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MINISTRY OF ECONOMY OF UKRAINE

SUSTAINABLE DEVELOPMENT GOALS

IMPACT ASSESSMENT

OF POLICY OPTIONS RELATED TO THE GUIDING FRAMEWORK OF STANDARDS AND TECHNICAL REGULATIONS ON THE GREEN RECONSTUCTION OF UKRAINE

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Contextualization

Ukraine finds itself at a crossroads between rebuilding the infrastructure the way it has been done in the past, or in sustainable manner, using green standards, the most advanced practices, and state-of-art technologies. This would contribute enabling the Country to use the massive reconstruction efforts as a springboard for sustainability. Indeed, if based on sustainability principles, reconstruction can overcome a major carbon footprint, reducing potential climate impact and improving energy and resource efficiency.

Following the growing global awareness of the impacts of climate change, improved international expertise, knowledge and best practices on circular economy, carbon neutrality and decarbonization have been codified into international standards. When these standards are used as a basis for or to support technical regulations, they are a key element in defining the specifications for public and private investment projects, public procurement, operations of services and their management.

UNIDO, together with the Ministry of Economy of Ukraine, developed a "National Guiding Framework of Standards and Technical Regulations for the Green Reconstruction of Ukraine" (NGF). The NGF effectively contribute to the green reconstruction of essential infrastructure, facilities, services and their management, by incorporating sustainability principles into national standards and binding technical regulations. Working towards this goal will, at the same time, contribute to the alignment of Ukraine with the European market and its requirements.

This document presents an impact assessment for the use of Standards and Technical Regulations for the Green Reconstruction of Ukraine.

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Acronyms and abbreviations

BSI	The British Standards Institution
CAB	Conformity Assessment Bodies
CBA	Cost Benefit Analysis
CBAM	Carbon Border Adjustment Mechanism
CEAP	Circular Economy Action Plan
CEN	The European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CPR	Construction Products Regulation
C&DW	Construction and demolition waste
EBRD	European Bank for Reconstruction and Development
EDD	Eco-design Directive
EE	Energy Efficiency
EPD	Energy Performance Directive
EPBD	Energy Performance of Buildings Directive
EPC	Energy performance certificate
EPDs	Environmental Product Declarations
ERBD	European Bank for Reconstruction and Development
ESAP	Environmental and Social Action Plan
ESCo	Energy Saving Company
ETI	Expected Transition Impact
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse gases
IEC	The International Electrotechnical Commission
ISO	International Organization for Standardization
Ktoe	Thousand tonnes of oil equivalent
MRV	Monitoring Reporting and Verification
Mtoe	Million tonnes of oil equivalent
NAAU	National Accreditation Agency of Ukraine
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NQI	National Quality Infrastructure
NSB	National Standards Body
OECD	Organisation for Economic Cooperation and Development
RIA	Regulatory Impact Assessment
SAEE	State Agency for Energy Efficiency and Energy Saving of Ukraine
SPI	Sustainable Products Initiative
UkrNDNC	Ukrainian Scientific Research and Training Centre for Standardisation, Certification and Quality Problems
UN	United Nations
UNIDO	United Nations Industrial Development Organisation

Executive summary

Most countries of the world now recognise climate change as the major and pressing existential threat that it undoubtedly is, at the very minimum to our ways of life, if not to security and stability issues caused by mass migration and famine. Transitioning to a carbon-neutral economy is a priority for the European Union (EU), with its Green Deal proposing a package of policy initiatives, whose objective is to position the EU on a green transition path, with the ultimate goal of climate neutrality by 2050.

The war in Ukraine, while tragic in many, especially humanitarian, respects, will also offer great opportunities for sustainable, green recovery, offering a holistic and cross-sectoral approach and including initiatives covering the climate, the environment, energy, transport, industry and finance, all of these being strongly interlinked. Those who object to green initiatives sometimes fear the economic burdens whereas, in fact, according to the European Council in December 2019, "The transition to climate neutrality will bring significant opportunities, such as potential for economic growth, for new business models and markets, for new jobs and technological development."

'Rebuilding' in the Ukrainian context refers not uniquely to war-damaged infrastructure. Various studies have identified the relatively poor overall levels of Ukrainian building stocks and vehicles throughout the whole country, especially from an energy-efficiency point of view. Consequently, 'rebuilding' in the meaning used in this report refers to the whole country, and includes upgrading and renovating of the whole building stock, as well as reconstructing or renovating specific war-damaged buildings and infrastructure.

So not only will there be a pressing need for reconstruction to address the estimated 4.5 million displaced Ukrainians and rebuild necessary industry and infrastructure, the opportunity exists for Ukraine to serve as a key role model for sustainable reconstruction and refurbishment, including countries wishing to upgrade their built infrastructure to meet their climate change commitments.

The EU's emphasis on energy and industry links closely to buildings, construction and construction products. Not only are buildings one of the largest, if not the largest, emitter of CO_2 (40%) apart from agriculture, some common construction products require large quantities of energy in their production. Indeed, sustainability of construction products has become a key regulatory issue in the EU in recent years. While the ultimate resolution to climate change may well require international action, it is equally important that individual countries "do their bit" to improve their sustainability and reduce CO_2 emissions.

The end of the war in Ukraine will ultimately lead to major reconstruction of national built infrastructure. Such reconstruction needs to be as sustainable and carbon-neutral as practicable. This is not only for the benefit of Ukraine itself but also to help towards addressing global climate change while, at the same time, helping Ukraine align with EU best practice in the construction sector and benefit from the associated economic growth. This report, prepared by BSI's expert team, concentrates on the greening of the Ukrainian construction sector, in which the overall approach has been to look at the opportunities for and consequences of introducing sustainability principles into the national construction sector.

This report considers a range of mandatory and voluntary options covering the construction products sector and the built environment, and these options include, for example, environmental product declarations, improvements to the environmental and energy performance design regulations, and certification of building environmental performance. Some consideration has also been given to urban transportation.

Because the situation in Ukraine is changing, especially in the war zone, and because reliable data are not always available, it has not always been able to assess the effects, either in monetary terms, on energy saving or CO_2 reductions, or on renewable energy savings. Accepting the assumptions which have had to be made (and which are explained throughout the report, the following estimates have been made:

Building sector

Building type	Energy saving potential	CO_2 reduction (million Toe/y)	Cost (€ billion)
Apartments	46 TWh/y 4 Mtoe/y	55	67
All residential	180 TWh/y 15.3 Mtoe/y		60
Educational	8 TWh/y 0.7 Mtoe/y		46.892 M

Construction products manufacturing

Product	Energy saving potential	CO_2 reduction (million Toe/y)	Cost (€ billion)
Cement	5 GWh/y 430 Toe/y	1	0.021
Steel and aluminium		750	
Concrete		1	

In addition to savings within the Ukrainian industry itself, further global savings could be made by policies favouring the import of construction products from low-carbon sources.

