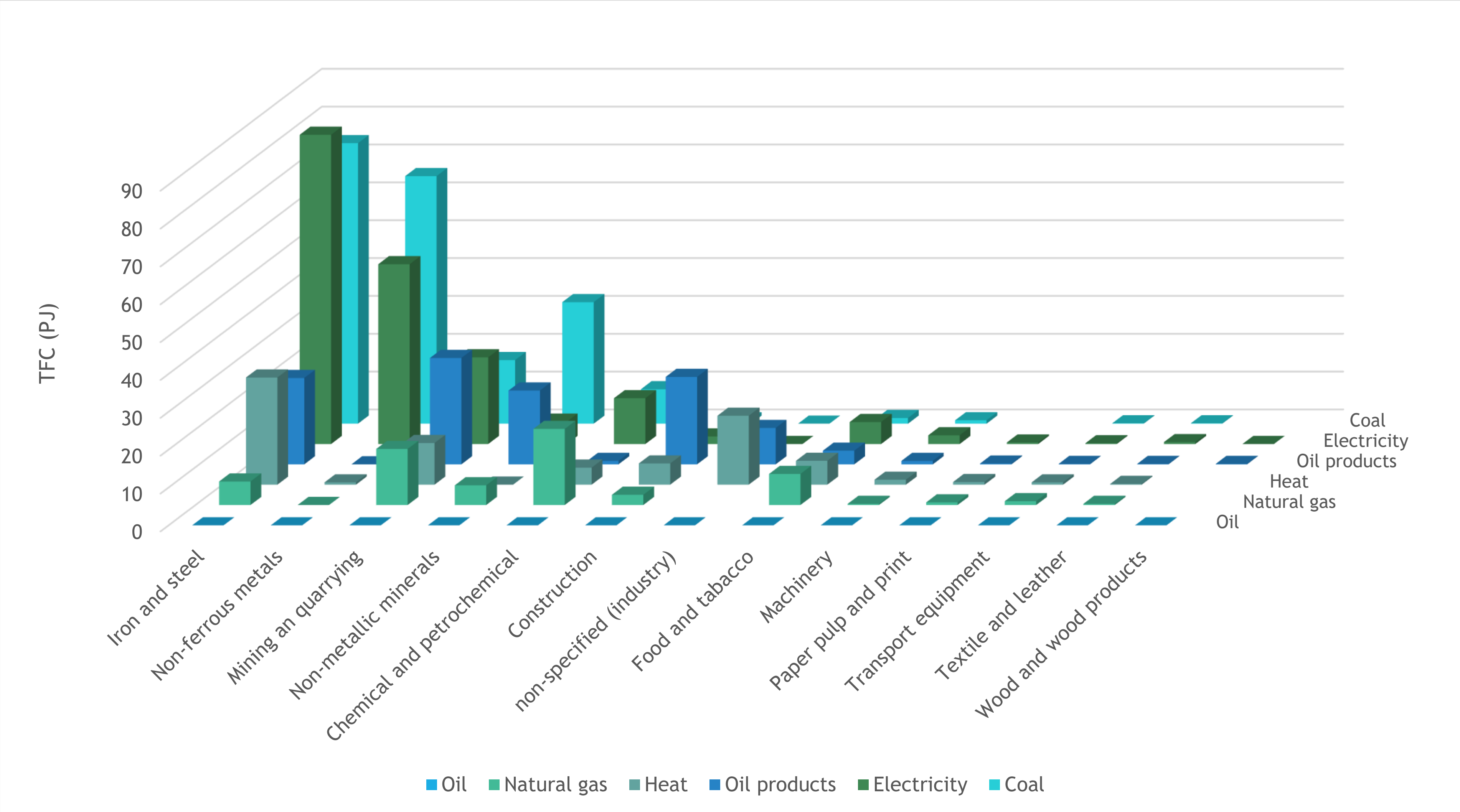
Figure 15: TFC of Kazakhstan's industry by sub-sector and energy source, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 16 helps visualising use of energy sources by sub-sectors. Within sub-sector "iron and steel", 38 per cent of energy is electricity and 34 per cent is coal; in "non-ferrous metals", mostly two sources are used: coal (58 per cent) and electricity (42 per cent); coal also dominates in sub-sector "non-metallic minerals" with 51 per cent, while natural gas dominates in sub-sector "chemical and petrochemical" with 43 per cent; in sub-sector "construction", the dominating largest share is oil products (67 per cent).

Figure 16: TFC of Kazakhstan's industry by sub-sectors and energy sources, sorted by total consumption 2018

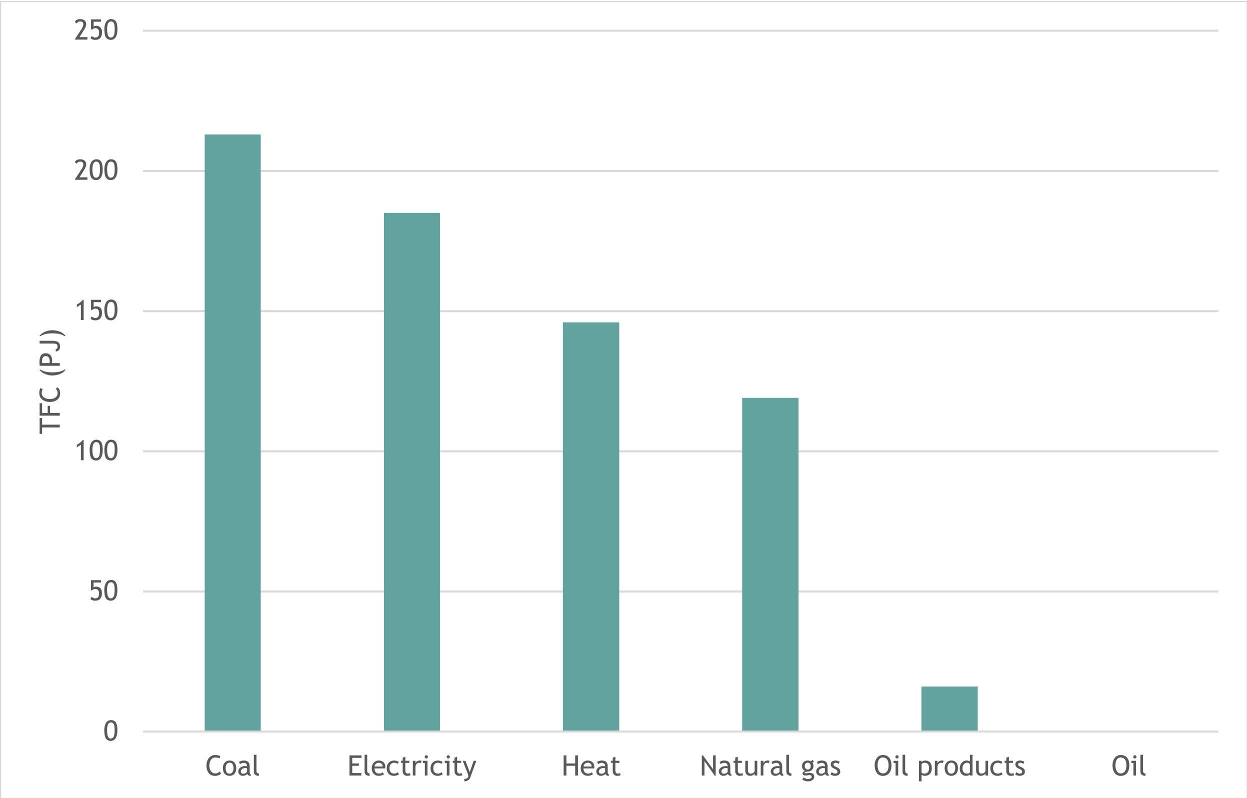


Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Ukraine:

In Figure 17, it is evident that use of energy sources by industry sub-sectors are distributed gradually starting with coal (213 PJ) and followed by electricity (185 PJ), heat (146 PJ) and natural gas (119 PJ).

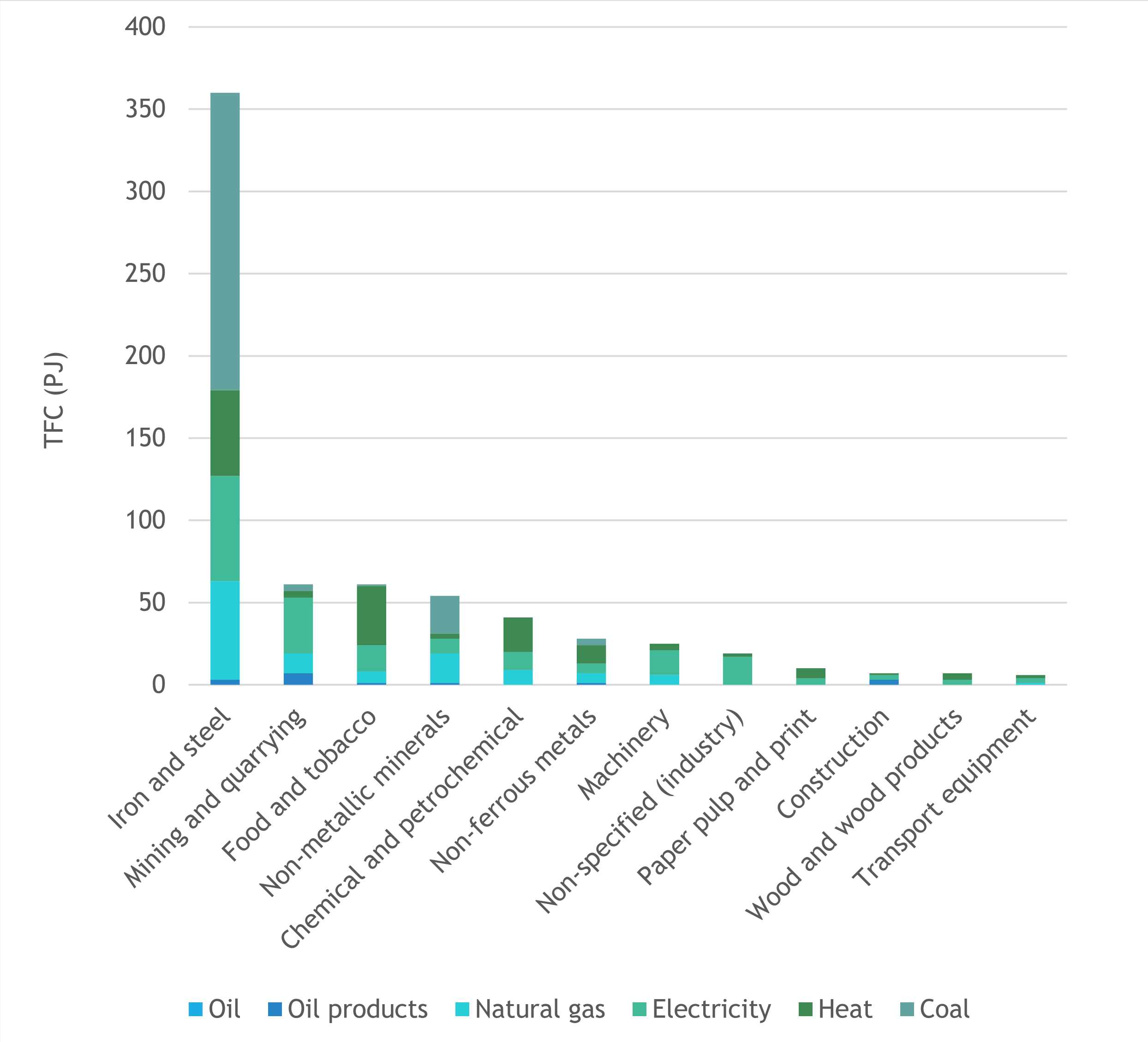
Figure 17: TFC of Ukraine's industry by energy source, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 18 shows that the most significant consumer in the industry sector by far is "iron and steel" with 360 PJ (53 per cent). "Mining and quarrying" and "food and tobacco" each consumed 61 PJ each. TFC of the remaining sub-sectors is gradually smaller. The smallest consumers (10 PJ or less) are "paper pulp and print", "construction", "wood and wood products" and "transport equipment".

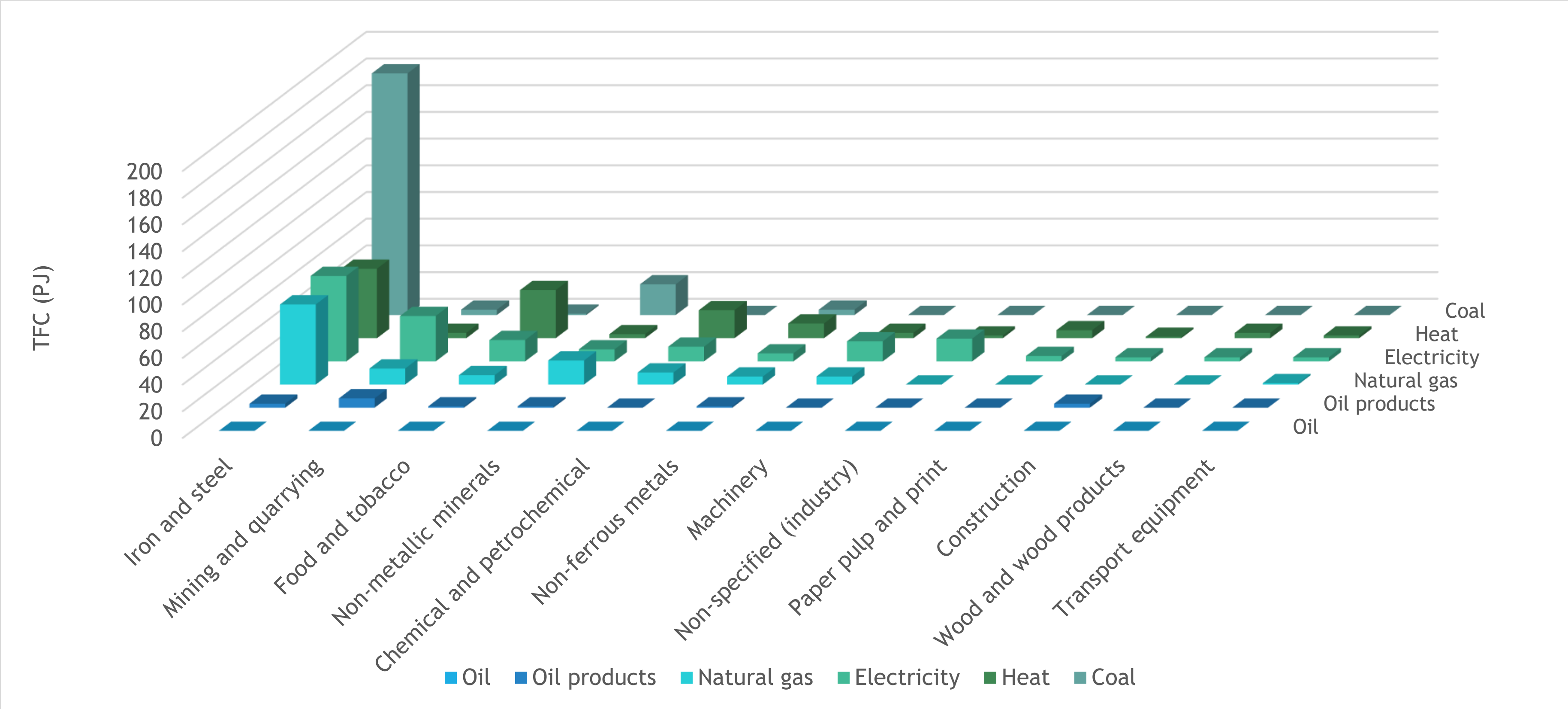
Figure 18: TFC of Ukraine's industry by sub-sector and energy source, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

As "iron and steel" is by far the largest end-use sub-sector, consumption of each category of energy sources in this sub-sector (with the exception oil products) is also the largest. Among those, coal still stands out as half of the consumed energy (181 PJ) (Figure 19). In each of the sub-sectors with a larger consumption it seems one energy source always dominates: 60 per cent of "mining and quarrying" is electricity; likewise, 60 per cent of "food and tobacco" is heat. Heat is also dominating with 50 per cent in "non-metallic minerals" and with 40 per cent in "non-ferrous metals".

Figure 19: TFC of Ukraine's industry for sub-sectors and energy sources, sorted by total consumption, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Energy intensity[5]

In the following nine figures (Figures 20 through 29), data for the industry sub-sectors of the IEA Energy Efficiency Indicator dataset are shown. This includes the sections ‘manufacturing’, ‘mining’, and ‘construction’. However, unlike for the IEA Energy Balance dataset used above, the IEA Energy Efficiency Indicator dataset only includes data for four sub-sectors within ‘manufacturing’: “paper, pulp and print”, “chemical and petrochemical”, “non-metallic minerals”, and “basic metals” (refer back to Figure 10 for details on IEA sub-sectors data availability and overlap with ISIC codes).

The sub-sector “basic metals” includes “iron and steel” and “non-ferrous metals” (Figure 13). This combined heading means a more granular analysis for these two most relevant sub-sectors is not possible.

It is important to note that when interpreting the plotted data, that IEA does not show energy intensity itself, but rather an index. As explained in section 1.a, the value of an index always references to a certain year (see Figure 6 as an example). In this case, it is 2015 which means the value of 2015 is set to 100. If the value for 2018 is lower than 100 it means the value for energy intensity of 2018 is lower than that of 2015. If the value of the index is higher than 100 then the opposite is the case.

A decrease of energy intensity may be due to a reduction of energy use. But this assumes a fixed ratio between energy consumption and value added[6], which is not necessarily the case. Another explanation for a decrease could also be a rise in price due to other reasons. To understand the changes of energy intensity in more detail, a deeper analysis is needed, and measures can be taken according to the observations to foster reduction of emissions.

[5]According to Figure 13 there is an index for energy intensity from the IEA for some selected sub-sectors. For other sub-sectors it is possible to calculate the ratio when using the final energy consumption data of IEA and the value added of the World Bank data. The planned calculation of the ratio could not be done as data of the World Bank are referring to the ISIC Revision 3 and there are differences in the relevant sections. The correspondence tables between Revision 4 and Revision 3 (source: United Nations Statistics Division (2007): Correspondence tables between Revision 4 and Revision 3.1 of the International Standard Industrial Classification of All Economic Activities (ISIC)) show that the changes are on the four-digit-level, i.e. the new two-digits do not fully correspond to the old two-digits. The data for sub-sectors are aggregated data of many two digit-levels, which makes it impossible to convert from one to another revision. As it is unknown which significance the divergent four-digits have, no calculation was done.

The loss of these sub-sectors is acceptable as the sub-sectors are “food and tobacco”, “textile and leather”, “chemical and petrochemical” and “machinery and transport equipment”. Except for “chemical and petrochemical” and “food and tobacco” the other sub-sectors are of minor importance. Moreover, a possibly calculated index of energy intensity would not have been comparable to the energy intensity index of IEA, as the year for the value-added PPP is different (2015 and 2017).

Below, the IEA data of the energy intensity index is presented in combination with the final energy consumption. In that way, the ratio (energy intensity), which is relative, is complemented with the absolute indication (final energy consumption). Then it is easier to assess which sub-sector has a significance. The higher the final energy consumption the more important is the energy intensity. Of course, it is always desirable to improve the energy productivity in each sub-sector, but it makes sense to assess the large consumers first.

[6] The change of the energy consumption is proportional to the change of the monetary value added.