As a result of these two tables, it can be seen that potential savings from buildings far exceed those of product manufacturing. The total investment costs are very different between the two, though; for apartments, it will cost about €1.2 million per tonne of CO_2 emission saved, while in the cement industry the cost is just €0.02 million for the same saving. Other data are required, though, for other building types and construction products.

Construction products manufacturing

Source	Energy saving potential	CO_2 reduction (million Toe/y)	Cost (€ billion)
Hydro power	0.2		
Solar power	7.6	71.0	
Wind power	1.5	350.0	
Biogas	0.3	10.0	
Total	9.6	875.0*	Cost (€ billion)

* This figure may include nuclear power, because it is not the sum to renewable sources alone.

It has not proved possible to identify the investment costs for renewable energy capacity, nor to quantify the energy and GHC emission savings from appliances or transport. The blank entries in all three summary tables above indicate the need for more research.

This report has been hampered by several factors in particular: firstly a lack of necessary data, in particular related to the environmental performance of buildings and industry, from which baselines for the effects of sustainable reconstruction can be compared; secondly, that where data are available, they are not necessarily representative of post-war activities and, finally, from the limited resources allocated to this project. Consequently, heavy reliance has had to been made on reports from other development agencies, such as UNIDO, UNECE and the EU.

Added to the above, there is an inbuilt assumption in many donor reports, firstly, that Ukraine will ultimately prevail in the war. Secondly, that it is worth rebuilding while the war continues and, finally, that there will be no substantial loss of territory by Ukraine as the result of any peace negotiations. None of these possibly outcomes can be known with any certainty and, in fact, to ensure that greening initiatives happen, it might well prove to be safer and more sustainable to concentrate, initially, on regions well away from the main conflict zones in the East and South-East of the countries.

Moreover, while it is possible to separate sustainability elements from other regulatory developments in Ukraine, it is unlikely that this is the route which will be followed. For example, regulatory requirements on EPDs of construction products will very likely come about as a result of new or expanded regulations covering all performance characteristics of construction products, which brings with it far greater consequences in terms of National Quality Infrastructure than EPDs alone. With the resources allocated, though, it has not been possible to look at consequences beyond the limited sustainable elements.

One last consideration is that many EU neighbourhood countries have been encouraged to transpose or approximate EU legislation as the most appropriate development route. The evidence shows, however (and this is particularly true in the construction and construction products fields) that the primary effect of transposition/approximation is to create a new legislative system in that country. When countries do not have the resources and/or awareness to implement and enforce the new legislation, the results are very low levels of compliance and many producers/suppliers forced to trade 'illegally', because they are unable (even if they would wish to) to comply with the new legislation.

This report does not advocate a move away from progressive approximation/transposition of EU provisions. It does, however, propose that any transposition/approximation of new regulatory provisions in Ukraine should be critically reviewed to assess the possibilities of them coming into force in the country. Such a review, however, is well beyond the scope of this report.

Finally, this report suggests that a true green reconstruction and renovation of Ukrainian infrastructure and transport will require, in some cases, radical new thought and changing paradigms. A figure quoted in this report, which suggests that a 20% reduction in living space for Ukrainian citizens could bring about a 70% reduction in CO_2 emissions (it has not proved possible to verify this claim), is one example of such radical though. The idea of making vehicles much lighter, and therefore more energy efficient, or indeed moving Ukraine away from reliance on individual vehicles, are others.

Conventional cost benefit analysis (CBA), especially when based upon 'absolute least cost', is not likely to prove

to be an appropriate decision-making tool for a green recovery. Environmentally-conscious options will, in many cases, be more expensive than conventional construction and transport practices. CBA can still continue to be used, of course, but only if 'green' solutions are considered to be the 'entry level' for decisions, i.e. non-green options are inadmissible. The same principle may well apply to both public and private purchasing decisions, whereby purchasers decide, as a general policy, to accept only green options, even if these are more costly.

Many countries practice what might be called 'supply management', of which two examples are that people want to travel everywhere by private vehicles and that households typically use 3 kW of energy, so there must be enough private vehicles and roads, and energy supply, to satisfy these demands. Assuming that 'supply management' can be applied across the board and green recovery achieved seems unlikely. 'Demand management' needs to play a part as well, whereby conventional needs and expectations may well need challenging and reducing if a true green recovery is going to be achieved.

The research in support of this report has also identified that, in some areas where greening strategies are undoubtedly required, there is currently no consensus on how to evaluate the benefits in a fully quantifiable way. This is the case, for example, in areas such as developing a circular economy and specifying only low embodied-carbon construction products. Until such evaluation methods do emerge and gain acceptance, it may well be that other measures than least-cost or most profitable must give way to more altruistic decision-making.

1 Introduction

Buildings and construction are responsible for around 39% of the world's annual CO_2 emissions (agriculture excluded). Of this, 28% comes from buildings (in particular heating, cooling and lighting) and 11% from embodied carbon, the emissions from the extraction and manufacture of products. Amongst very commonly-used construction products, cement and reinforcing steel often have poor environmental performance in their production.

Over the next 25 years, the global building stock is expected to double in size. Carbon emissions released before the built asset is used, what is referred to as 'upfront carbon', will be responsible for half of the entire carbon footprint of new construction between now and 2050, threatening to consume a large part of the carbon budget. Therefore, the built environment sector has a vital role to play in responding to the climate emergency, and addressing both upfront carbon and operational carbon is a critical and urgent focus.

In 2018, Ukraine's total final consumption accounted to 51.5 Mtoe, with industry being the largest final energy consumer (19.1 Mtoe in 2018) followed by the residential sector (16.7 Mtoe), with households being the major users of natural gas (8.7 Mtoe in 2018). in total, the building sector consumed 42% of total final energy in 2017 with commercial and public services consuming 9% [1]. the energy consumption of Ukrainian buildings is estimated at 250 to 275 kWh/m², which is at least double that of Western Europe's average of about 120 kWh/m² [2]. as of 1 January 2013, Ukraine's housing stock consisted of 10.2 million residential buildings with a total surface area of 1 094.2 million m². the average sizes of urban and rural housing units are 52.2 m² and 60 m², respectively.

In 2019, which might be considered to be the last 'normal' year, Ukraine consumed a total of 37.5 Mtoe (440 TWh). This was distributed by usage as shown in Figure 1[3] overleaf. as can be seen from this figure, transport, residential and industry, the three areas considered by this project, make up 83% of total energy consumption.