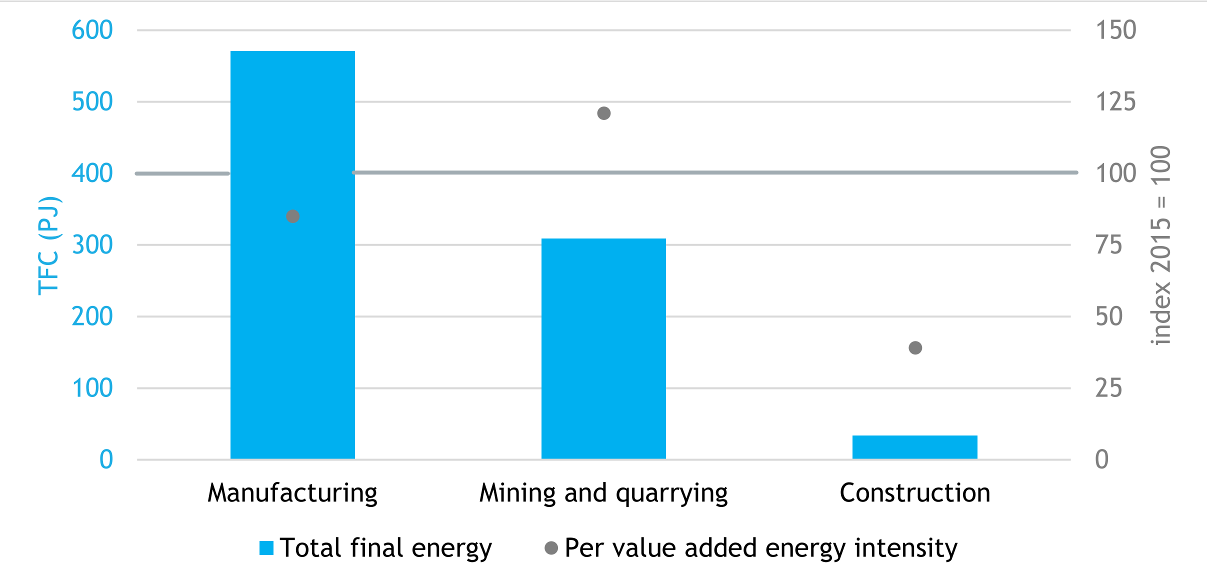
The charts below show both absolute energy consumption in PJ of the sections or sub-sectors on the left axis (indicated by the blue columns), and the index score compared to the 2015 basis on the right axis (indicated by the grey dots). All data can be found in the Annex.

Kazakhstan:

According to Figure 20 and Figure 21, since 2015 energy intensity in in ‘mining and quarrying’ (index score 132) as well as the sub-sectors of “paper, pulp and printing” (141) and “chemicals and chemical products” (102) have increased while in other sections and sub-sectors there is a reduction. Overall, there was a decrease in the ‘manufacturing’ (50) sector, which includes a decrease in the “basic metals” (85) sub-sector.

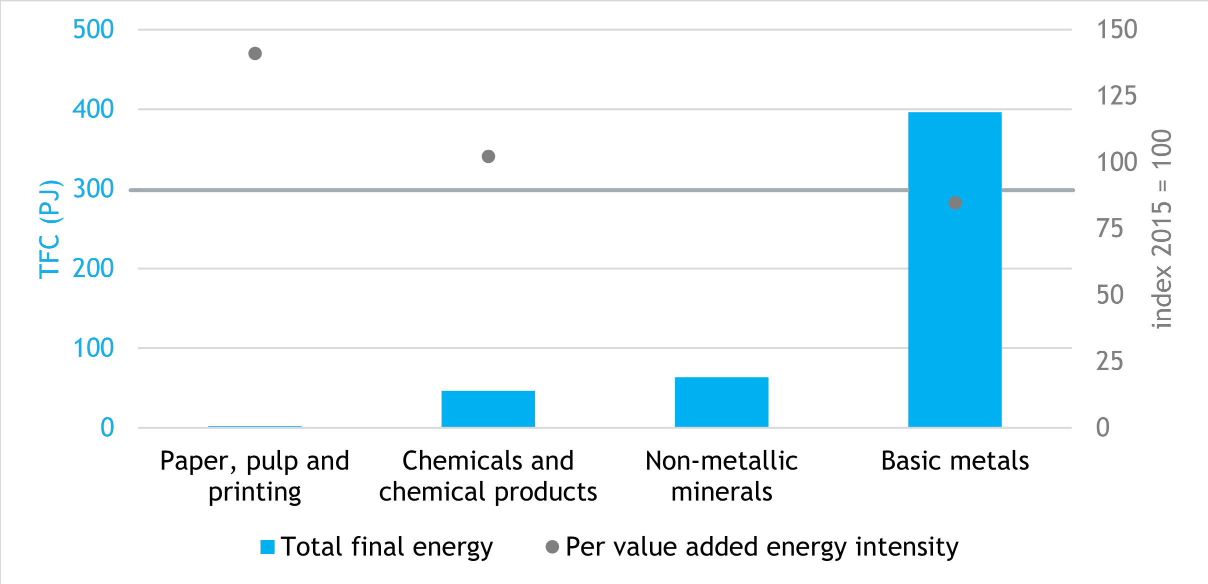
The final energy consumption of the “basic metals” sub-sector is quite high and thus represents a large share of the ‘manufacturing’ section’s overall final energy use. As such, “basic metals” has a big contribution in the overall performance in manufacturing. At the same time, there must be other sub-sectors performing even better than “basic metals”, as the index value of change for ‘manufacturing’ is equal to the value for “basic metals” despite other sub-sectors within ‘manufacturing’ increasing (e.g. “paper, pulp and printing”, 141 and “chemicals and chemical products”, 102). However, the share and consequently the effect of “paper, pulp and printing” is very small within manufacturing which can be seen from the value for total final energy (only 2 PJ). For the sub-sector “non-metallic minerals” (63 PJ), no index value is available. As this sub-sector has a higher total final energy consumption and would have the larger effect in comparison to “paper, pulp and printing” (2 PJ) and “chemicals and chemical products” (47 PJ), a value would have been helpful to understand the performance in manufacturing.

Figure 20: TFC and indices of energy intensities of the three sections within the industry sector in Kazakhstan (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 21: TFC and indices of energy intensities of the sub-sectors within the section ‘manufacturing’ in Kazakhstan (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015), 2018



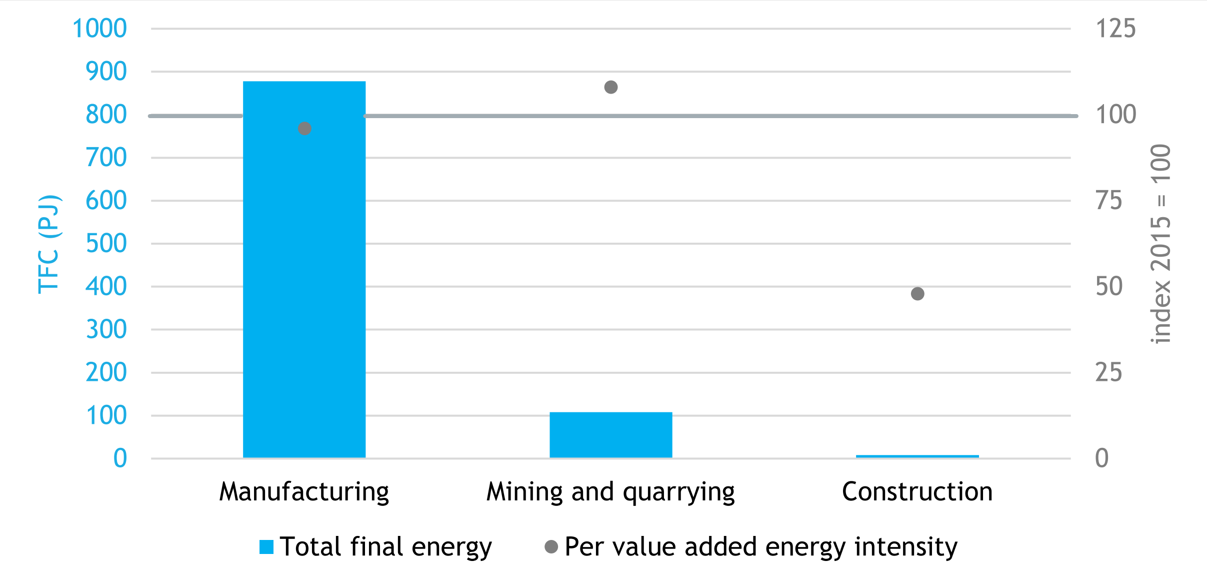
Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Note: no values for “non-metallic minerals” (per value added energy intensity)

Ukraine:

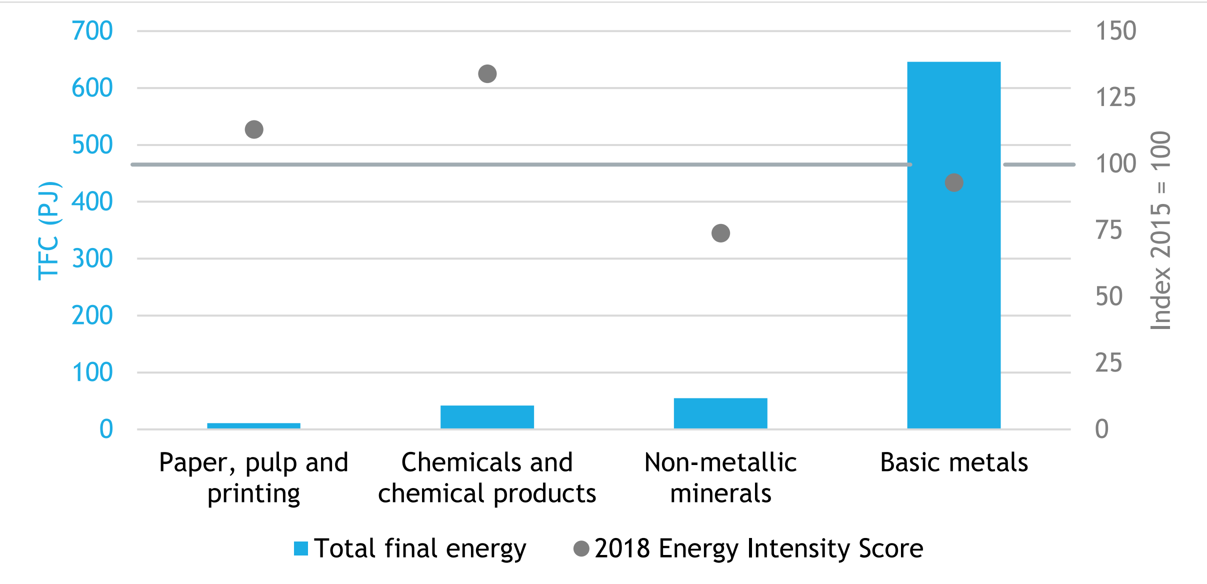
As shown in Figure 22 and Figure 23, the largest change in energy intensity was recorded in the sub-sector “construction” (48), which halved compared to its 2015 value. However, this sub-sector is not a large consumer (8 PJ), and the effect of this change is not significant for the industry sector overall. “Non-metallic minerals” (74) also decreased compared to 2015, while “mining” (108) has a slight increase. “Paper, pulp and printing” (113) and “chemical and petrochemical” (134) both increased between 2015 and 2018.

Figure 22: TFC and indices of energy intensities of the three sections within the industry sector in Ukraine (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 23: TFC and indices of energy intensities of the sub-sectors within the section 'manufacturing' in Ukraine (index of 2015 = 100, comparing energy intensity in MJ/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Emission/Carbon intensity

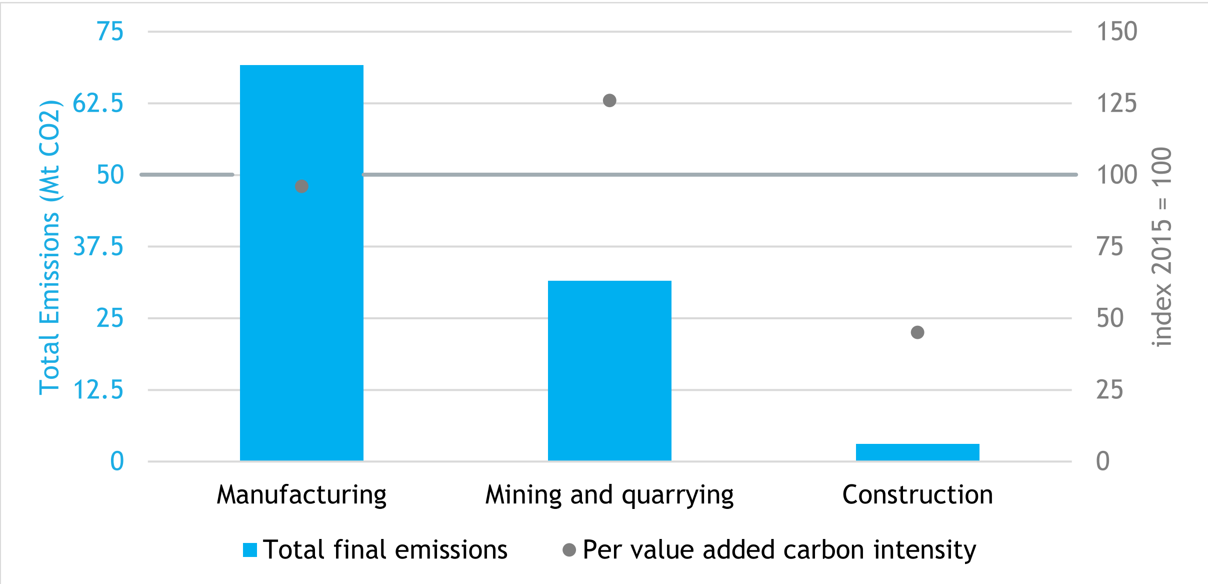
Kazakhstan:

Figure 24 and Figure 25 present a downward trend in the carbon intensity of 'construction' in 2018 (45) to less than half of that in 2015. The slight reduction of 'manufacturing' (96) may be in part due to the reduction in carbon intensity of the "basic metals" (97), which play a large role within the 'manufacturing' section. But there must be other sub-sectors contributing to this reduction, as both "chemicals and chemical products" (104) and "paper, pulp and printing" (141) carbon intensities have increase. Within 'mining and quarrying' (126), the carbon intensity rose by roughly one quarter.

When comparing index data of energy intensity (Figure 20) and carbon intensity (Figure 24) it is notable that the index scores of energy intensity show a sharper decline than the scores of carbon intensity over the 2015 to 2018 time period (with the exception of the "chemicals and chemical products" in which the index scores are the same).

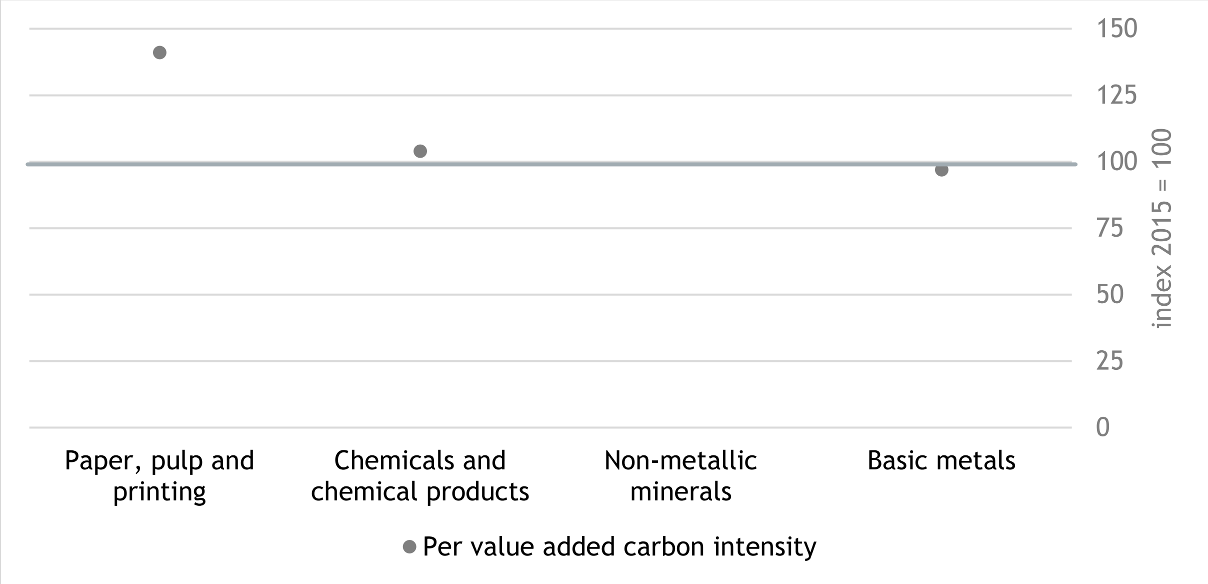
One explanation for a decrease of energy intensity along with an increase of carbon intensity is a change in the energy mix. As energy intensity and carbon intensity are both a ratio referring to the same monetary value added, it means that although a given sub-sector or section is using less energy, more emissions are produced, indicating a step away from decarbonization.

Figure 24: Total final emissions and indices of carbon intensities of the three sections within the industry sector in Kazakhstan (index of 2015 = 100, comparing carbon intensity in kg CO_2/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 25: Indices of carbon intensities of the sub-sectors within the section ‘manufacturing’ in Kazakhstan (index of 2015 = 100, comparing carbon intensity in kg CO_2/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

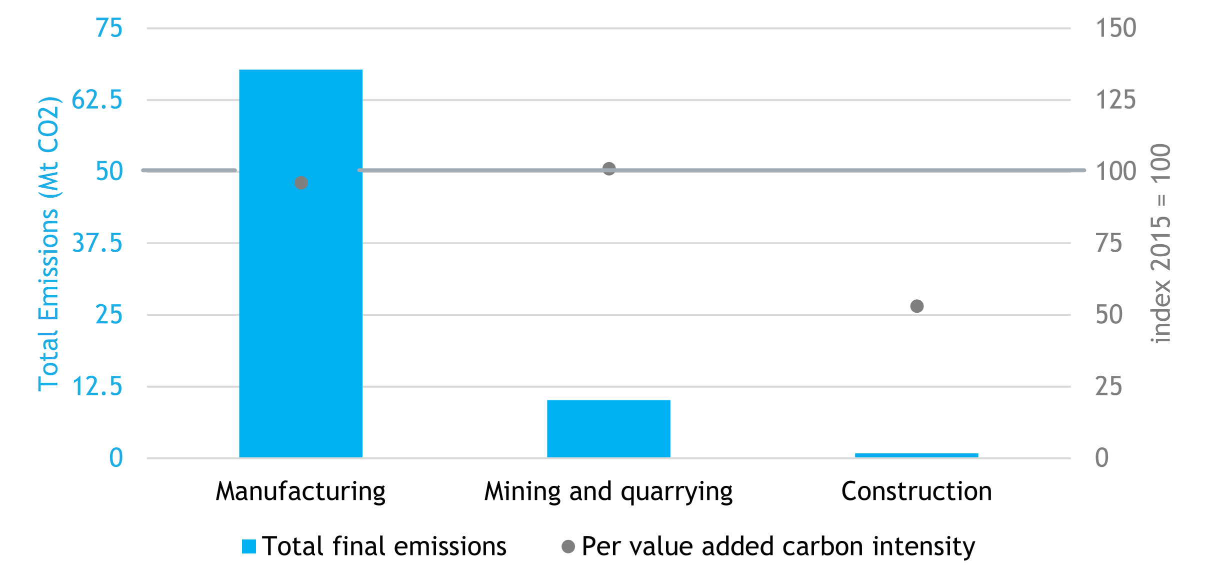
Note: No values for “non-metallic minerals” (per value added carbon intensity).

Ukraine:

The position of the dots in the energy intensity index (Figure 22 and Figure 23) and carbon intensity index (Figure 26 and Figure 27) are very similar, though the index scores of the energy intensity are slightly higher than those of the carbon intensity across most sections and sub-sectors. It may be concluded that energy consumption and CO2 emissions ratio stayed almost the same for the years 2015 and 2018. A possible explanation could be a relatively constant energy mix between 2015 and 2018.