On a broader energy front, another challenge is that Ukraine remains heavily dependent on fossil fuels, in particular gas, coal and oil, there making up about 70% of total primary energy usage, with nuclear power contributing about 23%, leaving renewable energy and biofuels currently supplying just 7%. in 2020, total energy consumption was of the order of 85 Mtoe; there is a need both to reduce this total, as a result of energy efficiency measures, and to increase the contributions of renewable and biofuels by 2050, the former to something like 25% and the latter to more than 50%.

With large-scale reconstruction becoming necessary in Ukraine once the possibility for it becomes possible, ensuring that this reconstruction follows current best practice in terms of environmental performance is exactly the approach to follow. Environmental concerns apply not only to the reconstruction itself; there will be substantial opportunities for the re-use, re-conditioning or re-purposing of construction products and materials from damaged buildings and infrastructure, which all help reduce embodied carbon.

According to a report from UkraineInvest[4], housing (it is unclear whether this means accommodation only or all buildings) is the sector with the most direct economic damage from the war (€45bn) due to intense shelling, while the need to relocate 4.5 million internally displaced Ukrainians also creates an urgency to rebuild rapidly and in the right areas; damage to critical infrastructure, including district heating and water supply, is also massive.

According to Kyiv School of Economics (KSE) estimates, some 132 000 residential buildings, dozens of shopping centres, enterprises, offices and other real estate have been destroyed or damaged. the Ministry for Communities and Territories Development of Ukraine reports that 60% of damaged buildings require major repairs and only 25% have suffered minor damage.

A second report[5] states that "The scale of the war damage in Ukraine is enormous, and rebuilding the ruined country will be a multi-year challenge, requiring direct involvement of the UN and the international community. According to the World Bank, the reconstruction of Ukraine will consume no less than €380 billion. the reconstruction of the energy sector alone, which has been horribly damaged by constant shelling, is an outlay of approximately €43 billion. Raising Ukraine from the devastation will cost no less than €46 billion annually, and for at least a decade. the war in Ukraine has also magnified the impact of the climate crisis and led to environmental losses estimated at around €47 billion. the damage and stress on the environment and lost species should be also taken into consideration."

Interestingly, this same report states that "Russia's grave military aggression against Ukraine has resulted in extensive infrastructure damage, environmental pollution, and economic and social crises. 817,000 residential units were damaged only between February and August 2022", some six times greater than the KSE estimate above. the 'target', therefore, of this report is constantly changing, as is the baseline, and there is no information that the war is anywhere near coming to an end. the demand for green reconstruction (or, rather, green renovation) outside of the areas currently in the conflict zone might be considered to be relatively stable (but difficult to identify, because reports are concentrating mainly on rebuilding war damage), but it is very unclear whether any rebuilding in the war zone would currently be beneficial.

A further report from the World Bank[6] suggests that "Total estimated reconstruction and recovery needs exceed €380 billion, which is 2.6 times the actual GDP of Ukraine in 2022. Costs, estimated for 10 years, consider inflation, market conditions, surge pricing in construction commonly seen in areas of mass construction, higher insurance premiums, and a shift toward lower energy intensity and more resilient, inclusive, and modern design. the highest estimated needs are in transport (22%), housing (17%), energy (11%, social protection and livelihoods (10%), explosive hazard

1 Ukraine energy profile — Analysis — IEA.
2 National Energy Efficiency Action Plan Through 2020
3 https://www.iea.org/reports/harnessing-energy-demand-restraint-in-ukraine-a-roadmap/overview-of-ukraines-policy-context-for-demand-restraint
4 Prerequisites for post-war rebuilding of Ukraine's housing and construction sector, UkraineInvest, 08/11/2022, ukraineinvest.gov.us/en/news/08-11-22/
5 United Business for Ukraine, Sustainable Reconstruction of Ukraine Global Compact — UNOPS, October 2023.
6 Ukraine – Rapid damage and needs assessment, February 2022 to February 2023, World Bank Group.

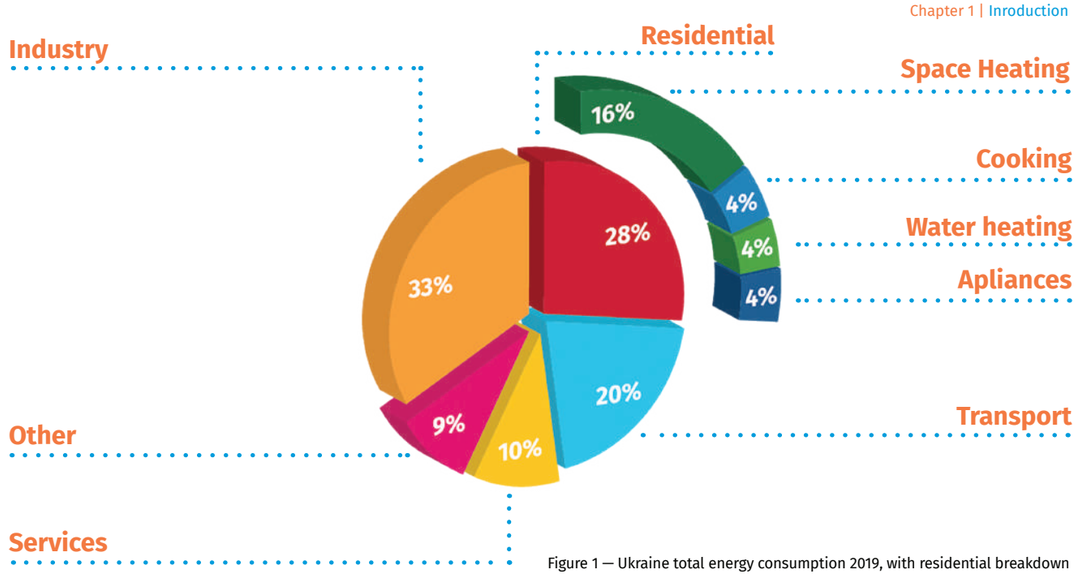

Figure 1 — Ukraine total energy consumption 2019, with residential breakdown

management (9%), and agriculture (7%)." the 17% allocated to "housing" (although it is unclear whether this means all buildings), €64 billion, is of the same order of magnitude as the €47 billion from the United Business report.

It is unclear from these reports whether it would be better to destroy and rebuild even those buildings which have suffered minor damage. the same UkraineInvest report states that "Ukraine's housing is composed primarily of buildings with poor insulation and low energy efficiency. Buildings in Ukraine are responsible for nearly 40% of final energy consumption. in the residential sector, 54% of final energy consumption is devoted to space heating or cooling. the situation is aggravated by the share of natural gas in residential energy supply (48% versus 32% for the EU), making Ukraine dependent on imported fossil fuels." This poses a challenge to the analysis in this report, which focuses primarily on energy efficiency and enhanced insulation levels of buildings. There may be other reasons, not linked to these factors, which mean that rebuilding is preferable to repair and upgrading, but the consideration of these reasons is outside the scope of this report.

As far as construction products are concerned, the regulatory system is that the vast majority of products are covered by mandatory harmonised European Standards under the Construction Products Regulation (CPR). There are a few notable exclusions from the coverage of the CPR, namely ready-mixed concrete, reinforcing steel for concrete, and plastics pipes. the CPR currently covers the thermal performance of products but does not cover their environmental performance.

It seems unlikely that Ukraine would regulate for thermal performance/environmental performance alone but would, more likely, approximate or transpose a version of the CPR. This would bring with it huge consequences in terms of NQI resources and, again, any assessment of these consequences is well beyond the scope of this report.

For appliances, the EU has a series of technical provisions covering a wide range of appliances within the scopes of the Eco-design Directive (2009/125/EC (recast)[7]) and the Energy Labelling Regulation (Regulation (EU) 2017/1369[8] of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU These provisions, which have been shown to work adequately in the EU, seems the appropriate ones for Ukraine to consider. Unfortunately, they do not cover the energy performance of gas appliances which, instead, are covered by the EU's Directive on efficiency requirements for new hot water boilers[9]. as with construction products, it would not seem logical for Ukraine to separate energy efficiency requirements of gas appliances from all the other mainly safety-related requirements of the Gas Appliances Regulation[10], but approximation or transposition of this regulation into Ukrainian legislation would also bring with it substantial NQI implications which cannot be covered by this limited report.

Finally, for urban transport, the EU's Energy Efficiency of Buildings Directive (Directive 2010/31/EU (recast[11])) sets minimum requirements on charging infrastructure for electric vehicles in all new buildings. There is a series of other legislative provisions for transport, too numerous to list here, which are also reviewed in the report.

7 Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009L0125-20121204.
8 Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02017R1369-20210501.
9 Council Directive 92/42/EEC of 21 May 1992 on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels.
10 Regulation (EU) 2016/426 of the European Parliament and of the Council of 9 March 2016 on appliances burning gaseous fuels and repealing Directive 2009/142/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32016R0426.
11 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02010L0031-20210101.

In 2004, Ukraine implemented the Kyoto Protocol to the United Nations Framework Convention on Climate Change, which is aimed at, among other things, the reduction of greenhouse gas emissions. In 2021, the Government of Ukraine updated its Nationally Determined Contribution under the Paris Agreement to reduce its greenhouse gas emissions by 65% by 2030 from the 1990 levels. Ukraine's previous commitment was to reduce emissions by only 40%. Among the undertakings relevant for this project, reduction of greenhouse gas emissions over the next ten years will be achieved through several complex solutions, including:

modernising and upgrading energy infrastructure and industrial enterprises, which can apply to the production of products

developing renewable energy sources and increasing the share of renewable energy in total energy consumption, which can mean renewable energy developed by the building (e.g. solar PV panels)

introducing energy efficiency measures in more sectors of the economy

promoting thermal modernisation of buildings, which should be expanded to all their energy uses

promoting the use of electric vehicles and upgrading transport fleets

introducing more efficient waste management, which can include re-use of products before they become waste

The minimum standards of energy performance are envisaged in the State Building Standards of Ukraine. These standards are mandatory for all individuals and legal entities in Ukraine. State agencies have adopted methodological recommendations providing for solutions to improve buildings in order to reduce the CO_2 emitted from buildings. New buildings in Ukraine will not be granted a building permit without a positive conclusion of an energy efficiency expert review. Furthermore, there are targets aimed at energy-use reduction and promoting energy efficiency in buildings.

The environmental performance of construction depends on several main elements: 1) the production of construction products, 2) appropriate design and construction of building works, 3) the operation of buildings over their lifetime and 4) the re-use, re-purposing or recycling of products and equipment at the end of the works' lifetime. The construction sector is, however, often resistant to change, relying instead on traditional designs and materials, and using a least-cost model. Change towards a more environmental approach will therefore come about by the following primary methods:

EPD

voluntary* 'pull', using Environmental Product Declarations (EPDs), which indicate the environmental performance of products throughout their whole lifecycle

regulatory 'push', through State Building Standards (or other regulatory instruments), which oblige more environmental design of construction works and the use of higher-performing products, and which also puts obligations on public purchasers

voluntary* 'pull', through the energy labelling/environmental certification of works

NQI

the creation of National Quality Infrastructure (NQI) services, in particular certification for the above and facilities for re-use and recycling

awareness-raising of all stakeholders, so that not only the regulatory 'push' is in place but also that the 'pull' of client/customer demand plays its part**

Equivalent figures for transport are not so easy to find. According to the World Bank, transportation produces roughly 23% of global CO_2 emissions from fuel combustion (agriculture excluded). Transportation is the fastest growing consumer of fossil fuels and therefore the fastest growing source of CO_2 emissions and, with rapid urbanisation in some countries, energy consumption and CO_2 emissions by urban transport are increasing rapidly.

The approaches listed above are those which form the basis of the analyses in this report.

* voluntary measures might also be made compulsory.
** according to research by Saint Gobain, in the EU 76% of customers want suppliers to be transparent about environmental impacts of their products and 72% want manufacturers to provide them with green products. This should be equalled in Ukraine if it is not already so.

2 Approach and delivery

2.1 Project overview

This was a relatively short project whose aim was to develop an impact assessment and roadmap/strategy to support the implementation of the guiding framework for the greening of the Ukrainian construction sector. Subsequent projects will need to take up the strategic recommendations to bring about the anticipated benefits.

This report concentrates only on the recovery of the Ukrainian construction industry with respect to its environmental performance, and the resulting strategy elaborates the measures necessary to allow the industry to respond to this. Where possible, the consequences have been quantified in financial terms (the section on a possible model for insulating buildings points to overall economic benefits for the Ukrainian construction sector), in energy saving terms and in terms of reductions in greenhouse gas emissions. There will undoubtedly be other regulatory initiatives required for any widespread green reconstruction throughout the country, such as ensuring the structural stability, fire and acoustic performance of buildings, but these are not considered in this report.

The key outputs of this project are suggestions to the Government of Ukraine and others of actions covering the regulatory framework for green reconstruction. These actions involve institutions, within government and in the NQI, and enterprises, including manufacturers/ suppliers of construction products, works designers and construction companies, and with consideration of client/customer/building users' interests.

With the same precision regarding the limitation to environmental performance given above, this report provides evidence through the cost-benefit analysis and experience/ developments from the European Union (EU), where it has been possible to do so (some areas have not been possible to properly quantify), with the framework (strategy) identifying short- and medium-term activities, taking account of likely developments over the same periods in the EU.

Greening initiatives are taking place throughout the EU at present, with Denmark, Finland, Sweden and France (along with the UK) introducing targets and other mandatory provisions this year or next, alongside activities in Germany. Consequently, experience has been drawn from throughout the Union (and the UK). With the time constraints of this project, the identification of potential future cooperation activities was not, however, possible.