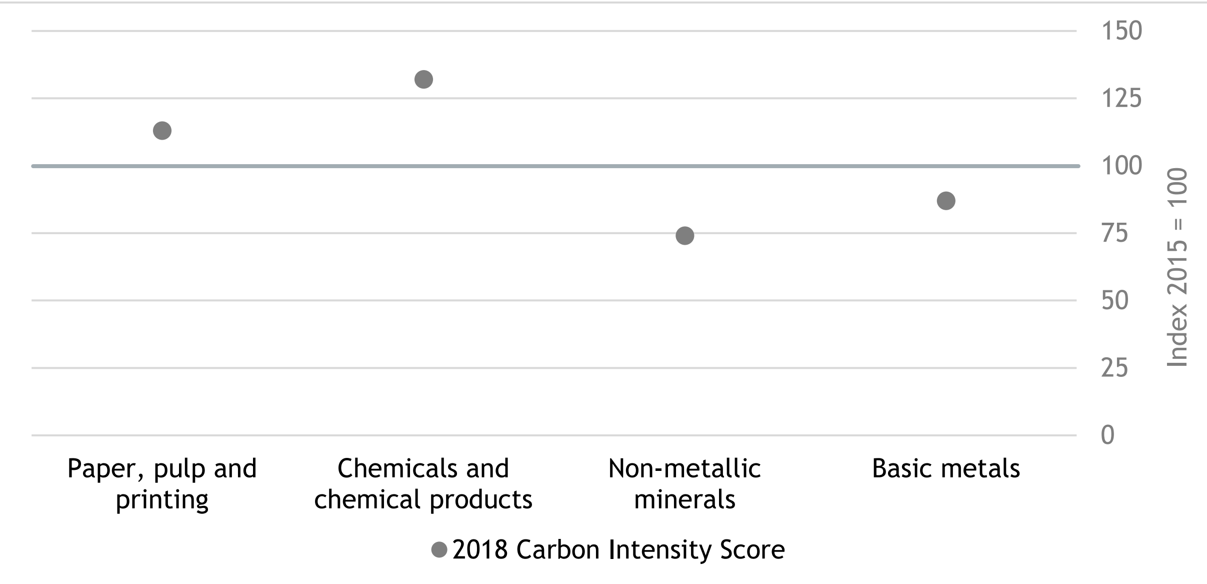
In the ‘construction’ section, however, the carbon intensity index value (56) was a bit higher than the energy intensity index value (50). For two other sections and the sub-sectors, “chemicals and chemical products” and “basic metals”, it is the opposite as the carbon intensity index values are a bit lower than the energy intensity value. In other words, while both the carbon intensity and energy intensities decreased over the 2015 to 2018 period, with the exception for ‘construction’ the relative reduction in carbon intensity over the time period was larger than that of energy intensity.

Figure 26: Total final emissions and indices of carbon intensities of the three sections within the industry sector in Ukraine (index of 2015 = 100, comparing carbon intensity in kg CO_2/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 27: Indices of carbon intensities of the sub-sectors within the section 'manufacturing' in Ukraine (index of 2015 = 100, comparing carbon intensity in kg CO_2/USD PPP 2015), 2018



Source: Based on data of IEA (2021): Energy efficiency indicators database (June 2021 edition) - Highlights. Paris XLS-File. https://www.iea.org/product/download/009723-000281-009459 (downloaded 21.11.2021); Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

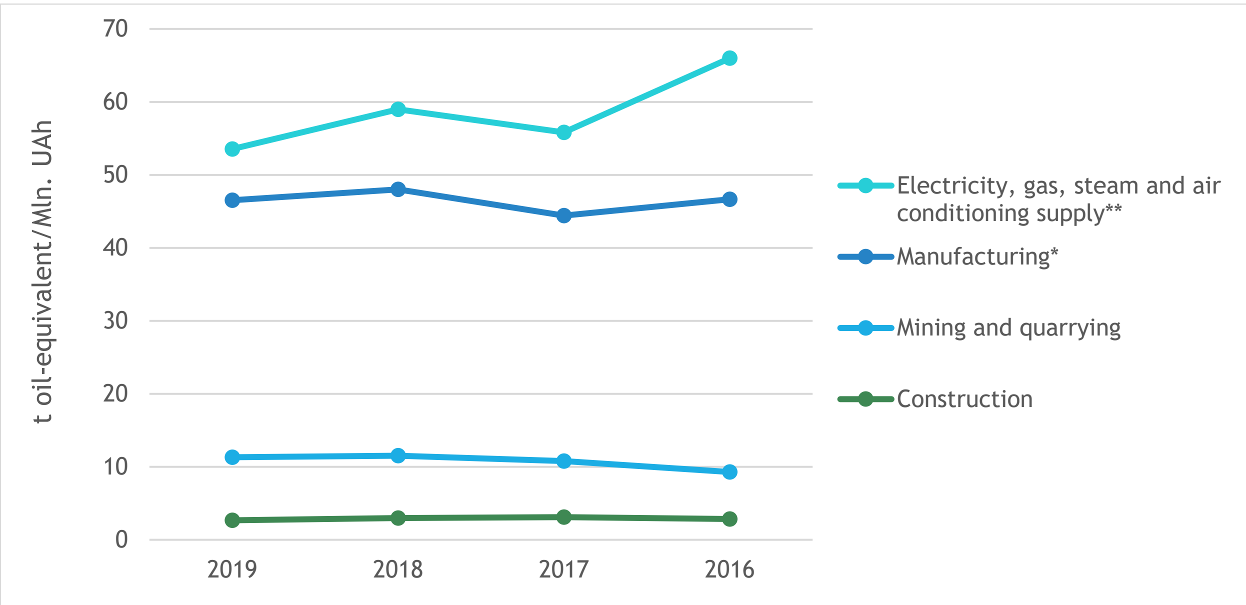
Ukraine: power generation sector and utilities (water utilities and heat generation companies)

To take a closer look at the other sub-sectors, power generation and water utilities data of the State Statistics Service of Ukraine for the ISIC Section D ‘electricity, gas, steam and air conditioning supply’ and Section E ‘water supply; sewerage, waste management and remediation activities’ were used. These are available for gross value added (constant prices of 2016) and emissions.

However, the exact classification is not given in the final energy consumption, thus correspondent matches are used. The industry sector, according to ISIC, includes the sections ‘mining and quarrying’, ‘manufacturing’ and ‘construction’. Consequently, the missing ‘manufacturing’ is calculated through the deduction of ‘mining and quarrying’ and ‘construction’ from industry.

For ISIC Section D ‘electricity, gas, steam and air conditioning supply’ the position ‘own consumption by energy sector’ is used. As there are no corresponding position within the list of final energy consumption for ISIC Section E ‘water supply; sewerage, waste management and remediation activities’ the energy intensity cannot be calculated.

Figure 28: Energy intensity for industrial sub-sectors in Ukraine, 2016-2019



Source: Based on data of State Statistics Services of Ukraine, http://www.ukrstat.gov.ua.

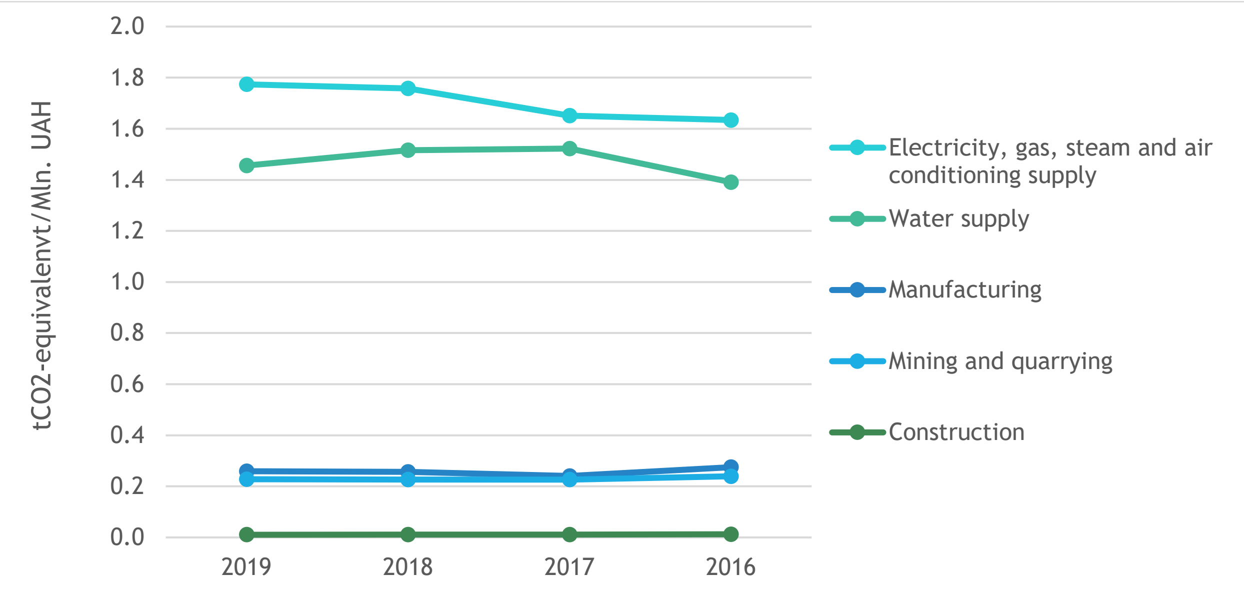
Note on calculation: total final energy (end use) / gross value-added constant price of 2016;
*: ‘Manufacturing’ = Industry - ‘Mining and quarrying’ - ‘Construction’;
**: own consumption by energy sector.

The sections ‘electricity, gas, steam and air conditioning supply’ and ‘manufacturing’ have consistently higher energy intensity than ‘mining and quarrying’ and ‘construction’, as shown in Figure 28. This is in part because power generation and manufacturing often need many times more energy to generate an output of the same economic value.

The lowest energy intensity of this observation is ‘construction’, which has a relatively low fluctuation over time. The fluctuation is also relatively low in the sub-sectors ‘mining and quarrying’ and ‘manufacturing’. An exception is ‘electricity, gas, steam and air conditioning supply' with a trend downwards, which reduction in energy intensity is important as this is the section with the highest energy intensity.

Figure 29 shows that for emissions, the highest intensity section is ‘electricity, gas, steam and air conditioning supply', which has an increasing trend over time. ‘Water supply’ has the second highest intensity. Following a rise from 2016 to 2017, the trend for ‘water supply’ has been downward from 2017 to 2019; a favourable sign for the section that still remains less efficient in 2019 than in 2016. Considering that the share of renewable energy is about 1.1 per cent (hydro energy, wind and solar) and 3.4 per cent (biofuels and wastes) for 2018, there is high potential to reduce the carbon intensity in both sections through the increase of overall renewable energy in the country’s energy mix.

Figure 29: Carbon intensity for industrial sub-sectors in Ukraine, 2016-2019



Source: Based on data of State Statistics Services of Ukraine, http://www.ukrstat.gov.ua.

Note on calculation: greenhouse gas emissions / gross value-added constant price of 2016.

1.d Analysis of national-level situation in industrial energy efficiency

Further assessment was made based on first-hand quantitative data and qualitative information collected through a survey conducted of companies operating within the industry sector.

Survey questionnaire

Energy Efficiency Barometer of Industry, managed by the Institute for Energy Efficiency in Production and in cooperation with UNECE, is a questionnaire-based survey covering categories such as: policy, measures, barriers, decision, investment, and drivers concerning energy efficiency and decarbonization.[7] For the purpose of this study, a selection of questions was sent to identified experts and their feedback has been incorporated in this report.

The experience of the experts was that collecting survey data is challenging as it is difficult to engage companies to participate. Taking this into account, two versions of the originally proposed questionnaire were created: (1) a one-minute abridged survey so that companies with less interest are more willing to participate and hence to have more companies participating, and (2) the originally planned set of questions to obtain a more detailed picture (though recognizing a risk of lower rate of response).

The final questionnaire, contained in Annex, was made available in English and Russian languages and was accompanied with an introduction for Kazakhstan and Ukraine.

Survey promotion

To identify stakeholders for promoting of the survey, interviews were conducted and online research was carried out to find relevant membership-based organizations such as associations, federations, or societies. Email and social media outreach were conducted, along with sharing details about the study. All materials were prepared in English and in Russian languages.

Survey conclusion

Despite all efforts, the response rate was too low to use results of the survey for analysis.

It may be concluded, however, that the interest in, and the importance of, that topic is not high enough. Hence, improving energy productivity necessitates, among other things, raising awareness of these topics.

[7] The methodology is described in: Stefan M. Büttner et al. (2022): How Do German Manufacturers React to the Increasing Societal Pressure for Decarbonisation? In: Applied Sciences 12 (2): 543. https://doi.org/10.3390/app12020543.

CHAPTER 2: TECHNOLOGY OPTIONS

In order to reduce the high energy use across the industrial sections and sub-sectors of Kazakhstan and Ukraine, innovative yet proven technologies must be adopted at scale. Chapter 2 explores a wide range of currently available and emerging technologies that can be applied to improve energy productivity and reducing carbon intensity in various processes. This section lays out specific technology recommendations for particularly energy-intensive processes (e.g., “iron and steel”), as well as a series of cross-cutting technologies that improve efficiency beyond the manufacturing process itself. A number of case studies are also included to illustrate specific instances of technology application and resulting efficiency gains.

2.a Options to improve energy productivity and reduce carbon intensity

This sub-chapter starts with technological options for “iron and steel”, then points out general options for industry and concludes with innovations with a high maturity level.

Production technologies: Iron and steel

As illustrated Chapter 1, the “iron and steel” manufacturing sub-sector is by far the largest consumer of energy in the industrial sector of both Kazakhstan and Ukraine. As such, the potential for improvement in this sub-sector is quite large. With respect to the production processes of iron and steel, there are two primary production pathways: blast furnace-basic oxygen furnace (BF-BOF) and direct reduced iron-electric arc furnace (DRI-EAF). In addition, there is also the possibility to use the secondary production with scrap and EAF.

In Table 3, final energy use and related CO_2 emissions show that between the two primary production pathways of BF-BOF and DRI-EAF, natural gas-based DRI-EAF requires the least energy and emits less CO_2[8].

[8] IEA (2020): Iron and Steel Technology Roadmap. Paris. https://www.iea.org/reports/iron-and-steel-technology-roadmap (accessed 25.11.2021).

Table 3: Final energy use and CO_2 emissions for steel production (per t crude steel)

	Energy input	Final energy	CO_2 emissions (direct)	CO_2 emission (indirect)	CO_2 emission (direct + indirect)
BF-BOF	coke and coal	21.4 GJ/t	1.2 t CO_2/t	1.0 t CO_2/t	2.2 t CO_2/t
DRI-EAF	coal	18 – 30 GJ/t	3.0 t CO_2/t	0.4 t CO_2/t	3.4 t CO_2/t
DRI-EAF	natural gas	17.1 GJ/t	1.0 t CO_2/t	0.4 t CO_2/t	1.4 t CO_2/t
Scrap-based EAF	electricity	2.1 GJ/t	0.04 t CO2/t	0.3 t CO2/t	0.34 t CO2/t

Source: Based on data of IEA (2020): Iron and Steel Technology Roadmap. Paris. https://www.iea.org/reports/iron-and-steel-technology-roadmap (accessed 25.11.2021); Based on data of World Steel Association (2021): World Steel in Figures 2021. https://worldsteel.org/wp-content/uploads/2021-World-Steel-in-Figures.pdf (accessed 25.11.2021).

The secondary production pathway with scrap and EAF uses considerably less energy and emits considerably less CO_2. So, a sharp reduction of final energy (to around one-tenth of that required for iron ore) is possible when using scrap[8]. At the same time electricity is the input energy rather than coal, which enables the possibility for fuel switching to clean energy inputs (reconsidering the primary energy sources used for electricity generation).

Process optimisation

There are generally applicable possibilities to improve efficiency through optimized operation and maintenance, notably by means of better process control or prediction (e.g. by minimizing downtime through predictive maintenance) with the help of digitalization. For steel plants such process optimisation can, for example, lead to less energy demand for reheating or less coke consumption through adjusting inputs.

Processes can also be optimized as part of energy management. Examples for steel plants are technical modifications such as waste heat recovery systems or blast furnaces with top-pressure recovery turbines; it can also be improved coke quality or the introduction of scrap to various stages[8].

Cross-cutting technologies

Cross-cutting technologies like pumps or compressed air, are often overlooked or disregarded as they are not entirely part of the production process, hence are often left behind for the purpose of optimization. This justifies, among other opportunities, a likelihood of a high potential for improvement in this area. At the same time, it is an advantage that cross-cutting technologies play a supporting role and are not restricted to certain sub-sectors. Thus, they have less or no influence on the production process, and measures that relate to energy-efficient infrastructure generally do not require an immediate change in the production process.

Fuel switching

As shown in Chapter 1, the main energy sources for industry are coal and electricity. To reduce carbon intensity, change of fuel can lead to lower GHG emissions. One option is switching from coal to natural gas (an example is described in Table 3[9]), which produces less CO_2 per unit of energy than coal.

Another option is to reconsider primary energy sources used for electricity generation (including on-site), with a view to increase the share of renewables, as and where feasible. By electrifying processes and using zero emission electricity generation to supply them, overall CO_2 can be reduced compared to coal and natural gas. Though this does not address the reduction of energy intensity of an industrial facility, it significantly reduces its carbon intensity.

Innovations

To reach the goal of net-zero emissions, the currently available measures described here are arguably insufficient and further technological and process innovations are necessary. In the Energy Technology Perspectives (ETP) Clean Energy Technology Guide, innovations are listed with a rating of the technology readiness level (TRL, presented in Annex).[10] For “iron and steel”, there are twelve technologies mentioned (including blast furnace alternatives, smelting reduction, direct reduced iron, ore electrolysis, etc.). In the publication, a TRL of nine is given to equipping direct reduced iron plants with chemical absorption-based CO_2 capture[11]. This means that the technology is commercially available and ready for a commercial operation.

The highest TRL, eleven, means that the technology can be called mature with predictable market growth. For cross-cutting technologies, there are eleven technologies with a TRL of nine and two with a rating of ten (electromagnetic high temperature heating for large-scale industrial processes[12] and novel separation for sorting metallic products[13]) and one

[9] the coal-based DRI-EAF pathway emits 3.4 t CO_2 / $t_{Crude\ Steel}$ while the natural gas-bases DRI-EAF emits only 1.4 t CO_2 / $t_{Crude\ Steel}$)

[10] IEA (2021): ETP Clean Energy Technology Guide. Paris. https://www.iea.org/articles/etp-clean-energy-technology-guide (accessed 25.11.2021).

[11] “Direct reduced iron plants could be equipped with chemical absorption-based CO2 capture, a common process operation based on the reaction between CO2 and a chemical solvent (e.g. amine-based). The CO2 is released at temperatures typically in the range 120°C to 150°C and the solvent regenerated for further operation.” (Ibid)

[12] “During induction, an electromagnetic field is generated when AC current flows through an inductor: this induces a current flow in a conductive material appositely placed nearby. The higher the current flow, the more the heat generated inside the object itself. If the field is raised enough to overcome the melting point, the material changes phase: this technology is used commonly for the melting of metals. While already commercial for some applications, research and development could expand the range of applications, further improve efficiency and reduce costs.” (Ibid)

[13] “While the separation of ferrous metals from non-ferrous metals is relatively easy (…), recovering precious and valuable metals takes more technologically advanced and sophisticated recycling equipment. New physical separation techniques can better sort materials, such as through shredding with more selective component breaking and mechanisms to reduce entangling.” (Ibid)

(fluidized-bed boiler for biomass fuels for high, medium and low temperature heating[14]) with a rating of eleven. Given the high TRL for these technologies, it is worthwhile to consider the near-term implementation where applicable.

2.b Case studies

In the following sub-chapter, technology case studies from both countries are presented.

Data gathering is important for systemic measurements, enabling the implementation of targeted energy efficiency measures. Some positive results are shown in Table 4, Table 5, and Table 6.

Kazakhstan:

Examples from the mining and metallurgy industry (audit results):

Table 4: Case study in Kazakhstan with diverse energy-efficient technologies

Title	Use of energy-efficient technologies
Scope	• Company-wide switch to LED lights • Installation of heat recovery units at compressor stations • Installation of capacitors to compensate reactive power • Installation of a system for automatic measurement of power

Results	• Energy consumption of boiler plants aimed at the production of heat is reduced
	  ▪ Lower consumption of diesel fuel
	  ▪ Less costs for reparation of the boiler
	  ▪ Extension of lifetime of the boiler
	• Power measurement
	  ▪ Reduced use of fuel and energy through improved management of assets
	• Monetary savings: 208,600 USD in 2016[15]

Responsibility	Oraltyk

Source: Based on Delegation der Deutschen Wirtschaft für Zentralasien (2018): KASACHSTAN - Energieeffizienz in der Schwerindustrie Zielmarktanalyse 2018 mit Profilen der Marktakteure. Almaty. https://www.german-energy-solutions.de/GES/Redaktion/DE/Publikationen/Marktanalysen/2018/zma_kasachstan_2018_energieeffizienz-in-der-schwerindustrie.pdf?__blob=publicationFile&v=4 (downloaded 21.11.2021).