Moreover, the green recovery programme together with concrete project proposals, as this project's key deliverables, aims at providing strategic guidance to the Government of Ukraine in achieving the goals set out in the country's national development and recovery plans, including the future industrial development strategy and the National Recovery Plan. The programme will enable counterparts to build on the country's comparative advantages and contribute to the efforts towards realizing the Sustainable Development Goals and meeting the criteria for integration into the European Union.

The State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) is a central executive body, whose activities are directed and coordinated by the Cabinet of Ministers of Ukraine through the Vice-Prime Minister for Reconstruction of Ukraine, head of the Ministry of Community, Territorial and Infrastructure Development. SAEE implements State policy in the field of efficient use of fuel and energy resources, energy saving and alternative fuels. Also subordinated to this ministry is the State Agency for the Restoration and Development of Infrastructure of Ukraine. The issue of renewable energy sources is the responsibility of the Ministry of Energy of Ukraine.

The government institutions that are key to the issues mentioned in the report are, therefore, the Ministry of Community, Territorial and Infrastructure Development and its two agencies, and the Ministry of Energy of Ukraine.

In order to organise its activities, the SAEE:

1

Ensures the implementation of measures to prevent corruption and control over their implementation in SAEE, enterprises, institutions and organisations belonging to the sphere of its management;

2

Organises planning and financial work in the SAEE, enterprises, institutions and organisation, carries out control over the use of financial and material resources, ensures the organisation and improvement of accounting;

3

Within the limits of powers stipulated by law, together with relevant central executive authorities, ensures control over the targeted and effective use of state funds provided for implementation of projects and programs;

The strategy presented in this report identifies short- and medium-term actions for the Government of Ukraine and other stakeholders to satisfy its strategic objectives, while at the same time assisting Ukraine to align with, in particular, the Energy Performance of Buildings Directive, the Renewable Energy Directives, the EU's Construction Products Regulation (CPR), and Eco-design and Energy Labelling legislation, as well as strengthening national regulations on energy efficiency and environmental performance of buildings.

3 Activities and findings

3.1 Introduction

The undertakings of this project were to develop proposals in support of:

promoting thermal and environmental modernisation of buildings, covering to all their energy uses

modernising and upgrading the environmental performance of construction products Performance of Buildings Directive of the EU

developing renewable energy sources and increasing the share of renewable energy, including renewable energy developed by the building (e.g. solar PV panels)

promoting the use of electric vehicles and upgrading transport fleets

introducing more efficient waste management, which can include re-use of products

This chapter takes each of the objectives of Chapter 2, explains the project's approach to the analysis and shows the finding. By way of introduction, the project considered five different areas:

1

Construction works regulations (compulsory) and voluntary provisions which may be applied to construction works. This also includes obligations arising from the Energy Performance of Buildings Directive of the EU

2

Construction products, sub-divided into product performance declarations covering thermal performance, environmental performance and dangerous substances content/ release, and energy efficiency in the production process

3

Renewable energy, sub-divided into larger-scale generation for Ukraine as a whole (under the Renewable Energy Directive in the EU), and local generation associated with individual buildings as relevant for the definition of near-zero and zero-energy buildings of the Energy Performance of Buildings Directive

4

Appliances/equipment used in buildings, with analysis of the consequences of Ukraine approximating or transposing the collection of regulatory requirements regarding eco-design and energy labelling

5

Urban transportation, considering the adoption of requirements from the Energy Efficiency of Buildings Directive of the EU, together with more general measures aimed at promoting more sustainable urban transport

3.2 Energy efficiency regulations and voluntary measures

3.2.1 Introduction

Construction works regulations cover all performance aspects of buildings, usually comprising: structural stability, fire safety, health and hygiene, safety in use, acoustic performance, rational use of energy and sustainable use of natural resources. As a result of EU-level action, there has been some harmonisation of the methods of assessment of works performance with, notably, the Structural Eurocodes in the EN 1990 series harmonising the methods of calculating structural and resistance to fire performance, and European Standards covering the calculation of energy usage in buildings. There has also been harmonisation of the methods of assessing the performance of elements (parts) of construction works where these are also considered as products, such as the resistance to fire of partitions and the thermal performance of doors and windows. However, while there has been harmonisation of methods, throughout the EU, each Member State is individually responsible for setting the regulatory requirements which apply to works in their territory.

In the UK, this is done through UK Building Regulations and, in particular, Approved Document L, Conservation of fuel and power, Volume 1 covers dwellings, while Volume 2 covers other buildings[12] . It is assumed that EU Member States have broadly similar regulatory requirements.

In the UK, for new buildings, the regulations require:

a target CO_2 emission rate, influenced by the fabric (construction) and fuel used

a target fabric efficiency rate, influenced by the fabric only

a target primary energy use rate, influenced by the fabric and fuel used

These factors are all calculated, from a knowledge of the building and its fabric, using the Standard Assessment Procedure (SAP), which is a simplified, computer-based calculation method and which compares the proposed building with a notional building of the same size and shape but with standardised properties for fabric and services. There are limitations (maximum U-values) placed on building element (e.g. wall ≤ 0.26 W/m²K, window ≤ 1.6 W/m²K) and minimum efficiencies of installed system (e.g. ≥ 92% for gas water heaters).

The result of compliance is an Energy Performance Certificate (EPC), mandatory for most buildings when they are sold. Existing buildings must also have an EPC when sold, but they only need to comply with minimum requirements when there is a change of use. The whole system is underpinned by a large number of standards, some national, some European and some international.

At EU level, the main provision is the Energy Performance of Buildings Directive, Directive 2010/31/EU[13], (recast in 2018). This requires Member States to establish Long-term Renovation Strategies for buildings, to set minimum energy performance requirements (but does not say what these are), to install electric vehicle charging points in non-commercial buildings, from 2021 to ensure that all new buildings are near-zero (provided that the CBA is positive), to set up energy certification systems, to require regular inspections of large (> 70 kW) heating and air conditioning systems, and to use the standards ISO 52000-1, ISO 52003-1, ISO 52010-1, ISO 52016-1 and ISO 52018-1 to calculate energy performance.

A near-zero-energy building (NZEB) is one with a high energy performance and where the remaining small energy demand is largely provided by local renewable energy sources (energy use means heating, cooling, hot water and lighting).

12 https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l
13 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02010L0031-20210101

Different Member States have set different provisions for NZEBs, with the requirements ranging rather widely from 0 kWh/(m².y) to 270 kWh/(m².y) (which includes energy use by appliances) and are mainly given as primary energy use in kWh/m²/y. The higher values are mainly for hospitals or other specialised non-residential buildings. For residential buildings, most Member States aim to have a primary energy use not higher than 50 kWh/(m².y). The maximal primary energy use ranges between 20 kWh/(m².y) in Denmark or 33 kWh/(m².y) in Croatia and 95 kWh/(m².y) in Latvia. Several countries (Belgium, Estonia, France, Ireland, Slovakia, United Kingdom, Bulgaria, Denmark, Croatia, Malta, Slovenia) aim at 45 or 50 kWh/(m².y)[14] . Member States have conducted Impact Assessments for the introduction of NZEBs.

The Commission proposes, from 2030, to move from NZEBs to zero-energy buildings (ZEBs), which are the same as NZEBs in terms of energy performance, but all energy demand is provided by renewable sources. The EPBD identifies nine generic building types.

One further EU legal provision is the Energy Efficiency Directive[15]. Ukraine should consider approximating this directive, although it applies much more widely than the construction sector and so is not considered in this report.

Beyond the regulatory provisions and considering environmental performance more widely, there are voluntary certification schemes based on standards such as ISO 14001 Environment management systems and ISO 50001 Energy management systems, and more general environmental assessment tools such as BREEAM, which is already in principle used in Ukraine.

There are few NQI provisions required for the construction sector as such, these being limited mainly to the accreditation of energy/environmental certification bodies and individuals, and some limited testing of e.g. air tightness of buildings. Building control (as it is called in the UK), i.e. the independent control of the design and construction phases, and the preparation of Certificates of Completion, are an important part of the whole process, but these are not conventionally considered to be a part of NQI, although they may be accredited.

Ukraine's progress in developing and implementing policy measures to improve the energy efficiency of buildings and appliances has been considerable, consistent with its 2014 Association Agreement to implement the standards of the EU Energy Efficiency Directive.

Key laws and regulations provide a foundation for monitoring and enforcing mandatory certification of energy efficiency in buildings, which was introduced in August 2020. Energy efficiency certificates have been issued for over 4 500 buildings by 2021[16]. A long-term building renovation strategy to 2050 is also being considered, and procedures for introducing energy management systems for public buildings are being developed.

Several important programmes have been established to help fund and drive improvements in the energy efficiency of residential buildings and appliances:

The Energy Efficiency Fund, established in 2017 in close co operation with the European Union in accordance with the Law on the Energy Efficiency Fund of 8 June 2017 (No. 2095-VIII). The Fund has so far focused on financing energy efficiency retrofits of apartment buildings, but it is expected to be extended to retrofits of privately owned detached housing.

The Warm Loans programme, established in 2014 to provide households with financial assistance to improve the energy efficiency of their residences through insulation, weatherisation and upgrading of major appliances such as space and water heaters. The programme has assisted 838 000 households to date, and supported investments of more than UAH 8.5 billion, including around UAH 3.2 billion in reimbursements to households.

23 technical regulations covering eco-design, and 11 covering energy labelling for a range of appliances. In 2020, the Ministry of Energy approved additional energy labelling regulations for decentralised heating; commercial refrigerators; residential ventilation systems; solid-fuel boilers; temperature controllers; and solar energy installations.

14 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016H1318
15 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02012L0027-20230504
16 IEA (2021), Harnessing Energy Demand Restraint in Ukraine: A Roadmap, IEA, Paris https://www.iea.org/reports/harnessing-energy-demand-restraint-in-ukraine-a-roadmap.

3.2.2 Analysis

Back in 2005[17], a World Bank project concluded the following:

Energy efficiency improvements in buildings, including heat meters, [of] 1 302 institutional buildings, including healthcare, educational and cultural buildings in Kiev, owned by KCSA, with a floor space of about 5.1 million square metres, were to be retrofitted under the project, utilizing the highest priority energy efficiency measures evaluated

The heat savings of the public buildings included in the project attained 214 440 Gcal (250 TWh, normalised by degree days in base line year) by the end of 2004 or about 17% compared to the heat consumption of the buildings before the project. The installation of energy conservation measures in the project buildings intensified during the first half year of 2005, and it is expected that the heat savings stemming from the whole project will reach about 26% starting from 2006 and beyond when all the energy saving devices installed under the project will be exploited the whole year.

The economic re-evaluation proved that the investments under the project generate robust economic benefits with an economic net present value (ENPV) equal to €10.3 million and an economic internal rate of return (EIRR) of 26.6%.

Energy efficiency improvements in buildings, including heat meters, [of] 1 302 institutional buildings, including healthcare, educational and cultural buildings in Kiev, owned by KCSA, with a floor space of about 5.1 million square metres, were to be retrofitted under the project, utilizing the highest priority energy efficiency measures evaluated

Space heating, water heating and household appliances accounted for over 85% of Ukraine's total residential energy consumption in 2019. Space heating alone represented over half of residential end use and around 16% of total final consumption. In this year, total energy consumption was 46 Mtoe (540 000 GWh)[18].

State construction codes SCN B.2.6-31:2016 «Heat insulation of buildings» were approved to ensure rational use of energy resources for the purposes of heating and cooling, and to meet the required sanitary parameters of indoor climate as well as to ensure long life of envelope structures in the course of their use. The said codes include requirements to energy efficiency and thermo-technical characteristics of thermal insulation envelope for buildings and structures and their calculation procedure. SCN B.2.6-31:2016 are designated to be applied in doing design for the buildings and structures with heat, conditioning and cooling, in doing Greenfield projects, modernisation, thermal insulation and capital repairs[19].

On June 22nd 2017 the Verkhovna Rada passed the Law of Ukraine № 2118-VIII «On Energy Efficiency in the Buildings» which establishes conditions enabling reduced energy consumption in buildings in accordance to Directive 2010/331/EU of the European Parliament and of the Council "On the energy performance of building" as a part to implementation of ratified Treaty Establishing the Energy Community. The Law regulates establishment of minimum requirements to energy efficiency in the buildings, envisions introduction of certification of energy efficiency and survey of engineering systems in the buildings.

The Law also intends to regulate professional activity in the sphere of energy efficiency in buildings. The Law of Ukraine passed on the 8th June 2017 envisioned establishment of Energy Efficiency Fund, which is an important instrument to support energy efficiency initiatives. The said fund complies with requirements of Directive 2012/27/EU of the European Parliament and of the Council as a part to implementation of ratified Treaty Establishing the Energy Community, and is designated to stimulate and support measures aimed at increasing energy efficiency and energy saving mainly in residential sector buildings with due incorporation of respective national plans and for reduction in GHG emissions.