[14] "Biomass fuels - such as wood, crop residues, wood pulp and chips, and municipal solid waste - are difficult to burn efficiently in conventional industrial furnaces due to their lower heating value and higher moisture content. Fluidized-bed boilers (…) operate by burning the fuel within a hot bed of sand or other inert particles, which are fluidized by passing a pressurized fluid through them. This enables oxygen to reach the fuel more easily and thus improved combustion." (Ibid)

[15] 70 million KZT, conversion with 1000 KZT = 2,98 USD

Table 5: Case study in Kazakhstan with focus on vehicle fleet

Title	Vehicle fleet of various opencast mines and shafts
Scope	• Energy saving and energy efficiency through installation of measuring instruments at 148 tanks and 57 filling stations
Results	• Investment: 5.4 million USD[16] • Savings: 10 million tonnes of fuel for the vehicle fleet, 1.5 million USD[17] each year (2013 – 2016)
Responsibility	Eurasian Resources Group (ERG)

Source: Based on Delegation der Deutschen Wirtschaft für Zentralasien (2018): KASACHSTAN - Energieeffizienz in der Schwerindustrie Zielmarktanalyse 2018 mit Profilen der Marktakteure. Almaty. https://www.german-energy-solutions.de/GES/Redaktion/DE/Publikationen/Marktanalysen/2018/zma_kasachstan_2018_energieeffizienz-in-der-schwerindustrie.pdf?__blob=publicationFile&v=4 (downloaded 21.11.2021).

Table 6: Case study in Kazakhstan with focus on waste heat recovery

Title	Waste heat recovery
Scope	• Installation of heat exchanger • Installation of an air separation plant
Results	• With the heat exchanger the heat consumption was reduced by 18 TJ per year • Savings: 4.7 million USD (2012 – 2018)
Responsibility	Kazzinc

Source: Based on Delegation der Deutschen Wirtschaft für Zentralasien (2018): KASACHSTAN - Energieeffizienz in der Schwerindustrie Zielmarktanalyse 2018 mit Profilen der Marktakteure. Almaty. https://www.german-energy-solutions.de/GES/Redaktion/DE/Publikationen/Marktanalysen/2018/zma_kasachstan_2018_energieeffizienz-in-der-schwerindustrie.pdf?__blob=publicationFile&v=4 (downloaded 21.11.2021).

[16] 1.8 billion KZT, conversion with 1000 KZT = 2,98 USD
[17] 500 million KZT, conversion with 1000 KZT = 2,98 USD

Ukraine:

The following case study does not refer to a specific industry sector company but shows that district heating is worth consideration. In this case, the Khmelnytskyi city utility company uses boilers to provide heat for the district heating network, but industries with waste heat can also be a source for district heating. For example, “iron and steel” produces high-temperature waste heat that could be supplied to local residential (for space heating) or industrial consumers (as process heat). Based on this case, further exploration of this option is recommended.

Table 7: Case study in Ukraine with focus on district heating

Title	Optimisation Potential for Khmelnytskyi City in Ukraine
Scope	• Investigation of further technical improvements. • Assessment of the identified improvements including an estimate of the total economy of the city. • A holistic analysis of the interplay of production, distribution and consumption, including but not limited to lowering temperatures in the heating networks and utilizing storage for lowering peak production. • Development of recommendations for data collection in the district heating system • Effect on knowledge generation and economic efficiency.
Results	In the study these areas are “identified to be most advantageous: 1. Utilisation of Solar Thermal and Energy Storage for Solar Thermal and Peak Load reduction; 2. Demand Side Management; 3. Heat and Hot Water Metering and Data Collection; 4. Hot Water Supply 24/7; 5. Investigation of further optimisation potential to increase Energy Efficiency in Production Chain by the Economisers; 6. Assessment of Low Temperature District Heating Network; 7. The Interconnection of Different Districts and Boiler Houses in between and Container Boiler House utilisation for the Reliability Increase.”
Responsibility	UNEP DTU Partnership: Danish Energy Agency and State Agency on Energy Efficiency and Energy Saving of Ukraine.

Source: Based on R. Savickas, T. Antoshchuk, V. Antonenko (2020): Investigation of Further Optimisation Potential for Khmelnytskyi City in Ukraine. UNEP DTU Partnership. Danish Energy Agency. State Agency on Energy Efficiency and Energy Saving of Ukraine.

Table 8: Case study in Ukraine with focus on solar power

Title	Solar power plant
Scope	• Installation of 1.6 hectare, 1 MW ground-mounted solar power plant in Chernobyl (total investment: 1.2 million USD)
Results	• Approval for feed-in tariff (2018) • Annual output: 3,700 GJ
Responsibility	Rodina in cooperation with Enerparc AG

Source: Based on Deutsch-Ukrainische Industrie- und Handelskammer (2019): Bauen, Energieeffizienz und erneuerbare Energien in der Ukraine - Ihr Leitfaden. Gemeinsame Publikation des Ausschusses «Bau und Energieeffizienz» der AHK Ukraine. Kiew. https://ukraine.ahk.de/filehub/deliverFile/b0fccedc-ae97-4ed9-9f4b-b4504d8a0a7f/834143/Broschuere_Bauen_EnEff_EE_2019_06.pdf (downloaded 21.11.2021).

CHAPTER 3: IDENTIFICATION OF SUCCESSFUL BUSINESS MODELS

Chapter 3 provides an overview of successful business models applied to improve energy efficiency and energy productivity of industrial facilities. This chapter identifies case studies deemed suitable for further adaptation to the national circumstances of Kazakhstan and Ukraine. These are grouped into two categories:

1. Models to accelerate technological change, in which, subject to availability of advanced technologies (actual or anticipated), specific regulations in support of modernisation of existing, or construction of new industrial facilities, are implemented. Examples include mandatory and voluntary energy audits, energy management systems, use of Best Available Techniques (BAT), and stringent energy performance standards for industrial equipment.
2. Models that mobilise and scale-up industry sector cooperation to share best practices and increase implementation of state-of-the-art technologies. Examples include voluntary agreements and industrial networks, often coupled with financial incentives.

3.a Energy auditing and facilitating implementation of energy efficiency measures

Mandatory or voluntary energy audits are the most used instruments and play a crucial role in defining energy strategies within the industrial sector. Energy audits are conducted to assist industrial facilities in understanding how they use energy and to help identify areas where inefficiencies occur and opportunities for improvement and energy savings exist. Mandatory energy audits are often required for large industry operators and are typically accompanied by other energy policy measures. These include subsidies for energy audits, certified energy management systems, financing support for energy efficiency investments, and target setting for required energy-efficiency improvement. Small- and medium-sized enterprises are encouraged to undertake energy audits on a voluntary basis.

Table 9 Case study: Mandatory energy audits

In Spain, Royal Decree 56/2016, establishes mandatory energy audits for all companies deemed to be "large companies"[18]. Large companies must undergo an energy audit every 4 years. The audit must cover at least 85 per cent of the final energy consumption of the facilities located in Spanish territory that belong to the company activities. The application of a certified energy or environmental management system is equivalent to the energy audit obligation. The audits must be carried out by duly qualified energy auditors, or by qualified technicians from peer group companies who do not have a direct relationship with the activities being audited and belong to an internal control department of the company providing the audit. The execution of audits must be verified through an independent inspection service under an entity that is competent in matters of energy efficiency.
In Sweden, a law on energy mapping to enhance energy efficiency in large enterprises took effect in June 2014 (2014:266). The Swedish Energy Agency is responsible for monitoring the implementation of the law. By January 2016, all 1,200 large companies[19] affected by the law (both private and public), were obligated to register at the Energy Agency. According to the law, all large enterprises are obliged to carry out quality-guaranteed energy mappings at least every fourth year. A preliminary analysis shows that close to 30 per cent of the large enterprises affected are industrial enterprises. In the reports to be submitted to the Swedish Energy Agency, the companies must identify which processes are consuming significantly more energy than others, and how these have previously been addressed. In addition, a plan for cost-efficient savings must be included. The mapping has to be conducted by persons with particular qualifications and the Energy Agency has issued specific guidelines for companies on the process to be followed during the mapping. .
In Bulgaria the Energy Efficiency Law stipulates obligatory energy investigation and auditing of all producers of goods and services in the country with overall annual energy consumption over 3,000 MWh. The obligatory energy audits apply to all industrial enterprises with annual consumption above the threshold set, as well as public lighting systems in populated areas with more than 200,000 inhabitants. Enterprises that

[18] "Large company" is defined as a company which employs at least 250 people and/or has an annual turnover in excess of EUR 50 million or a balance sheet total in excess of EUR 43 million per year.
[19] Same "large company" definition as above

implement an energy or an environmental management system certified by an independent body for conformity to European or International Standards are exempted from the mandatory energy efficiency audit requirements, provided that the management system implemented includes an energy audit of the enterprise or industrial system concerned. During 2014-2020, a total of 594 enterprises have been audited and the cumulative annual saving achieved in 2018 was 615 GWh.

In Kazakhstan, the 2012 Law "On Energy Conservation and Energy Efficiency" mandates energy audits every four years for all entities of the State Energy Register[20], except for government agencies. The main tasks of the energy audits as defined by the Law are to identify potential opportunities to save energy resources; develop a program of energy-saving measures and introduce energy-saving technologies; determine the economic effect of the introduction of energy saving measures; determine the payback period of energy saving measures and the costs of their implementation and improve the system of control and accounting of energy consumption. In Kazakhstan, the procedure for conducting energy audits is established by an Order of the Minister of Investment and Development dated March 31, 2015 № 400 "Rules of energy audit". To facilitate implementation of the recommendations of the energy audits, in 2021 the Kazakhstan Association of Energy Auditors published methodological guidelines on best practices in the field of energy saving and energy efficiency of the Republic of Kazakhstan. In addition, the Association published a guideline for conducting energy audits, including the basic requirements for the presentation and the content of energy audit reports.

Sources:
https://sede.serviciosmin.gob.es/es-es/procedimientoselectronicos/Paginas/detalle-procedimientos.aspx?IdProcedimiento=146
https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/1353
https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/1358
http://www.energimyndigheten.se/
https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html
http://kazae.kz/index.php/energoaudit/zakazchikam-energoaudita/energoaudit

[20] Includes individual enterprises and legal entities consuming energy resources in the amount equal or greater than 1,500 tons of coal equivalent (tce) annually (12,200 MWh/yr), as well as government agencies, quasi-public sector entities and natural monopolies consuming energy resources equivalent to 100 or more tce per year (814 MWh/yr)

Table 10 Case study: Voluntary energy audits

In Finland, the Energy Audit Programme (EAP) is a voluntary programme promoted by a 40 per cent subsidy for industry participants. It consists of programme administration, detailed guidelines, auditor training and authorisation, as well as a monitoring system and promotion activities. Nine audit models have been developed for different types of buildings and sectors. All have three basic elements: evaluation of energy consumption, identification of energy saving possibilities, and reporting. The Energy Audit Models include: ▪ Industrial Energy Audit: a "lighter" model for facilities with low energy intensive core processes or facilities where the saving potential of the process is known to be marginal ▪ Industrial Energy Analysis: a "medium" model for energy intensive core processes or facilities where the saving potential of the process is known to exist ▪ Process Industry Energy Analysis: A two-step energy audit model for energy intensive process industries, including a scanning phase and a detailed energy audit ▪ Energy Inspection: for very small buildings in the commercial and industrial sectors ▪ Building Energy Audit: The basic model for commercial buildings ▪ Post-acceptance Energy Audit: for new and renovated buildings designed to optimise energy use after construction ▪ Follow-up Energy Audit: A model to update previous energy audits ▪ Power Plant Energy Analysis: for electric power plants for communities or for industry ▪ District Heating Analysis: A model for heating plants and distribution networks All industry is eligible for the audit subsidy, and the same company/site can reapply for the subsidy three years after the previous audit. Auditing is carried out by private consulting companies in order to establish a local industry. Since June 2014, large companies have not been receiving subsidies for audits because they are within the sphere of mandatory audits required by the Energy Efficiency Directive. From 1992 to 2014, audit subsidies given totalled 37.6 million Euro covering industry, services, and energy sectors. The number of sites audited totalled about 900 by the end of 2014. In 2014, 82% of energy audit subsidies were given to industries participating in the Voluntary Energy Efficiency Agreements scheme.
Sources: https://businessdocbox.com/Green_Solutions/74789896-Fin3-energy-audit-programme-in-industry-eap.html https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/1118

Table 11 Case study: Effective enforcement of requirements to implement energy efficiency measures

In the Netherlands, the Environmental Law obliges small and medium enterprises (SME) to implement energy-efficiency measures with a return of investment of 5 years or less. Experience has shown, however, that companies often do not consider efficiency measures themselves. Usually it is not their core business and most find it a difficult subject. Another barrier is that municipalities and provinces are responsible for enforcement of the law in their own region. As these entities set their law enforcement budgets and priorities, energy efficiency may be less of a priority than other laws. The province of Groningen wanted to take responsibility together with the municipalities of Groningen. The province assigned the Groningen Environmental Service (GES) to execute law enforcement on energy-efficiency in the region of Groningen. The GES hired specially trained law enforcers for this project. The enforcers visited SMEs and explained to them about the energy-efficiency measures must be implemented. Companies above a certain energy usage (50,000 kWh or 25,000 m3 natural gas) also must develop an energy saving plan. SMEs must send their saving plan to the GES, where it is checked. After a certain time, the law enforcers visit the SMEs again to check if the measures have been taken. The costs per SME is 1,500 Euro, paid for by the province of Groningen (60 per cent) and the municipalities (40 per cent). Total annual costs were roughly 300,000 Euro per year, for three years. The province secured budget through a 4-year energy program (2016-2019) and the municipalities through their annual budget process. More than 700 SMEs were visited and supported in the process of energy efficiency measures identification and implementation.
Source:http://www.interregeurope.eu/policylearning/good-practices/item/3803/energy-efficiency-through-law-enforcement/

3.b Energy management system and benchmarking

Benchmarking is used to compare the energy used in an industrial facility to that of other similar facilities or to national or international best practice energy use facilities. A number of countries have introduced benchmark indicators for selected industries. The United Nations Industrial Development Organisation (UNIDO) has also developed the Competitive Industrial Performance Index for industrial organisations in low to middle income countries who want to compare their energy performance to competitors in upper-income countries.

An Energy Management System (EMS) can be applied to different energy consumers including industrial, commercial, and public sector organizations. It provides a framework to manage an organisation's energy use and helps enterprises identify energy savings opportunities, including measures that do not necessarily require high capital investment. EMS further provide guidance and tools on how to integrate energy efficiency into the daily management practices and production processes.

Table 12 Case studies: Energy Performance Indicators (EnPI) and benchmarking

Since 2011, EnPIs have been formally defined by the International Standards Organization (ISO) as a quantitative index of energy performance which can be applied to compare an organisation's energy performance at different times. The UNIDO-led network of industrial energy efficiency accelerators has produced a knowledge kit on EnPIs. The knowledge kits and accompanying training are aimed at inspiring and equipping industry practitioners to take the first steps toward enhancing their energy systems.
Canada's Office of Energy Efficiency benchmarked the energy use of various national industries including ammonia, cement, fertiliser, food and beverage, mining, oil sands, petroleum products, pulp and paper, steel, textiles, and transportation manufacturing facilities. In the Netherlands, a negotiated agreement titled The Energy Efficiency Benchmarking Covenant was concluded in 1999. Nearly all energy-intensive Dutch enterprises have signed the Covenant, including the Federation of Netherlands Industry and five sector organisations, including the Association of Dutch Chemical Industry, the Association of Dutch Paper and Cardboard Manufacturers , the Dutch Electricity Generating Board , and the bodies representing the metallurgical industry and refineries. The Covenant encourages industrial companies to compare themselves to their peers and to commit to becoming among the top 10 per cent most energy efficient plants in the world, while at same time enjoying a reduced Energy Tax rate. In the United States, ENERGY STAR provides Energy Performance Indicators and excel based tools to help industrial companies benchmark industrial plant energy performance. Lawrence Berkeley National Laboratory, also in the United States, developed BEST, 'Benchmarking and Energy Saving Tool,' for industry to benchmark a plant's energy performance against international best practice. In Moldova, UNIDO supported S.A. JLC dairy processing in introducing an energy performance monitoring and reporting system, which allowed for:

- Automatically developing energy performance models, baselines and indicators for each significant energy use considering the impact of the baseload and all relevant variables. This reduced JLC staff time spent on data collection and management
- Comparing actual and expected energy consumption in real time, calculating and showing energy performance improvements, and comparing EnPIs against target values
- Verifying energy savings based on best international practices and protocols
- Detecting deviations using appropriate EnPIs

The total investment amounted to 15,550 USD and the annual energy saving achieved is 147,558 kWh or 4,984 USD, making the total payback time only 3.1 years.

Sources: https://www.yumpu.com/en/document/read/4320380/global-industrial-energy-efficiency-benchmarking-an-unido
https://www.industrialenergyaccelerator.org/wp-content/uploads/FINAL-EnPIs_brochure.pdf
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https://www.iea.org/policies/1605-energy-efficiency-benchmarking-covenant?country=Montenegro%2CNetherlands&page=3&region=Europe&type=Voluntary%20approaches%2CPayments%20and%20transfers
https://www.energystar.gov/industrial_plants/measure-track-and-benchmark/energy-star-energy
https://www.industrialenergyaccelerator.org/moldova/optimizing-dairy-production-in-moldova/

Table 13 Case study: Energy Management System – energy intensive industries

St Marys Cement Bowmanville plant in Canada has been in operation since 1968 and recognised a need for a more systematic approach to energy management in 2006 with the formation of an energy management committee. Prior to ISO 50001 certification in 2011, the committee sought to solidify the systematic approach already ingrained by ISO 9001, 14001, and OHSAS 18001 certifications starting in 1996. Since the formation of the energy management committee, including the certification process for ISO 50001, all identified improvements have been tracked using the committee's action plan. Since its inception the action plan has documented over 300 actions on improving energy management practices. Periodic updates of energy action initiatives are provided to all employees to keep them up to date with the evolving energy program. A survey was recently conducted of all plant personnel to gauge their knowledge of the energy program. The information gathered will be used to develop training packages in the future for areas of identified weaknesses. The Bowmanville plant holds an annual Sustainability Week where employees are encouraged to participate in various information sessions presented by sector specific experts. These sessions have been very successful in garnering employee input and commitment to energy management and conservation efforts. The reported annual energy saving for 1 year is 9,500 MWh, equal to 2.1 million USD in energy cost saving. The energy management system certification cost 46,100 USD, with a 4.68 per cent energy performance improvement.

PJSC Magnitogorsk Iron & Steel Works (MMK) is Russia's largest supplier of galvanised steel products. In 2019, MMK consumed 4.72 billion kWh of electricity and 4.27 billion m^3 of natural gas. The organisation of the technological process at all levels—from the management of the enterprise to the management of a separate technological unit—is the most significant factor in improving energy efficiency and productivity. The company developed in 2016 an EMS and received in 2019 subsequent certification in accordance with ISO 50001. Cost reduction measures have been developed and implemented in all production and functional divisions of the company. The direct benefits of EMS Implementation include:

- implementation of organisational and technical measures aimed at improving energy efficiency, saving an additional 23.2 million USD for the period from 2016 to 2019;
- implementation of special low-budget, high-performance investment projects (Baby Capex), the economic effect of which amounted to 17.1 million USD for the period from 2016 to 2019.
- The share of costs for purchased energy resources in the cost of products sold decreased by 1.3 per cent.

MMK has organised monitoring of energy resources based on the collection of data from an automated system. Using this monitoring, areas of significant energy consumption have been identified and the largest consumers defined. In addition, the company promotes energy saving initiatives among employees via various programmes and training.

The reported energy improvement for four years is 2,376 GWh energy saving, resulting in 40.4 million USD in energy cost saving. Energy management system certification resulted in a 5 per cent energy performance improvement and an estimate savings of 418,300 USD.

Sources: https://cleanenergyministerial.org/sites/default/files/2018-12/St_Marys_Cement_Canada.pdf
https://cleanenergyministerial.org/sites/default/files/2020-06/CEM_EM_CASESTUDY_MMK_RUSSIA.pdf

Table 14 Case study: Energy Management System - non-energy intensive industries

Novoorzhytskyi Sugar Plant is part of the Agro-industrial holding Astarta-Kyiv, Ukraine. Since 2008, Astarta-Kyiv is a member of the Global Compact Network in Ukraine, an official representative of the UN Global Compact, a global initiative that brings together the United Nations and companies around the world and annually reports on its progress in fulfilling the principles of the treaty, as well as has been publishing sustainable development reports for several years now. In 2016 the Program for Ensuring Energy Efficiency Improvement at the Novoorzhytskyi Sugar Plant was approved. The main purpose of the program was to provide energy efficiency improvements to enterprises and reduce resource consumption. The program envisaged the introduction of an EMS, which complemented the already existing corporate integrated management system that met the requirements of ISO 9001, ISO 14001, OHSAS 18001 and ISO/FSSC 22000. The implementation of energy management system not only strengthened the ability to fulfil the tasks of the plant, but also made it possible for the enterprise to be one of the leading enterprises of the Astarta-Kyiv and sugar industry in Ukraine. Novoorzhytskyi Sugar Plant took an active part in the UNIDO-GEF project *Introduction of EMS standard in Ukrainian Industry*. The enterprise received theoretical and practical knowledge about the functioning of the EMS. As part of the training to improve the skills of the employees, four modules of training were introduced that fully covered the requirements of the international standard ISO 50001. The reported energy improvement for four years is:

7,900 kWh energy saving, 258,000 USD energy cost saving, energy management system certification 196,000 USD, 27 per cent energy performance improvement.

Wyeth Nutrition in Askeaton, Ireland is an infant nutrition producer. Since 2012 it has been part of the Nestle Nutrition parent company. Wyeth Nutrition have always had a great history of delivering energy efficiency projects. In 2004 the site delivered a significant project in transitioning from heavy fuel oil to gas and installed a CHP, which has since provided most the site's electricity requirements. In 2012 Wyeth set up a programme of energy projects and energy management that led to certification under ISO 50001. The energy management system is integrated with the company's environmental, quality, and health & safety systems. Continual improvements are replicated across all systems. All energy savings are verified by a Certified Energy Measurement and Verification Professional. A cross functional energy team was put together, comprised of team members from all activities and departments throughout the organisation. Responsibilities include to communicating and raising energy awareness throughout the organisation and providing feedback. Energy team members also organise special events, such as energy awareness days/weeks, provide input into improvements of the energy programme, provide updates on how each department/section is progressing and any problems they encounter with regard to their energy reduction objectives, and work with other members of the Energy Team to ensure the overall objectives of energy reduction are met. Since the introduction of the energy management programme in 2012, the following results have been achieved (2012-2018): cost savings of nearly 2.2 million USD; energy savings of 122 GWh, cost to implement the EMS 400,000 USD, 38 per cent energy performance improvement.

Vitmark-Ukraine is a company, producing baby food and fruit juices, which are exported to CIS countries, Europe, the United States, Canada, and Israel. In 2013, the company got certified to ISO 9001:2008 (International Quality Management System Standard) and ISO 22000:2005 (International Food Safety Management System standard). In 2016, the company joined the UNIDO-GEF project "Introduction of Energy Management System Standard in Ukrainian Industry" and started implementing an EMS as per ISO 50001 requirements. Within the UNIDO project, the company acquired both theoretical and practical knowledge of EMS operation. A training program was implemented, comprised of 3 modules that encompassed all the requirements of ISO 50001 and trained the company staff to evaluate its actual energy consumption with regard to production output. The training also provided a more detailed understanding of the use of statistical methods, in particular regression analysis, as a tool for comparing energy consumption under normalized conditions. The key benefits after EMS implementation included improved culture of energy consumption; use of normalization to account for driving factors; improved operational control and analysis, and incorporation of energy performance into procurement and design.

Sources: https://cleanenergyministerial.org/sites/default/files/2020-06/CEM_EM_CASESTUDY_ASTARTA_UKRAINE.pdf
https://cleanenergyministerial.org/sites/default/files/2019-05/CEM_EM_CaseStudy_Wyeth_Ireland.pdf
Materials. Provided by UNIDO-GEF project "Introduction of Energy Management System Standard in Ukrainian Industry"

Table 15 Case study: Energy Manager

In Italy local authorities and energy-intensive companies are required to designate a responsible Energy Manager (art. 19 of Law 10/91). The obligation is for all companies in the industrial sector with energy consumption more than 10,000 tonnes of oil equivalents (toe) per year and companies in the service sector and local/regional authorities with energy consumption over 1,000 toe per year. 65 per cent of questioned Energy Managers implemented energy saving measures in the past three years. Companies appoint an expert who deals with the analysis of energy flows, promotes energy efficiency measures, and supports the top management and policymakers to pursue sustainable development. This Energy Manager can be an employee of the company (technician or an engineer). Every year the companies must communicate the name of the designated engineer to the Ministry of the Industry. A process of voluntary certification of energy managers was initiated, with a goal to create a list of certified individuals.
Sources: https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/1199 http://em.fire-italia.org/

3.c Voluntary agreements and industrial networks

A number of governments have negotiated voluntary agreements with industry, which usually set realistic, long-term (typically 5-10 years) targets for improving the energy efficiency. They require participating industrial facilities to develop implementation plans for reaching their targets and to provide annual monitoring and reporting of progress toward those targets. International experience suggests that often such agreements are supported by the establishment of a set of accompanying policies that provide strong economic incentives as well as technical and financial support to the participating industries.

Industrial energy efficiency networks are established with the aim to exchange know-how and build technical capacity on energy efficiency among similar industries. Such networks have been operational in various countries and recently the concept was introduced in Ukraine as well.

Table 16 Case study: Long-term Energy Efficiency Agreements with Industry

In the Netherlands Long-term Energy Efficiency Agreements have been implemented since 2009 with the aim to improve the energy efficiency of industry. More than 1,000 companies from 37 sub-sectors have established agreements to reduce their energy use by implementing energy efficiency measures with payback periods up to five years. A last addendum to the Agreement resulted in participating companies achieving 9 PJ in additional final energy savings. The latest addendum runs from 2017 to 2020.

The Ministry of Economic Affairs and Climate in the Netherlands established specific agreements with several companies for energy efficiency measures that go beyond the long-term agreement (MEE Covenant). Eligible measures include utilising residual heat, projects where equipment is replaced by state-of-the-art energy-efficient equipment, or innovative projects where a new energy-saving technology is demonstrated. These gains must be additional to those specified in the long-term agreements (participating companies include Shell, Havenbedrijf Rotterdam, Dow and others). The national result in 2019 of the participants in the long-term agreement was a 1,695 GWh (1.2 per cent) energy efficiency improvement of their total energy consumption in 2019. This result is lower in absolute terms than the national result of 2,056 GWh in 2018, but the same in relative terms because the total energy consumption of the participating companies fell sharply in 2019. The MEE covenant participating companies in 2019 achieved 1,861 GWh (1.5 per cent of the total energy consumption in 2019). This result is lower than the result of 2,389 GWh (1.2 per cent) that was achieved in 2018, mainly due to the lower savings on process efficiency. The overall results for the period 2009-2019 are 21,611 GWh (12.7 per cent). This is an average saving of 1.3 per cent per year.

In Finland the Energy Efficiency Agreements have been a long-running and important national initiative to improve energy efficiency in industry and other sectors since 1997. Currently, the third period of the agreements is underway from 2017 through 2025. The parties committed to this agreement are the Ministry of Economic Affairs and Employment (MEAE), the Energy Authority Motiva, and the Confederation of Finnish Industries and its member associations. The agreement is also an alternative to mandatory energy audits in accordance with the EU Energy Efficiency Directive for large companies if they also implement the national energy efficiency system , which resembles energy efficiency standards. Participants implement energy efficiency actions and annually report on their progress to a database through web access. According to the 2017 National Energy Efficiency Action Plan, the annual energy savings expected in 2020 from actions implemented by participants in the 1997–2007, 2008-2016 and 2017-2025 agreement periods are 770 GWh in mid-sized industry and 11,691 GWh in energy-intensive industry. Similar Voluntary agreements with industry are implemented in a number of EU countries (see details at https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/search).

Sources: https://www.rvo.nl/sites/default/files/2020/11/resultatenbrochure-meerjarenafspraken-energie-efficientie-2019.pdf
https://www.rvo.nl/sites/default/files/2020/11/resultatenbrochure-meerjarenafspraken-energie-efficientie-2019.pdf
https://www.iea.org/policies/7739-long-term-industry-agreements-on-energy-efficiency-lta3-mee?country=Netherlands&qs=netherlands&sector=Industry&topic=Energy%20Efficiency
https://epatee.eu/sites/default/files/epatee_case_study_finland_energy_efficiency_agreement_for_industries_ok_0.pdf
https://ec.europa.eu/energy/sites/default/files/documents/fi_neeap_2017_en.pdf

https://tem.fi/en/energy-efficiency-agreements-and-audits

Table 17 Case study: Industrial energy efficiency networks

Energig is a project supporting energy efficiency networking among industries in Sweden's Gävleborg region involving 44 local SMEs working to improve energy efficiency. Initially, SMEs were trained in small groups (networks) of 5 to 15 SMEs and received support on how to carry out energy efficiency actions at their companies (e.g. conduct an energy audit and implement the energy-saving measures). After the training, the networks met 3-4 times per year. Network meetings included round-table presentations about monitoring, implementation of measures, and lectures on energy use for end-use processes. In Sweden, on average, 3-9 per cent energy saving is achieved after energy audits are performed. However, the participating local SMEs achieved an average of 16 per cent energy saving within the energy efficiency network program, higher than expected. In addition, SMEs gained non-energy benefits such as increased lifetime of equipment, less maintenance, improved company image, and new contacts.

The Large Industry Energy Network (LIEN) in Ireland is a voluntary network initiative for Ireland's largest industrial energy consumers (those spending more than €1 million on energy annually). In 2017 LIEN comprised 192 of Ireland's largest energy users and accounted for 19% of total primary energy consumption and 55% of Industrial total primary energy consumption. LIEN provides for sharing of best practice and case studies. Information seminars are organised on a regular basis to build capacity and exchange new learning and approaches to reducing energy consumption. This voluntary approach has been effective in enabling members to choose profitable energy saving projects and actions. Members of the network employ a wide variety of technologies and management approaches. These include investments in technologies such as compressed air, refrigeration, energy efficient lighting, building management systems, and combined heat

& power . Other approaches include staff awareness campaigns and energy management teams. The cumulative annual energy saving in 2020 was 1,895 GWh.

The first Ukrainian energy efficiency network was established in the Lviv region and encompasses 11 industrial members coordinated by the Lviv Chamber of Commerce and Industry. Through energy audits that were carried out for all companies, 95 energy efficiency measures were identified with the overall saving potential of 20,000 MWh and 6,500 tCO_2 per year. The companies agreed on a joint target of 6,330 MWh and 4,270 tCO_2 by the end of 2020 and announced their commitment during the public network meeting in June 2019. As of May 2020, Lviv member companies implemented altogether about 20 measures which are currently saving 9,700 MWh and 3,300 t CO_2 per year. Hence, the energy saving target is exceeded by 50 per cent and two-thirds of the CO_2 target has been achieved. Another 25 measures are underway. upon implementation the network will be expected to save as much as 17,300 MWh and 5,200 t CO_2 per year.

Sources: www.interregeurope.eu/policylearning/good-practices/item/3716/energig-energy-efficiency-networks/
https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/1183
Materials provided by GIZ Ukraine

3.d Best Available Techniques (BAT) and Industrial equipment standards

The Best Available Techniques (BAT) concept is defined as “an evidence-based, multi-stakeholder tool that supports the establishment of legally binding emission limit values in environmental permits, to effectively prevent and control industrial emissions to air, water and soil”. The BAT approach is adopted by a number of OECD member and partners, including the United States, China, Korea, India, Russian Federation, Japan, New Zealand.

The adoption of minimum energy performance standards have shown to be a highly effective way generally to improve the efficiency of energy-using products including electric motors in industry.[21] According to UNIDO[22], According to UNIDO, electric motors account for roughly 60 per cent of global industrial electricity consumption and close to 70 per cent of industrial electricity demand, which means there are substantial savings potentials from improved motor efficiency. In some countries standards for high efficiency motors have been mandated. For example, in the USA and Canada mandates cover more than 70 per cent of the motors. The EU approach has been to introduce minimum energy performance requirements, thus allowing import and sales of only equipment that meets the minimum level of requirements and rejecting from the market the worst-performing products.

Table 18 Case study EU Best Available Techniques reference documents (BREF)

The European Union’s Industrial Emissions Directive defines BAT as "the most effective and advanced stage in the development of activities and their methods of operation, indicating the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where this is not practicable, to reduce emissions and the impact on the environment as a whole". The EU BREFs cover specific agro-industrial activities, referred to as “sectoral BREFs”. However, there are also a number of “horizontal BREFs” dealing with cross-cutting issues such as energy efficiency, industrial cooling systems, and emissions from liquids, liquefied gases and solids with relevance for industrial manufacturing in general. A specific BREF, for example, was developed for the monitoring of emissions to air and water from installations under the Industrial Emissions Directive.

In Kazakhstan the new Environmental Code was adopted on 2 January 2021 to replace the 2007 Environmental Code. Following the recommendations by the OECD, Kazakhstan introduced considerable changes in the 2021 Code. According to the update, the 50 largest companies, which account for 80 per cent of emissions in Kazakhstan, will have to replace their old technologies with BATs by 2025. Eight BAT reference documents are currently under development and are being discussed within relevant national stakeholder groups

Sources: https://eippcb.jrc.ec.europa.eu/reference/
https://igtipc.org/ru/ndt/20210514-044949

[21] According to a recent IEA report the average energy efficiency of appliances in countries with energy performance standards and labelling programmes has increased two to three times the underlying rate of technology improvement. This has resulted in average energy reductions of 10-30% over 15 to 20 years in the stock of most regulated products across all countries.
[22] https://open.unido.org/api/documents/4818324/download/Energy

Table 19 Case study Industrial equipment standards

Energy efficiency standards and labels have been in introduced by various governments since the 1970s. According to a recent IEA report, as of 2021 energy efficiency standards and labelling programmes operate in more than 120 countries around the world and apply to more than 100 types of appliances and equipment in the commercial, industrial and residential sectors. The longest-running programmes with the largest product coverage have saved approximately 15 per cent of their country's total electricity consumption. And while the majority of savings were derived from the residential sector, IEA estimates that equipment standards and labels for the industrial sector account for at least one-sixth of the total savings. The EU Eco-design Directive (2009/125/EC) allows the European Commission to regulate the minimum energy performance of products (MEPPs), pushing away from the market the worst-performing products at the design and production phase. The eco-design features a series of different parameters regarding environmental impacts such as material; energy; water; waste; emissions to air, water and soil; hazardous substances; and other physical impacts from the use phase. The Eco-design Directive does not create binding requirements on products itself, but product requirements are set through the implementing measures of the Commission Regulations. In case a manufacturer is not established in EU, the importer shall ensure that the product placed on the market and/or put into service is complying with this directive and the applicable implementing measure. The manufacturer will also keep and make available to the European Commission a declaration of conformity and technical documentation.
Sources: https://www.iea.org/reports/achievements-of-energy-efficiency-appliance-and-equipment-standards-and-labelling-programmes https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign_en

CHAPTER 4: IDENTIFICATION OF POLICY OPTIONS TO IMPROVE ENERGY PRODUCTIVITY AND DECARBONISATION OF INDUSTRY IN KAZAKHSTAN AND UKRAINE

While some legislative measures related to industrial energy efficiency have been already adopted in Kazakhstan and Ukraine, more tailored policies are needed to address the special needs and contexts within each country, and to accelerate industrial actions to improve energy productivity and efficiency.

In Kazakhstan the Energy Conservation and Energy Efficiency law (adopted 2012, latest amendment in 2019) mandates energy audits at least every five years for industrial enterprises consuming more than 1,500 tce per year. The law also provides for voluntary agreements between the state authority and industrial enterprises with annual energy consumption of at least 100,000 tce to reduce energy consumption by 15% within five years. The Ukrainian Law of Energy efficiency (adopted in October 2021) for the first time introduced mandatory energy audits for "entities of large business" (defined within the Commercial Code of Ukraine). Such entities are obliged to conduct an energy audit every four years.

To ensure efficient enforcement of the legal requirement, future policy in both countries should be focused on further strengthening the institutional and legal framework around energy efficiency regulations, laws, and rules, and creating a holistic system of incentives for industrial enterprises. Applying a systems approach to the implementation of energy efficiency measures will also improve the outcome of energy use and carbon emission reductions at both the individual enterprise level and for the state as a whole.

Systematic implementation of the proposed policy options in the field of energy efficiency will promote competitiveness, contribute to sustainable development within Kazakhstan and Ukrainian economies, reduce air-pollutants and greenhouse gas emissions, and improve the health and well-being of citizens.

Based on the best practices analysed and following consultations with local stakeholders active in industrial energy efficiency[23], a number policy options have been identified and are presented in this chapter as most relevant for implementation in Ukraine and Kazakhstan. These policy options are recommended for implementation into the Outline of a National policy roadmap for both countries, as presented in the Chapter 5.