17 Implementation Completion Report (SCL-45340) on a loan in the amount of US$ 18.29 million to Ukraine for a Kiev public buildings energy efficiency report, Report No: 33154-UA, December 6, 2005.
18 https://www.iea.org/reports/harnessing-energy-demand-restraint-in-ukraine-a-roadmap/overview-of-ukraines-policy-context-for-demand-restraint
19 https://unfccc.int/sites/default/files/resource/Ukraine_LEDS_en.pdf

3.2.3 Regulatory Impact Assessment of the transposition and enforcement of the EPBD 2010/31 EU & EPBD 2018/844 EU in Ukraine

3.2.3.1 Background

Ukraine is ranked as the world's fifth most energy-intensive country. The energy consumption per unit of GDP is almost 3-fold that of the OECD average whereas the intensity of CO_2 emissions per unit of GDP is 3.2-fold the EU average[20]. The primary energy supply is dominated by fossil fuels, accounting for nearly 71% of the total in 2017. The heating sector is largely dependent on the use of fossil fuels.

In 2018, Ukraine's total final consumption accounted to 51.5 Mtoe, with industry being the largest final energy consumer (19.1 Mtoe in 2018) followed by the residential sector (16.7 Mtoe), with households being the major users of natural gas (8.7 Mtoe in 2018). In total, the building sector consumed 42% of total final energy in 2017 with commercial and public services consuming 9%[21]. The energy consumption of Ukrainian buildings is estimated at 250 to 275 kWh/m², which is at least double that of Western Europe's average of about 120 kWh/m² [22]. As of 1 January 2013, Ukraine's housing stock consisted of 10.2 million residential buildings with a total surface area of 1 094.2 million m². The average sizes of urban and rural housing units are 52.2 m² and 60 m², respectively.

Regarding ownership, Ukraine's housing stock is 93.7% privately-owned, 4.9% municipally-owned and 1.4% state-owned[23]. Apartment type residential houses account for nearly all housing stock (98.1%). The share of hostels and residential premises in non-residential buildings in the total housing stock constitutes 1.9% (20.4 m. m²).

Residential building stock

The housing stock in Ukraine is relatively old with only 7% of residential housing stock being built since 1991 and 42% built before 1960, so, both require major and routine repairs. This includes Soviet-era multifamily houses, which have nearly exhausted their potential use after two decades of mismanagement and disrepair. Most of the housing stock in apartment blocks was built from 1960 to 1980. Close to 20% of multi-unit housing was built before 1960, therefore, a typical multi-unit building is 30 to 50 years old.

The condition of buildings throughout Ukraine is poor due to the slow pace of capital repairs. According to 2012 statistical data, only 0.1% of the housing stock underwent capital repairs, restricted mainly to urgent repairs and not resulting in substantial increase in housing quality and energy efficiency.

Public building stock

The share of public buildings (offices, educational, health, commercial, hotels, warehouses, etc.) in the total building stock accounts to max. 15%, with the majority being built before 1990. Official statistics lack information on structural breakdown by types of public buildings and includes information only on the general number of certain types of public buildings in Ukraine. Their traditional architectural and building systems include mostly large-panel, large-block, frame made systems with precast concrete, etc.) and do not meet modern requirements as for energy efficiency, and therefore are characterised by low energy efficiency properties, a large part of them is in need of integral renovation[24].

Their poor physical conditions are amplified by the absence of metering and heat consumption measurement as well as lack of regulators/thermostats, which leads to a high use of heat and water consumption. 22% of non-residential buildings are not equipped with heat meters, 5% with cold water meters and 46% with hot water meters, which shows that Ukraine still does not meet the obligations on commercial heat metering standards (SAEE, 2019a).

The impact of the war on building infrastructure

The direct damage to Ukraine's infrastructure caused by Russia's full-scale invasion in 2022 exceeded €138 billion, as reported by the Kyiv School of Economics. Almost €52 billion of this amount is the loss of housing stock. More than 150 000 buildings and structures in Ukraine have been destroyed because of the war, with most of them being residential buildings. According to other sources, 18 600 apartment buildings and nearly 1.5 m.[25] homes were damaged or destroyed by May 2023. Over one-third of the damaged homes are destroyed (499 100), while two-thirds are partially damaged[26].

20 OECD 2019, Snapshot of Ukraine's Energy Sector.
21 Ukraine energy profile – Analysis – IEA.
22 National Energy Efficiency Action Plan Through 2020.
23 Chapter_2_Ukraine.pdf_unece.org.
24 Energy efficiency in Public buildings-Low Carbon Ukraine 2020.

In the country's effort to rebuild the damaged infrastructure, energy efficiency is becoming extremely relevant as the main road to post-war recovery, reduce dependence on the imports of fossil fuels and strengthening of the national economy. Furthermore, as Ukraine aims at accelerating accession to the EU, post-war reconstruction should be carried out according to EU standards and the level of energy efficiency of the building stock should be increased. To this end, the legal framework on the energy performance of buildings in force needs to be improved and expanded, enforcement and implementation mechanisms to be strengthened.

3.2.3.2 Policy initiatives on energy efficiency

Since 2016, Ukraine has been developing a consistent energy policy by issuing the Nationally Determined Contribution (NDC) strategy, under the Paris Agreement, targeting to 40% reduction of greenhouse gas emissions below 1990 levels by 2030, a target increased to 65% in 2021. A series of general strategic and sectoral documents followed and adopted by the Ukrainian Government, on energy security, efficiency and competitiveness, specifying policies and actions by energy sector.

Despite the ongoing military aggression of the Russian Federation, the economic crisis of 2014-2015 and the COVID-19 pandemic, Ukraine has taken many steps to significantly reduce energy consumption, promote energy efficiency and renewable energy. In the sector of Energy Efficiency, Ukraine has achieved the national 2020 energy efficiency target set out in the "National Energy Efficiency Action Plan (NEEAP)" of 2015, as reported in the sixth Annual Progress Report to the Energy Community Secretariat in July 2022. The new Energy Efficiency Law, which includes the specific targets and policy measures in line with the Energy Efficiency Directive, was adopted in October 2021.

The 2030 energy efficiency targets and policy measures were integrated in the "National Energy Efficiency Action Plan Through 2020" for the period up to 2030, adopted in December 2021. The new NEEAP sets a national energy efficiency target and a concrete plan of measures to achieve it. By 2030 the primary energy consumption should not exceed 91.5 Mtoe while the target for the final energy consumption is 50.5 Mtoe. Therefore, it is expected to reduce energy consumption by 22.3% and by 17.1% (primary and final, respectively). To achieve this goal, the National Plan includes a number of sectoral and intersectoral measures to improve energy efficiency in different sectors such as housing, transport, industry and energy. Measures include promoting the energy efficiency of industrial enterprises and residential buildings, energy labelling and eco-design, full commercial accounting of utilities, reduction of losses in electricity transmission and distribution networks, natural gas distribution, etc.

25 Breaking barriers, building hope in Ukraine | United Nations Development Programme (undp.org).
26 Ukraine Rapid Damage and needs assessment, February 2022-February 2023, World Bank Group.