[23] For Kazakhstan – GIZ Kazakhstan, DENA, Association of Energy Auditors; For Ukraine – GIZ Ukraine, UNIDO Ukraine, Clean Resource Efficient and Cleaner Production Centre of Ukraine

4.a Outline of a National Policy Roadmaps for Kazakhstan and Ukraine

Policy measure	Country	Goals	Objectives	Risks or barriers
Industrial energy audits	Kaz	Improve quality of the energy audits performed by regulating and controlling the application of international energy auditing standards and procedures Prompt the implementation of energy efficiency measures prescribed by the energy audit Introduce a national-level system of energy savings monitoring Implement supportive financial and risk-mitigating mechanisms	Actively promote and recommend the use at the national level of the following reference documents, developed by the Association of Energy Auditors of Kazakhstan (with DENA support) ▪ Handbook on best practices in Industrial Energy conservation and energy efficiency, ▪ Recommended standard for Energy Audits and for Energy Audit Reporting. Encourage voluntary energy audits by all industrial enterprises Analyse and prioritise financial mechanisms, incentives, and risk mitigating schemes to support implementation of prescribed energy efficiency measures	Energy tariffs do not provide effective price signals for implementing energy efficiency measures Low level of awareness of energy auditors of the required energy audit quality and standards Insufficient financial resources to implement recommended energy efficiency measures Low interest among financial institutions to implement monetary mechanisms and instruments for project financing
	Ukr	Minimum requirements for energy auditors and energy audit reports adopted (based on international	Prompt adoption of certification scheme for energy auditors and	Energy tariffs do not provide effective price signals for

Policy measure	Country	Goals	Objectives	Risks or barriers
		energy auditing standards and procedures) Prompt implementation of energy efficiency measures prescribed by the energy audit Introduce a national-level system of energy savings monitoring Implement supportive financial and risk-mitigating mechanisms	recommended standard energy audit report Encourage voluntary energy audits by all industrial enterprises Organise training courses and accreditation for energy auditors Analyse and prioritise financial mechanisms, incentives and risk mitigating schemes to support implementation of prescribed energy efficiency measures	implementing energy efficiency measures Insufficient financial resources to implement recommended energy efficiency measures Low interest among financial institutions
EMS and voluntary agreements	For both countries	Implement energy management systems in the majority of industrial enterprises Establish and sign into agreement negotiated industrial voluntary agreements and sector specific energy saving targets Implement supportive financial and risk-mitigating mechanisms	Incentives for SMEs to implement EMS Organize capacity building and training for company representatives /energy managers on ISO 50001 Analyse and prioritise financial mechanisms, incentives and risk mitigating schemes to support implementation of EMS	Lack of enforcement procedures and practices Lack of interest among industrial enterprises to implement EMS Lack of support from industry associations and enterprises towards voluntary agreements
BATs	Kaz	Introduce best available technologies for all applicable industrial enterprises according to the BAT handbooks	Adopt the 8 BAT handbooks currently under discussion (as of the end of 2021)[24]	Energy tariffs do not provide effective price signals for implementing BATs

[24] https://igtipc.org/ru/ndt/20210514-044949

Policy measure	Country	Goals	Objectives	Risks or barriers
		Implement supportive financial and risk-mitigating mechanisms	Publish and disseminate Guidelines for BAT implementation of industrial enterprises Analyse and prioritise Financial mechanisms, incentives and risk mitigating schemes to support implementation of BATs Organise capacity building to ensure effective BAT handbooks application	Insufficient capacity and resources among industry to implement BATs Lack of enforcement procedures and practices Insufficient financial resources to introduce BATs Low interest among financial institutions
	Ukr	BAT handbooks for industry developed and adopted Supportive financial and risk-mitigating mechanisms in place	Initiate comparative analysis of the energy efficiency of industrial enterprises in Ukraine and the development of BAT handbooks for types of industry Upon adoption of BAT handbooks, ensure effective enforcement and follow up on the development and implementation of action plans by industrial enterprises on BAT implementation Analyse and prioritise financial mechanisms, incentives and risk mitigating schemes to support	Low energy tariffs do not provide effective price signals for implementing BATs Insufficient technical capacity to develop BAT handbooks Insufficient capacity and resources among industry to implement BATs Lack of enforcement procedures and practices Low interest among financial institutions

Policy measure	Country	Goals	Objectives	Risks or barriers
			implementation of prescribed energy efficiency measures Organise capacity building to ensure effective BAT handbooks application	
Minimum energy performance or eco-design requirements for industrial equipment	Both countries[25]	Mandatory minimum energy performance or eco-design requirements for a wide range of industrial equipment adopted and enforced Support mechanism for local manufacturers of industrial equipment in place	Develop regulations introducing eco-design requirements for industrial equipment i.e. electric motors, machine tools, professional refrigeration and air conditioning units, water pumps, industrial furnaces and electrical transformers, etc Develop and adopt compliance and enforcement procedure Introduce support mechanism for local producers of industrial equipment to allow rapid integration of new requirements in manufacturing products	Lack of alignment of standards and regulations with international best practices Development of non-mandatory Minimum Energy Performance Standards Lack of technical capacity for regulations development and enforcement
Industrial Energy Efficiency Networks	Both countries	Creation of platform to support the exchange of experiences, best practices and organising contacts between industrial companies	Organise broad consultation on potential model of and Industrial energy efficiency network/exchange platform	Lack of interest among industrial enterprises

[25] In 2019 Ukraine adopted Technical regulations on ecodesign requirements for water pumps and electric motors

Policy measure	Country	Goals	Objectives	Risks or barriers
			Disseminate international best practice examples from similar associations Support the establishment of Pilot Energy Efficiency Networks (consisting of 5-10 companies), with guidance and support at national and international level Support of activities by partly financing the costs of energy efficiency counselling and moderation of the network activities Organise Public awards for successful Networks	

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This study has investigated and recommended technology, program, and policy options for improving energy efficiency and reducing carbon emissions in the industrial sector in Kazakhstan and Ukraine. Based on the case studies presented and the sector data analysed, we find that there are ample opportunities through partnerships, knowledge sharing, and policy implementation to make meaningful improvements on these issues within the sector.

As a next step, a set of indicators for the industry sub-sectors should be developed. Given the limited data availability on the various sub-sectors (particularly those most relevant and energy-intensive such as “iron and steel” and “non-ferrous metals”), additional data must be collected in order to develop such indicators. Once available, such indicators can be used to underpin political decisions in support of industrial energy efficiency across both countries.

As the available data for this study was limited, it is necessary to collect relevant data for all sub-sectors (or at least for the most relevant sub-sectors like “iron and steel” and “non-ferrous metals”) in order to develop a set of indicators following a consistent industry definition so that an analysis with significant results can be produced serving as a reliable basis for political decisions.

Changes in energy intensities of some industry sub-sectors over time have been identified in this study, however the driving factors for these changes are not evident. A further analysis with more granular data is needed to find out why energy intensity has changed over these periods—whether there were truly improvements of energy efficiency or other driving factors not related to energy efficiency projects. If there is a tangible energy efficiency improvement identified in a certain sub-sector, success factors and drivers should be determined so that progress can be continued and expanded to other relevant sub-sectors.

Several key opportunities for energy use and emission reductions are evident across both countries. The sub-sector “iron and steel” is by far the largest energy consumer relative to other industry sub-sectors. The most promising technology options for this sub-sector are the use of scrap with electric arc furnaces and the natural gas-based direct reduced iron plants. Given the high heat output of industrial processes, district heating that utilizes waste heat as a resources for nearby residential and commercial needs could also be quite impactful. And fuel switching away from coal to all-electric or natural gas-based processes can help reduce greenhouse gas emissions, particularly when coupled with decarbonizing of electric grids. Each of these should be investigated in more detail at the sub-sector and individual facility levels.

The data also shows that energy use and greenhouse gas emissions are not necessarily coupled. With electricity from renewable sources, emissions can be reduced even without a change in energy consumption. The study shows that, with few exceptions, the share of renewable energy sources within the UNECE RPTC countries is very small. At the same time, electricity is one of the main sources of energy into industrial processes. The potential of renewables should be identified as a key strategy for decarbonizing the existing systems.

Using this combination of broad analysis and policy tools, Kazakhstan and Ukraine can help lead in industrial energy efficiency and decarbonization efforts among the UNECE RPTC countries. Based on these nations’ efforts, new lessons learnt and best practices will be acquired to accelerate the transition more broadly across the RPTC countries and the UNECE’s member states at large.

Recommendations

To fully achieve the potential for improving industrial energy efficiency in Kazakhstan and Ukraine, the following actions are suggested:

1. Accelerate technological change

- Governments, in close cooperation with industry, should develop legislation and regulations that support swift modernisation of existing industrial facilities and utilisation of advanced technologies for newly designed facilities.
- Adopt mandatory energy audit requirements for large industrial enterprises. For Ukraine, adopt international standards to conduct energy audits and develop a certification/accreditation scheme for energy auditors.
- Introduce a system for monitoring the implementation of the energy efficiency measures prescribed by the energy audits and a procedure for post-installation measurement and verification to track the savings.
- Promote the adoption of ISO 50001 standards by all industrial enterprises and encourage such enterprises to implement actions to deliver cost-effective energy savings.
- Mandate, where possible, the implementation of BATs for industrial enterprises according to the energy efficiency handbooks developed and approved. For Ukraine, establish BAT handbooks for different industrial sub-sectors beginning with those with the highest energy intensity. For Kazakhstan, ensure effective enforcement of the 2021 Environmental code and follow up on the development and implementation of action plans by industrial enterprises on BAT implementation.
- Initiate comparative analysis and benchmarking on technical and economic energy efficiency potential in the industrial sector in general and strategic sub-sectors.
- Revise existing industrial equipment standards and minimum performance standards and introduce eco-design requirements for industrial equipment (e.g., electric motors, machine tools, professional refrigeration and air conditioning units, water pumps, industrial furnaces and electrical transformers).
- Consider revising the normative energy consumption set for different industries and incorporate advanced energy savings technologies in the design regulations and norms for industrial facilities.

2. Mobilize and scale-up industrial actions

- Intensify collaborative action across all relevant stakeholders to increase adoptions of state-of-the-art technologies and to share best practices.
- Develop and introduce various incentive schemes (subsidies, fiscal incentives) for industrial enterprises that undertake energy audits in order to support the implementation of the recommended measures.
- Establish a voluntary agreement between government and industry to prioritize and advance energy efficiency improvements in new and existing industry facilities.

- Train and upskill subject matter experts and trade practitioners on the subject of energy efficiency through professional training sessions, qualification and certification programs, and research and academic institutions with established energy efficiency course offerings.
- Develop support mechanisms for local producers of modern energy efficient equipment. Such support mechanisms can include new incentive measures, subsidised loans, tax exemptions, etc.
- Stimulate the creation of networks among industries for better knowledge exchange of best practices and lessons learnt from the implementation of energy efficiency measures and technological improvements.
- Create better conditions for sustained funding and supportive risk-mitigating mechanisms to promote the development and demonstration of new technologies and processes (e.g., introducing loan guarantee mechanism).

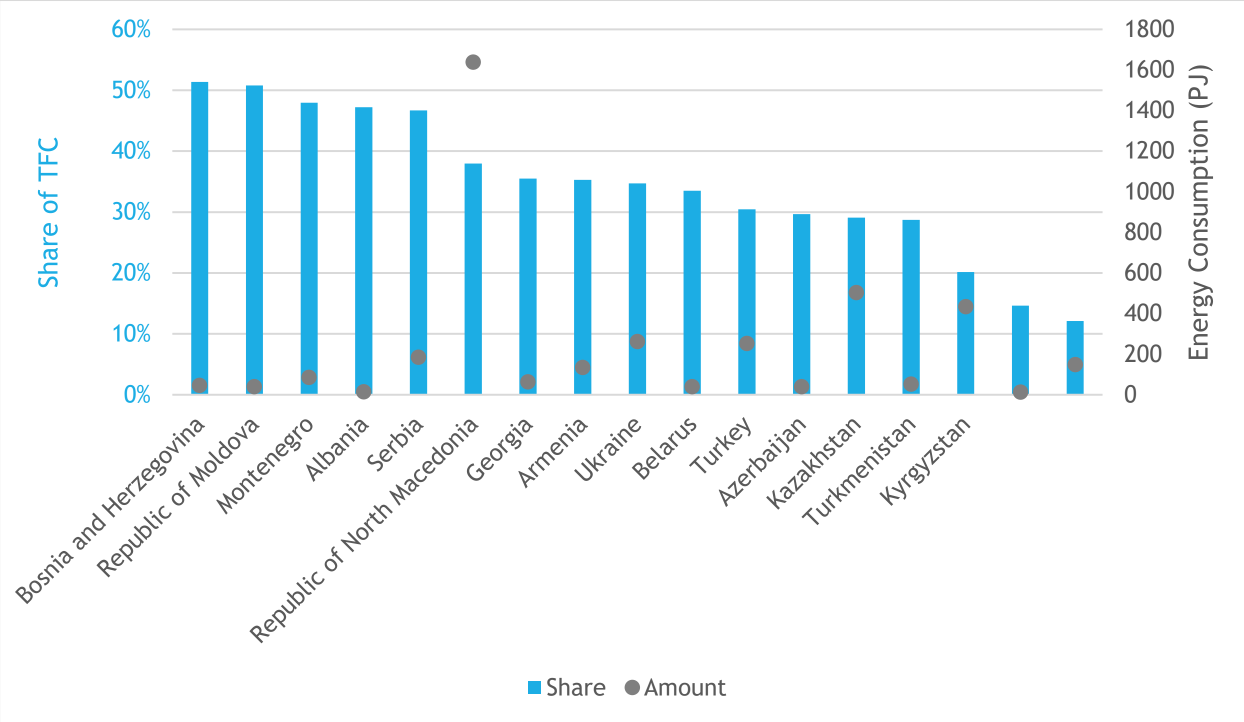
3. Consider technological options

- Prioritize energy efficiency projects in the sub-sectors with the highest energy and carbon intensities.
- Encourage industrial process optimization across sub-sectors starting with the usage of measurement systems for power.
- Advance the use of cross-cutting technologies to increase energy and carbon reduction impacts, especially those with co-benefits that benefit both industrial sector efficiency and adjacent energy consumers (such as district heating, etc.).
- Where possible and where electricity generation is as clean or cleaner than fossil fuel burning, implement fuel switching of industrial processes to electricity. Undertake complementary renewable energy projects that increases the share of clean energy sources in the electricity mix.
- Prioritize innovative technologies with a TRL of 9 or higher for near-term implementation and consider options for supporting the development of more nascent but impactful technologies.
- Foster the establishment of frameworks of energy management or other systems to establish a long-term approach in the industry.

ANNEX

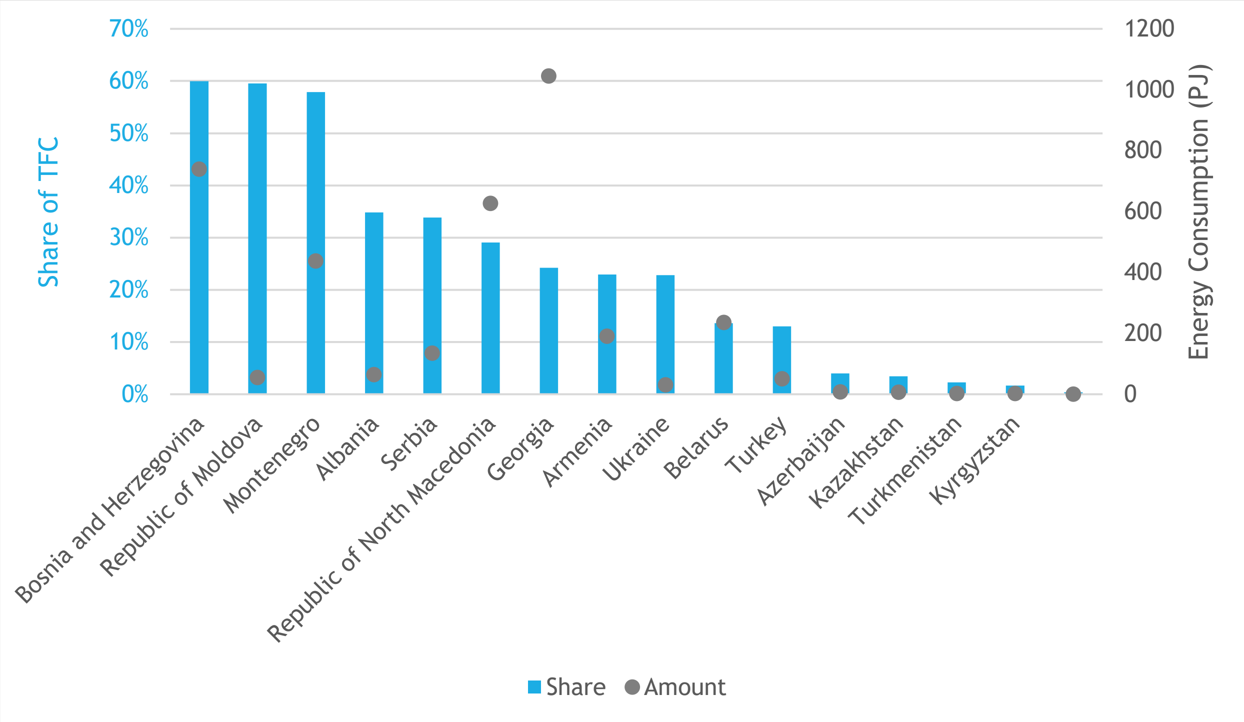
Shares And Amounts of Energy Consumption By Energy Sources

Figure 30: Total amount (PJ) and share of total final energy consumption of **oil products** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



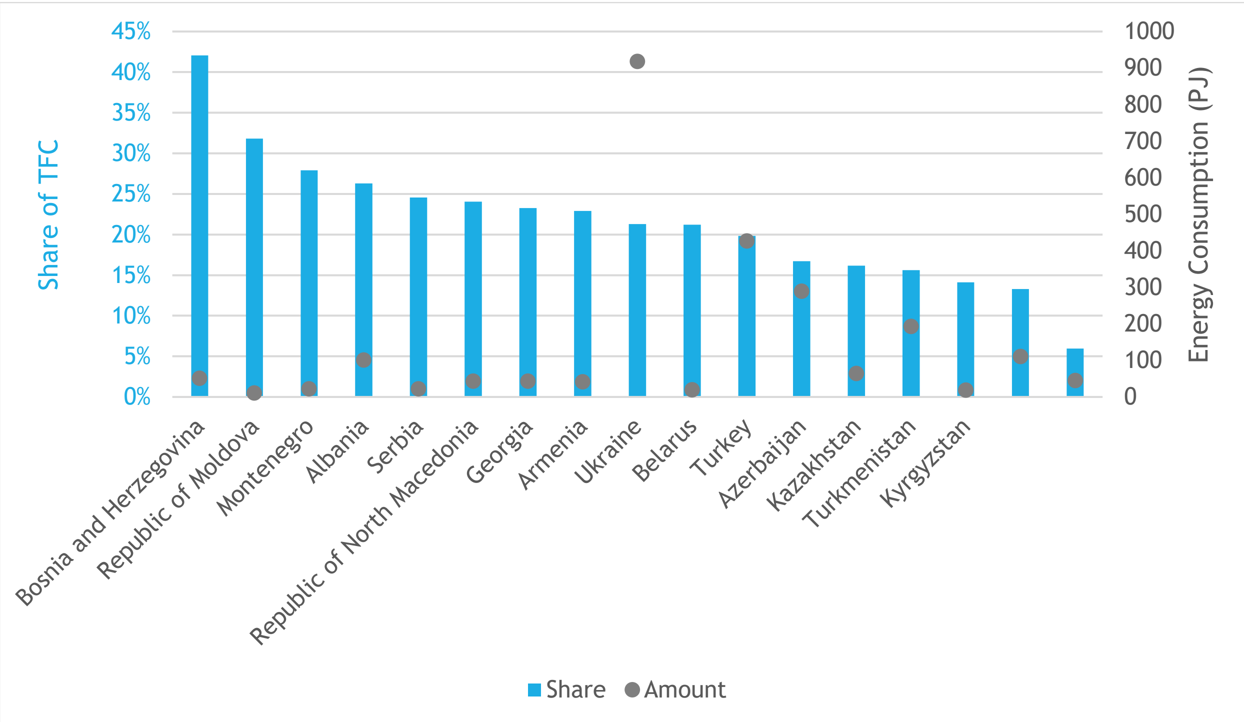
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 31: Total amount (PJ) and share of total final energy consumption of **natural gas** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



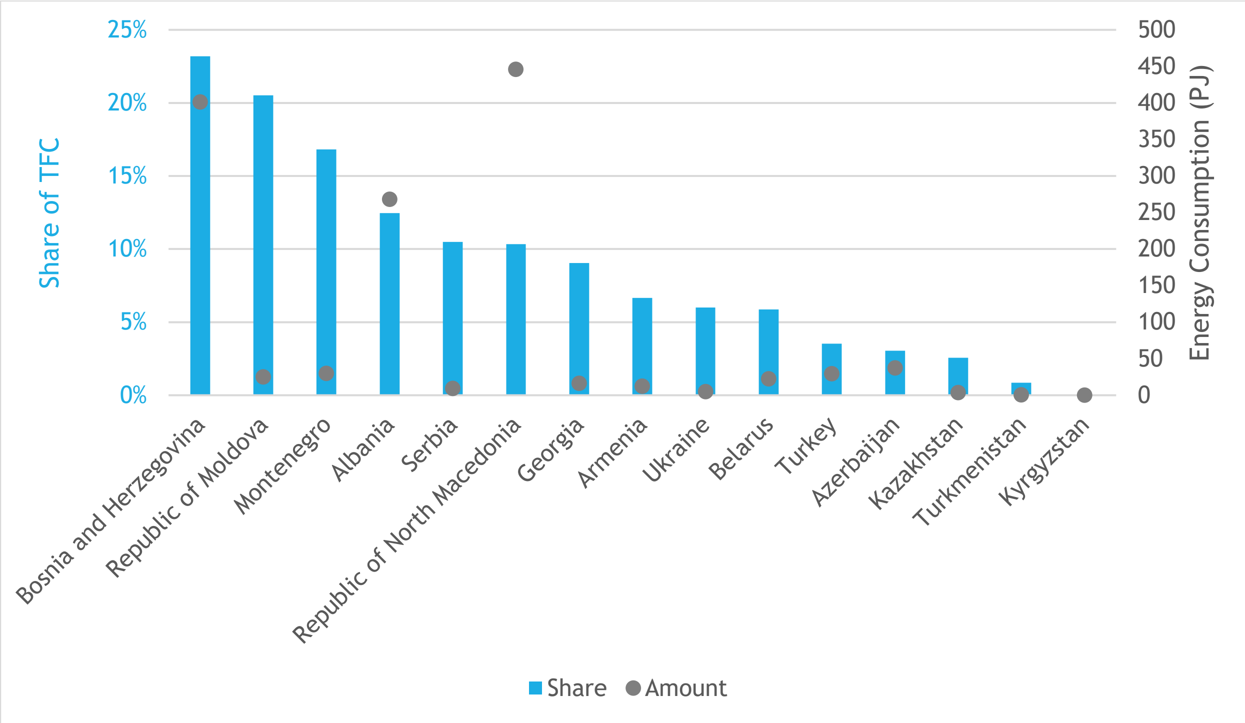
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 32: Total amount (PJ) and share of total final energy consumption of **electricity** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



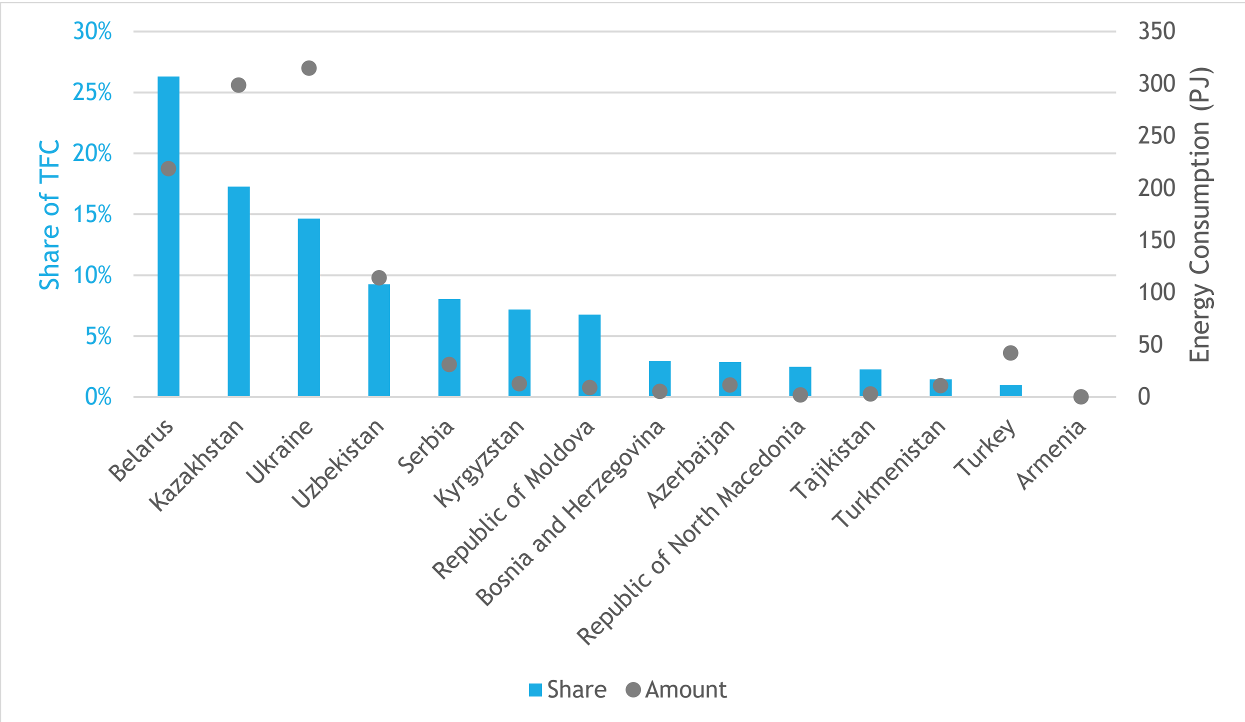
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 33: Total amount (PJ) and share of total final energy consumption of **coal** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



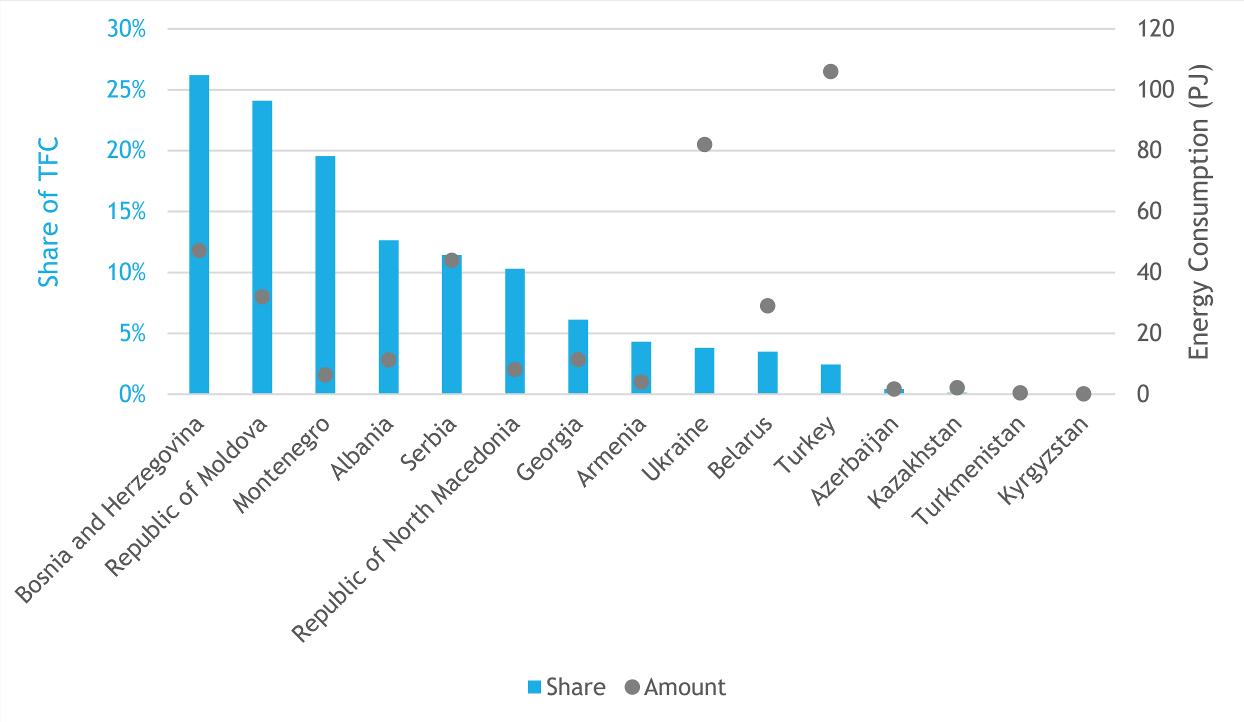
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 34: Total amount (PJ) and share of total final energy consumption of **heat** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



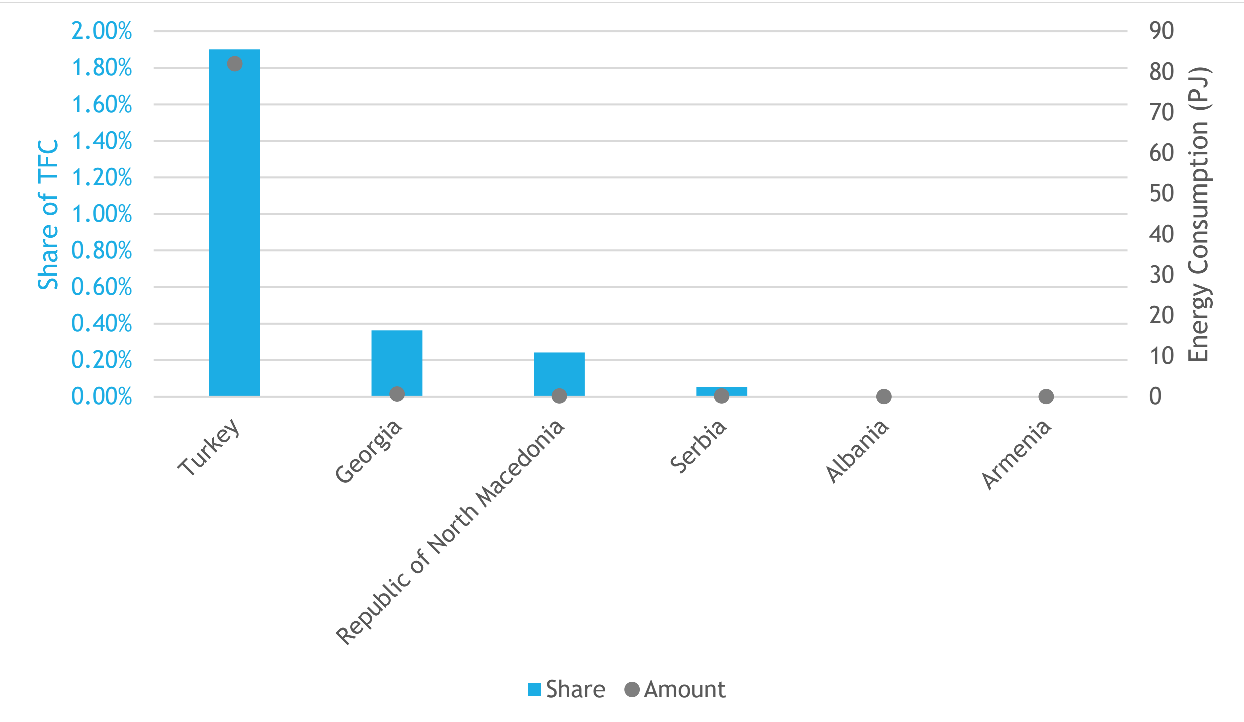
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 35: Total amount (PJ) and share of total final energy consumption of **biofuels and waste** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



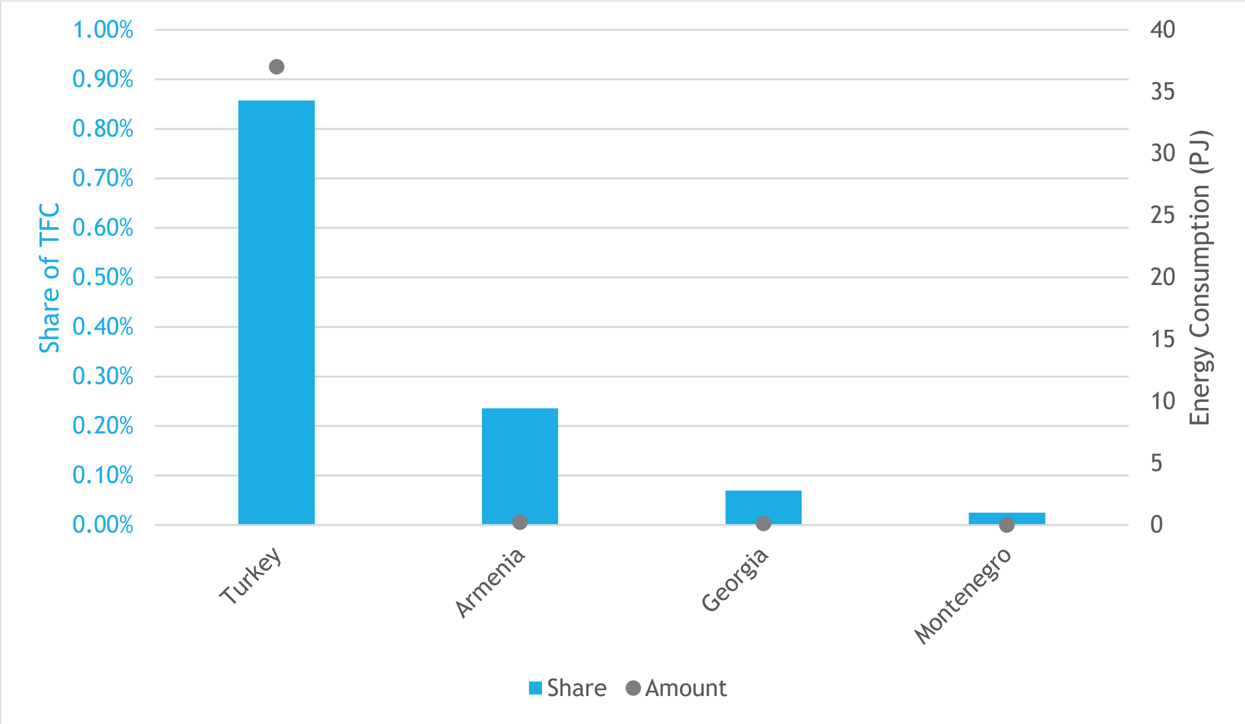
Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 36: Total amount (PJ) and share of total final energy consumption of **geothermal** for each RPTC country in the UNECE region, sorted by the height of the share, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Figure 37: Total amount (PJ) and share of total final energy consumption of **solar, wind, and tidal** power (combined) for each RPTC country in the UNECE region, 2018



Source: Based on data of IEA (2018): World Balance. Paris. https://www.iea.org/sankey (accessed 25.11.2021).

Total Final Energy Consumption by Industry Sub-Sector

Kazakhstan

(PJ)

	Oil	Natural gas	Heat	Oil products	Electri-city	Coal	Sum
Wood and wood products	0.0	..	..	0.1	0.0	..	0.1
Textile and leather	0.0	0.3	0.2	0.1	0.5	0.1	1.2
Transport equipment	0.0	1.0	0.6	0.1	0.2	0.1	2.0
Paper pulp and print	0.0	0.7	0.7	0.2	0.4	..	2.0
Machinery	0.0	0.3	1.3	0.9	2.3	0.9	5.7
Food and tobacco	0.0	8.2	6.3	3.6	5.8	1.5	25.4
Non-specified (industry)	0.0	..	18.2	9.6	0.0	0.0	27.8
Construction	0.0	2.7	5.6	23.1	2.0	0.9	34.3
Chemical and petrochemical	0.0	20.1	4.5	0.9	12.1	9.1	46.7
Non-metallic minerals	0.0	5.2	0.0	19.5	5.9	32.1	62.7
Mining and quarrying	0.0	14.8	11.0	28.1	22.9	16.8	93.6
Non-ferrous metals	0.0	0.0	0.6	0.0	47.5	65.4	113.5
Iron and steel	0.0	6.2	28.3	22.8	81.7	74.1	213.1
Sum	0.0	59.5	77.3	109.0	181.3	201.0	628.1

Ukraine

(PJ)

	Oil	Oil products	Natural gas	Heat	Electri-city	Coal	Sum
Transport equipment	0	..	1	2	3	..	6.0
Wood and wood products	0.0	..	0.0	4.0	3.0	..	7.0
Construction	0.0	3.0	0.0	1.0	3.0	0.0	7.0
Paper pulp and print	0.0	..	..	6.0	4.0	..	10.0
Non-specified (industry)	0.0	0.0	0.0	2.0	17.0	0.0	19.0
Machinery	0.0	0.0	6.0	4.0	15.0	0.0	25.0
Non-ferrous metals	0.0	1.0	6.0	11.0	6.0	4.0	28.0
Chemical and petrochemical	0.0	0.0	9.0	21.0	11.0	0.0	41.0
Non-metallic minerals	0.0	1.0	18.0	3.0	9.0	23.0	54.0
Food and tobacco	0.0	1.0	7.0	36.0	16.0	1.0	61.0
Mining and quarrying	0.0	7.0	12.0	4.0	34.0	4.0	61.0
Iron and steel	0.0	3.0	60.0	52.0	64.0	181.0	360.0
Sum	0.0	16.0	119.0	146.0	185.0	213.0	679.0

Energy And Carbon Intensity Index, Total Final Energy Consumption, And Total Final Emissions By Section and Sub-Sector

Kazakhstan

	Per value added energy intensity	Total final energy	Per value added carbon intensity	Total final emissions
	index 2018[26]	PJ	index 2018[27]	Mt CO_2
Manufacturing	85	570.98	96	69.19
Paper, pulp and printing	141	2.06	141	..
Chemicals and chemical products	102	46.54	104	..
Non-metallic minerals	..	63.43	..	..
Basic metals	85	396.57	97	..
Mining	121	309.19	126	31.5
Construction	39	33.61	45	3.03

Ukraine

	Per value added energy intensity	Total final energy	Per value added carbon intensity	Total final emissions
	index 2018[26]	PJ	index 2018[27]	Mt CO_2
Manufacturing	96	877.81	94	67.8
Paper, pulp and printing	113	10.96	113	..
Chemicals and chemical products	134	41.88	132	..
Non-metallic minerals	74	54.84	74	..
Basic metals	93	645.93	87	..
Mining	108	107.66	101	10.15
Construction	48	8.28	53	0.83

[26] Per value added energy intensity index scores calculated from original measurements in MJ/USD PPP. 2018 score verses a 2015=100 index.
[27] Per value added carbon intensity index scores calculated from original measurements in CO_2/USD PPP. 2018 score verses a 2015=100 index.

Survey Questionnaire (English)

First page - suitable for all participants

Question	Economic sector (mandatory)
	■ 05 Mining of coal and lignite ■ 06 Extraction of crude petroleum and natural gas ■ 07 Mining of metal ores ■ 08 Other mining and quarrying ■ 09 Mining support service activities ■ 10 Manufacture of food products ■ 11 Manufacture of beverages ■ 12 Manufacture of tobacco products ■ 13 Manufacture of textiles ■ 14 Manufacture of wearing apparel ■ 15 Manufacture of leather and related products ■ 16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials ■ 17 Manufacture of paper and paper products ■ 18 Printing and reproduction of recorded media ■ 19 Manufacture of coke and refined petroleum products ■ 20 Manufacture of chemicals and chemical products ■ 21 Manufacture of basic pharmaceutical products and pharmaceutical preparations ■ 22 Manufacture of rubber and plastics products ■ 23 Manufacture of other non-metallic mineral products ■ 24 Manufacture of basic metals ■ 25 Manufacture of fabricated metal products, except machinery and equipment ■ 26 Manufacture of computer, electronic and optical products ■ 27 Manufacture of electrical equipment ■ 28 Manufacture of machinery and equipment n.e.c ■ 29 Manufacture of motor vehicles, trailers and semi-trailers ■ 30 Manufacture of other transport equipment ■ 31 Manufacture of furniture ■ 32 Other manufacturing
Question	How many employees does your company have? (mandatory) (please indicate rounded figure)
	☐
Question	Can you assign your turnover/revenue to one of the following turnover/revenue classes? (mandatory) *To convert Hrywnja (UAH) into Euros (EUR) please multiply with 0,03.*
	■ less than 250,000 Euro ■ 250,000 to less than 500,000 Euro ■ 500,000 Euro and above ■ 500,000 to less than 1 million Euro ■ 1 million to less than 2 million Euro ■ 2 million to less than 5 million Euro ■ 5 million to less than 10 million Euro

	■ 10 million to less than 25 million Euro ■ 25 million to less than 50 million Euro ■ 50 million to less than 100 million Euro ■ 100 million to less than 500 million Euro ■ Unknown.
Question	Do you know the energy demand in your company in the previous financial year? *(mandatory)*
	■ Yes, I know the exact demand. ■ No, but I know the mixture. ■ No.
Question	Please give an assessment of the situation in your company: *(mandatory)*

	very important	important	less important	not important
Increasing energy productivity				
efficiency (energy savings)				

Question	Do you know measures to ...

	Yes, technical measures.	Yes, organisational measures.	No.
... increase energy productivity			
efficiency (energy savings)			

Question	Did you implement measures to ...

	Yes, technical measures.	Yes, organisational measures.	No.
... increase energy productivity			
efficiency (energy savings)			

Questions for advanced companies

Question	The following questions are for advanced companies in energy productivity and decarbonisation. Do you want to continue?
	■ Yes. ■ No.
Question	What do your answers relate to?
	■ My answers relate to one specific site. ■ My answers relate to multiple sites.
Question	The energy demand is [in MWh]:

	(convert your consumption into Megawatt hours (MWh) here: *http://www.unitconverters.net/*)
	☐ (>= 0)
Question	Please indicate the composition of your energy demand (i.e. electricity, oil, gas, heat, biomass) in the following box. Example: "1000 liters oil, 300 MWh electricity".
	☐
Question	Please indicate the energy demand on the basis of the following categories. (convert your consumption into Megawatt hours (MWh) here: *http://www.unitconverters.net/*)
	■ under 10 MWh ■ 10 to less than 50 MWh ■ 50 to less than 100 MWh ■ 100 to less than 500 MWh ■ 500 to less than 1,000 MWh ■ 1,000 to less than 2,500 MWh ■ 2,500 to less than 5,000 MWh ■ 5,000 to less than 10,000 MWh ■ 10,000 to less than 50,000 MWh ■ 50,000 MWh and above ■ No answer
Question	How do you assess the potential contribution of the following measures/options for the industry sector to help achieve energy efficiency targets?

	High contribution	Low contribution	No contribution	Negative contribution	Don't know
Bundling and simplification of support programmes for industry, with a focus on complex and holistic production processes					
Competitive allocation of funding with a focus on more ambitious, complex projects					
Increased promotion and assistance with regard to resource efficiency					
Expansion of minimum standards to increase the					

level of efficiency, with a focus on cross-cutting technologies					
Promotion of low CO2 production processes					
Voluntary commitment for the implementation of recommended energy efficiency measures from energy audits/EMS (payback period up to 3 years)					
Enlargement of state research and innovation programmes					
Promotion of technologies and processes for the storage and use of CO2					

Question	Which of the following energy efficiency measures have you already implemented in your company?

	implemented more than a year ago	implemented within the last year	currently working on it	planned for the future	neither nor	don't know / n/a
Technical measures with an investment (e.g. purchasing energy efficient technology, machinery, equipment)						
Technical-organisational measures (e.g. energy-optimised process controls)						
Organisational measures (e.g. energy audit, energy team, b2b efficiency networks)						
Information related measures (e.g.						

energy monitoring, energy advise)						
Competency related measures (e.g. workshops, trainings, internal capacity building)						
Awareness- and behaviour-related measures (e.g. staff awareness, behaviour rules)						

Question: In your opinion, what is the most significant cause for energy efficiency measures not being tackled?

- No skilled staff for planning/implementation
- Return on investment
- Waiting for more attractive stimulation
- Other strategic priorities

Question: How do the following decision criteria rank in context of energy efficiency investments?

	very important	rather important	not that important	not at all important	I cannot assess that
return of investment (ROI)					
lifecycle costs (LCC)					
net present value (NPV)					
investment level [sum]					
climate change and GHG emission reduction					
energy savings					
other financial criteria: ☐					
non-financial criteria: ☐					

Question: Do you have an overview of the funding opportunities for increasing energy efficiency?

- Yes.
- No.

Question: Do you have a fixed budget for energy efficiency measures?

- Yes.
- No.

Question: What type of incentive is most likely to encourage you to invest in energy efficiency measures?

- Investment premium

	■ Investment allowance ■ Advance or declining balance depreciation ■ Deduction of special expenses for sole proprietorships ■ Reduced VAT rate on energy-efficient sales goods ■ Facilitation of licensing procedures / deregulation ■ Other ■ None
Investments into Energy Efficiency	
Question	In the <u>previous 12 months</u>, what percentage of your total investments can be attributed to improving energy efficiency? If you do not know the figure exactly, please estimate [in %].
	☐ (0 - 100)
Question	In the <u>coming 12 months</u>, what percentage of your total investments can be attributed to improving energy efficiency? If you do not know the figure exactly, please estimate [in %].
Improvement of Energy Efficiency	
	☐ (0 - 100)
Question	On average, what percentage improvement in energy efficiency have you achieved over the <u>past 12 months</u>? If you do not know the figure exactly, please estimate [in %].
	☐ (0 - 100)
Question	On average, what percentage increase in energy efficiency are you planning for the <u>next 12 months</u>? If you do not know the figure exactly, please estimate [in %].
	☐ (0 - 100)
Question	Please indicate which of the following measures you are taking to reduce the CO2 footprint of your company or products?
	■ Reduction of energy consumption through efficiency measures ■ Self-generation of renewable energy ■ Purchase of renewable energy ■ Compensatory measures (e.g. reforestation projects) ■ Requirements on the supply chain ■ No measures ■ Don't know ■ Other, please specify: ☐
Question	The following 7 factors are considered to drive the reduction of greenhouse gas emissions: Please indicate which 3 factors motivate your company most.

	Most important:	Second most important:	Third most important:

Customer requirements			
Investor requirements			
Government requirements			
Image improvement			
Corporate social responsibility			
Long-term economic advantages			
Reduction of cost risks			
Other			

If you have selected "Other", please specify:

Question	Which are the main barriers for the implementation of low emission technologies?

	Big obstacle	Low obstacle	Is not an obstacle
investment costs			
(non-energy) operating costs			
energy costs			
operating cost uncertainty			
technological reliability			
technological availability			
regulatory uncertainty			
lack of infrastructure			

Question	What type of government action is suitable for supporting the implementation of low emission technologies?

	high contribution	low contribution	no contribution	counterproductive
investment subsidies				
operating subsidies				
support for technological innovations				
protection against global competition				

CO2 taxes for final consumers				
fixed CO2 price (contracts)				
guarantees for renewable PPAs Power purchase agreements				
reduction of electricity network and tariff fees				
green public procurement based on sustainability criteria				
on the long run, banning materials with high process emissions				
financing of pilot projects on an industrial scale				
provision of infrastructure				

Question	Are you planning to make your company net-climate-neutral?
	▪ Yes, already implemented ▪ Yes, implementation started ▪ Yes, planned ▪ No, for technical reasons ▪ No, for economic reasons ▪ Not yet determined ▪ No, for capacity reasons ▪ Don’t know ▪ No, for other reasons, please specify: ☐
Question	Did your company receives any technical assistance and/or financing aimed at improving energy productivity and reducing carbon intensity?
	▪ No. ▪ Yes, the following organisation is providing technical assistance/financing: ☐
Question	Which technologies need to be implemented for your specific industry/sectors to improve energy productivity?

	☐
Question	Which technologies need to be implemented for your specific industry/sectors to reduce carbon intensity?
	☐
Question	Have you introduced such technologies?
	■ No. ■ Yes, those following technologies to improve energy productivity: ☐ ■ Yes, those following technologies to reduce carbon intensity: ☐
Question	What or business/financial models would support the implementation of the above technologies?
	☐
Question	Have you implemented such a business/financial model?
	■ No. ■ Yes, the following: ☐
	How did you learn about this questionnaire?
Question	Through whom have you learnt about us?
	☐
Question	Would you like to be notified when the results are published?
	■ Yes. ■ No.
Question	Please enter your e-mail address:
	☐
	Would you like to send us a comment?
	☐

Survey Questionnaire (Russian)

Первая страница - подходит для всех участников

Question	Экономический сектор (обязательно)
	■ 05 Добыча каменного и бурого угля ■ 06 Добыча сырой нефти и природного газа ■ 07 Добыча металлических руд ■ 08 Прочая добыча полезных ископаемых и разработка карьеров ■ 09 Деятельность по оказанию вспомогательных услуг в горнодобывающей промышленности ■ 10 Производство пищевых продуктов ■ 11 Производство напитков ■ 12 Производство табачных изделий ■ 13 Производство текстильных изделий ■ 14 Производство одежды ■ 15 Производство кожи и изделий из нее ■ 16 Производство древесины и изделий из дерева и пробки, кроме мебели; производство изделий из ■ 17 Производство бумаги и бумажных изделий ■ 18 Печатание и воспроизведение записанных носителей информации ■ 19 Производство кокса и очищенных нефтепродуктов ■ 20 Производство химических веществ и химических продуктов ■ 21 Производство основных фармацевтических продуктов и фармацевтических препаратов ■ 22 Производство резиновых и пластмассовых изделий ■ 23 Производство прочих неметаллических минеральных продуктов ■ 24 Производство основных металлов ■ 25 Производство готовых металлических изделий, кроме машин и оборудования ■ 26 Производство компьютерной, электронной и оптической продукции ■ 27 Производство электрооборудования ■ 28 Производство машин и оборудования ■ 29 Производство автомобилей, прицепов и полуприцепов ■ 30 Производство прочего транспортного оборудования ■ 31 Производство мебели ■ 32 Прочее
Question	Сколько сотрудников работает в вашей компании? (обязательно) (пожалуйста, укажите округленную цифру)
	☐
Question	Можете ли вы отнести свой оборот/доход к одному из следующих классов оборота/дохода? (обязательно) Для перевода гривны (UAH) в евро (EUR), пожалуйста, умножьте на 0,03.
	■ менее 250.000 евро ■ от 250.000 до менее 500.000 евро ■ 500 миллионов евро и вышеы ■ от 500.000 до менее 1 миллиона евро ■ от 1 миллиона до менее 2 миллионов евро ■ от 2 миллионов до менее 5 миллионов евро

	■ от 5 миллионов. до менее 10 млн. евро ■ от 10 миллионов до менее 25 миллионов евро ■ от 25 миллионов. до менее 50 млн. евро ■ от 50 миллионов. до менее 100 млн. евро ■ от 100 миллионов до менее 500 миллионов евро ■ Неизвестно.
Question	Знаете ли вы спрос на энергию в вашей компании в предыдущем финансовом году? (обязательно)
	■ Да, я знаю точную потребность. ■ Нет, но я знаю смесь. ■ Нет.
Question	Пожалуйста, дайте оценку ситуации в вашей компании: (обязательно)

	очень важно	важно	менее важно	не важно
Повышение энергоэффективности (экономия энергии)				
Снижение углеродоемкости (меньше парниковых газов)				

Question	Знаете ли вы меры по ...

	Да, технические меры.	Да, организационные меры.	Нет.
... повышению энергоэффективности (экономии энергии)			
... снижению интенсивности выбросов углерода (снижению количества парниковых газов)			

Question	Применяли ли вы меры по ...

	Да, технические меры.	Да, организационные меры.	Нет.
... повышению энергоэффективности (экономии энергии)			
... снижению интенсивности выбросов углерода (снижению количества парниковых газов)			

Вопросы для передовых компаний

Question	Следующие вопросы предназначены для передовых компаний в области энергоэффективности и декарбонизации. Хотите ли вы продолжить?
	▪ Да. ▪ Нет.
Question	К чему относятся ваши ответы?
	▪ Мои ответы относятся к одной конкретной локации. ▪ Мои ответы относятся к нескольким локациям.
Question	потребность в энергии составляет [в МВт-ч]: (переведите ваше потребление в мегаватт-час (МВтч) здесь: http://www.unitconverters.net/)
	☐ (>= 0)
Question	Пожалуйста, укажите состав вашего спроса на энергию (т.е. электричество, нефть, газ, тепло, биомасса) в следующем поле. Пример: "1000 литров нефти, 300 МВтч электроэнергии".
	☐
Question	Пожалуйста, укажите потребность в энергии на основе следующих категорий. (переведите ваше потребление в мегаватт-часы (МВтч) здесь: http://www.unitconverters.net/)
	▪ менее 10 МВт-ч ▪ от 10 до менее 50 МВтч ▪ от 50 до менее 100 МВтч ▪ от 100 до менее 500 МВтч ▪ от 500 до менее 1.000 МВтч ▪ от 1.000 до менее 2.500 МВтч ▪ от 1.000 до менее 2.500 МВтч ▪ от 5.000 до менее 10.000 МВтч ▪ от 10.000 до менее 50.000 МВтч ▪ 50.000 МВтч и выше ▪ Нет ответа
Question	Как вы оцениваете потенциальный вклад следующих мер/опций для промышленного сектора в достижение целевых показателей энергоэффективности?

	Высокий вклад	Низкий вклад	Нет вклада	Отрицательный вклад	Не знаю
Объединение и упрощение программ поддержки для промышленности с акцентом на сложные и целостные производственные процессы					
Конкурентное распределение финансирования с					

акцентом на более амбициозные, сложные проекты					
Более активное продвижение и помощь в отношении эффективности использования ресурсов					
Расширение минимальных стандартов для повышения уровня эффективности с акцентом на межсекторные технологии					
Продвижение производственных процессов с низкой эмиссией CO_2					
Добровольное обязательство по внедрению рекомендованных мер по энергоэффективности по результатам энергоаудита/ Системы управления энергией (срок окупаемости до 3 лет)					
Расширение государственных программ исследований и инноваций					
Продвижение технологий и процессов для хранения и использования CO_2					

Question	Какие из перечисленных ниже мер по повышению энергоэффективности вы уже внедрили в своей компании?

	внедрено более года назад	реализовано в течение последнего года	в настоящее время работаем над этим	запланировано на будущее	ни то, ни другое	не знаю , нет ответа
Технико-инвестиционные меры (например, приобретение энергоэффективных технологий, машин, оборудования)						
Организационно-технические меры (например, энергооптимизированное управление процессами)						
Организационные меры (например, энергоаудит, команда энергоэффективности, сети эффективности бизнес к бизнесу)						
Меры, связанные с информацией (например, энергетический мониторинг, энергетические консультации)						
Меры, связанные с компетентностью (например, семинары, тренинги, наращивание внутреннего потенциала)						
Меры, связанные с информированностью и поведением (например, информированность персонала, правила поведения)						

Question	По вашему мнению, что является наиболее существенной причиной того, что меры по повышению энергоэффективности не внедряются?

- Отсутствие квалифицированного персонала для планирования/реализации
- Возврат от инвестиций
- Ожидание более привлекательных стимулов
- Другие стратегические приоритеты

Question	Какое место занимают следующие критерии принятия решений в контексте инвестиций в энергоэффективность?

	очень важно	довольно важно	не очень важно	совсем не важно	Я не могу оценить это
возврат от инвестиций (ROI)					
стоимость жизненного цикла (LCC)					
чистая приведенная стоимость (NPV)					
уровень инвестиций [сумма]					
изменение климата и сокращение выбросов ПГ					
экономия энергии					
другие финансовые критерии:					
нефинансовые критерии:					

Question	Есть ли у вас обзор возможностей финансирования для повышения энергоэффективности?

- Да.
- Нет.

Question	Есть ли у вас фиксированный бюджет на мероприятия по повышению энергоэффективности?

- Да.
- Нет.

Question	Какой тип стимула с наибольшей вероятностью побудит вас инвестировать в меры по повышению энергоэффективности?

- Инвестиционная премия
- Инвестиционная надбавка
- Авансовая амортизация или амортизация с уменьшающимся остатком
- Вычет специальных расходов для индивидуальных предпринимателей
- Снижение ставки НДС на энергоэффективные товары для продажи
- Упрощение процедур лицензирования / дерегулирование
- Другие
- Нет

Инвестиции в энергоэффективность

Question	За <u>предыдущие 12 месяцев</u>, какой процент от общего объема ваших инвестиций можно отнести на повышение энергоэффективности? Если вы не знаете точную цифру, пожалуйста, оцените ее [в %].
	☐ (0 - 100)
Question	В <u>ближайшие 12 месяцев</u> какой процент от общего объема ваших инвестиций можно отнести на повышение энергоэффективности? Если вы не знаете точную цифру, пожалуйста, оцените ее [в %].
	☐ (0 - 100)
Повышение энергоэффективности	
Question	В среднем, какого процента повышения энергоэффективности вы добились за <u>последние 12 месяцев</u>? Если вы не знаете точную цифру, пожалуйста, оцените ее [в %].
	☐ (0 - 100)
Question	В среднем, какой процент увеличения энергоэффективности вы планируете в <u>ближайшие 12 месяцев</u>? Если вы не знаете точную цифру, пожалуйста, оцените ее [в %].
	☐ (0 - 100)
Question	Пожалуйста, укажите, какие из перечисленных ниже мер вы предпринимаете для снижения CO2-следа вашей компании или продукции?
	▪ Сокращение потребления энергии за счет мер по повышению эффективности ▪ Самостоятельная выработка возобновляемой энергии ▪ Закупка возобновляемой энергии ▪ Компенсационные меры (например, проекты по восстановлению лесов) ▪ Требования к цепочке поставок ▪ Нет мер ▪ Не знаю ▪ Другое, пожалуйста, укажите: ☐
Question	Для сокращения выбросов парниковых газов рассматриваются следующие 7 факторов: Пожалуйста, укажите, какие 3 фактора больше всего мотивируют вашу компанию.

	Самый важный:	Второй по важности:	Третий по важности:
Требования клиентов			
Требования инвесторов			
Требования правительства			
Улучшение имиджа			
Корпоративная социальная ответственность			

Долгосрочные экономические преимущества			
Снижение стоимостных рисков			
Другие			

Если вы выбрали "Другое Другие ", пожалуйста, укажите: [ ]

Question	Каковы основные барьеры для внедрения технологий с низким уровнем выбросов?

	Большое препятствие	Низкое препятствие	Не является препятствием
инвестиционные затраты			
(неэнергетические) эксплуатационные расходы			
энергетические затраты			
неопределенность эксплуатационных затрат			
технологическая надёжность			
технологическая доступность			
нормативная неопределенность			
отсутствие инфраструктуры			

Question	Какой тип действий правительства подходит для поддержки внедрения технологий с низким уровнем выбросов?

	высокий вклад	низкий вклад	отсутствие вклада	Контрпродуктивный
инвестиционные субсидии				
операционные субсидии				
поддержка технологических инноваций				
защита от глобальной конкуренции				
налоги на CO2 для конечных потребителей				

фиксированная цена на CO2 (контракты)				
гарантии для возобновляемых источников энергии договор купли-продажи электроэнергии				
снижение платы за пользование электрическими сетями и тарифами				
зеленые государственные закупки, основанные на критериях устойчивости				
в долгосрочной перспективе запрет на материалы с высоким уровнем технологических выбросов				
финансирование пилотных проектов в промышленных масштабах				
обеспечение инфраструктуры				

Question	Планируете ли вы сделать свою компанию климатически нейтральной?

- Да, уже реализовано
- Да, реализация начата
- Да, планируется
- Нет, по техническим причинам
- Нет, по экономическим причинам
- Еще не определено
- Нет, по причинам, связанным с возможностями
- Не знаю
- Нет, по другим причинам, пожалуйста, укажите: ______

Question	Получала ли ваша компания какую-либо техническую помощь и/или финансирование, направленные на повышение производительности энергии и снижение углеродоемкости?

- Нет.

	■ Да, следующая организация предоставляет техническую помощь/финансирование: ☐
Question	Какие технологии необходимо внедрить в вашей конкретной отрасли/секторах для повышения производительности энергии?
	☐
Question	Какие технологии необходимо внедрить в вашей конкретной отрасли/секторах для снижения углеродоемкости?
	☐
Question	Внедряли ли вы такие технологии?
	■ Нет. ■ Да, следующие технологии для повышения производительности энергии: ☐ ■ Да, следующие технологии для снижения углеродоемкости: ☐
Question	Какие или бизнес/финансовые модели могли бы поддержать внедрение вышеуказанных технологий?
	☐
Question	Внедрили ли вы такую бизнес/финансовую модель?
	■ Нет. ■ Да, следующие: ☐
	Как вы узнали об этой анкете?
Question	От кого вы узнали о нас? (ОБЯЗАТЕЛЬНО)
	☐
Question	Хотели бы вы получить уведомление о публикации результатов? (ОБЯЗАТЕЛЬНО)
	■ Да. ■ Нет.
Question	Пожалуйста, введите свой адрес электронной почты:
	☐
	Хотите отправить нам комментарий?
	☐

Technology Readiness Level Scale Applied By The IEA[28]

TRL Level	Description
1	Initial idea: basic principles have been defined
2	Application formulated: concept and application of solution have been formulated
3	Concept needs validation: solution needs to be prototyped and applied
4	Early prototype: prototype proven in test conditions
5	Large prototype: comp onents proven in conditions to be deployed
6	Full prototype at scale: prototype proven at scale in conditions to be deployed
7	Pre-commercial demonstration: solution working in expected conditions
8	First-of-a-kind commercial: commercial demonstration, full-scale deployment in final form
9	Commercial operation in relevant environment: solution is commercially available, needs evolutionary improvement to stay competitive
10	Integration at scale: solution is commercial but needs further integration efforts
11	Proof of stability: predictable growth

[28] IEA (2019): Innovation gaps - Key long-term technology challenges for research, development and demonstration. Technology report. https://www.iea.org/reports/innovation-gaps (accessed 25.11.2021).