3.2.3.3 Transposition of the EU's Energy Performance of Buildings Directive

The Ukrainian Law on Energy Efficiency of Buildings, transposing the EU Directives on the Energy Performance of Buildings (Directive 2010/31/EU (recast) and the amending Directive 2018/844), into the legislative framework of Ukraine, was put in force in June 2017, followed by a series of amendments in 2019, 2021 and 2022. Since 2017, the majority of by-laws to implement the law were developed and adopted (a list of by-laws is given in 3.2.3.10). Key points of Directive 2010/31 and amendments of Directive 2018/844 are summarised below.

In the table of 3.2.3.9, the current status of the transposition of the Directives 2010/31/EU and 2018/844 in the Ukraine Law on Energy Efficiency of Buildings is presented. It is noted that an in depth analysis of the legislative framework in force and a gap analysis was not feasible within the timeframe of this project. However, a review of the main provisions of the EPBD 2010/31 and 2018/844 and the corresponding provisions of the Law was performed with the aim to highlight main issues that would require further actions.

Key points of Directive 2010/31

- Adoption of a methodology for calculating the energy performance of buildings and building units.
- Application of minimum energy performance requirements in new buildings and building units as well as in existing buildings undergoing major renovation.
- Application of minimum energy performance requirements for building elements and technical systems with a view to achieving cost-optimal levels.
- Energy certification of buildings/building units; issue of energy performance certificates.
- Regular inspection of heating and air-conditioning systems.
- Independent control of energy performance certificates and inspection reports.
- Display of energy performance certificates in public buildings.
- Independent accredited or qualified experts carrying out energy performance certification and inspection of technical systems.
- Independent control system for energy performance certificates and inspection reports.
- Lay down rules of penalties applicable to infringement of the national provisions.
- By 31st December 2020 all new buildings to be nearly Zero energy buildings; setting out national plans for increasing the number of nearly-zero energy buildings.
- Information campaigns.
- The energy performance indicator to be included in property advertisements.

Key amendments of the Directive 2010/31 included in EPBD 2018/844

- The introduction of building automation and control systems.
- The establishment of a Long-Term Renovation Strategy for buildings.
- The installation of controls and temperature self-regulating devices.
- The installation of recharging points for electric vehicles in new non-residential buildings and installation of ducting infrastructure in new residential buildings.
- Smart readiness indicator: establishing an optional common Union scheme for rating the smart readiness of buildings.
- Establishment of databases for energy performance certificates.

3.2.3.4 Main issues identified

Energy performance certificates

According to the EPBD, an energy performance certificate shall be issued for buildings or building units, which are constructed, sold or rented out.

There is no reference in the Law on the energy certification of building units/apartments, when these are sold or rented out.

Independent control systems — Quality assurance

Provision for independent monitoring of energy certificates and reports of inspections technical systems is set out: independent monitoring is carried out by:

- the central executive authority in charge of developing the state policy in the area of energy,
- expert institutions or other energy auditors.

There is no reference in the Law on the requirements of Annex II of the EPBD foreseeing the process of control and the verification of a statistically significant percentage of energy certificates and reports issued annually. Furthermore, there is no information available on the methodology/process of quality control performed.

Building automation and controls

According to the Law on Energy Efficiency of Buildings, the introduction of automated systems for monitoring and control of engineering systems of buildings is one of the priority areas for the provision of state support.

There is no specific obligation for the installation of automation and controls.

Electromobility

According to the EPBD:

- In new non-residential buildings and non-residential buildings undergoing major renovation, with more than ten parking spaces, the installation of at least one recharging point is required.
- In new residential buildings ducting infrastructure, to enable the installation at a later stage of recharging points for electric vehicles, is required.

There is no provision in the Law on the Electromobility infrastructure in buildings.

3.2.3.5 Regulatory Impact Assessment

In the following paragraphs, an estimate of the impact of the Law on Energy Efficiency of Buildings in place as well as of the required amendments/improvements, where gaps in the harmonisation with the EPBD 2010/31 and amending Directive 2018/844 were identified, is presented.

Calculation of the energy performance of buildings and implementation of minimum energy performance requirements

Transposition of the EPBD required the development and enforcement of a new legislative and regulatory framework, guidance and practice.

Sectors and groups affected

The following groups and sectors are affected:

- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- urban planning institutions responsible for approvals of building permits and compliance control,
- certification commissions responsible for the professional certification/attestation of energy auditors and inspectors,
- training institutions,
- owners of buildings undergoing major renovation, when fall under CC3 and CC2 category of consequence, defined in accordance with the Law of Ukraine 'on Regulation of Urban Planning Activities',
- owners of public buildings (the State) with a heated area exceeding 250 m², which are often visited by the public,
- owners of municipal buildings (municipal authorities) with a heated area exceeding 250 m² (if thermal modernisation is carried out),
- owners of buildings in which thermal modernisation is carried out, for which public support is provided,
- public sector institutions responsible for setting out implementation and quality assurance mechanisms and tools,
- local authorities,
- building materials and equipment manufacturers/suppliers,
- software developers/providers,
- the public at large.

Benefits

The direct benefits deriving from the obligation for the calculation of the energy efficiency and the implementation of minimum energy performance requirements are presented below, provided that the Law is fully implemented:

a) Ukraine will meet the requirements of the EPBD and contribute to the country's efforts to accelerate accession to the EU,

b) obligations set out on energy efficiency calculation and implementation of minimum energy performance requirements will promote the issue of energy efficiency in buildings.

Considering the low level of energy efficiency of the building stock, accounting for approximately 10.2 million residential buildings (2013 statistics) and the damaged building infrastructure due to Russia's invasion in 2022, it is estimated that for more than 150 000 buildings, most of them being residential, there is an urgent need for reconstruction/ renovation. On the other hand, energy efficiency is becoming extremely relevant as the main road to post-war recovery and to achieving the national targets for green recovery and the development of a low-carbon, energy-efficient economy.

Post-war reconstruction should be carried out according to EU regulations and the level of energy efficiency of the building stock should be increased. To this end, full implementation of the legal framework on the energy performance of buildings in force is a pre-requisite while, at the same time, it needs to be improved and expanded, and enforcement and implementation mechanisms need to be strengthened.

c) Energy savings in the building sector

Official statistics on energy consumption by different types of buildings in different climate zones are not available in Ukraine. Considering the lack of statistical data and the timeframe of this project, an estimate of the impact of a full implementation of the energy certification of buildings in terms of energy savings and costs would not be feasible. Therefore, the estimates of energy saving potential, included in the "National Energy Efficiency Action Plan Through 2020", based on simulations of a sample of buildings, are transferred here.

- In the residential building sector, the results show that implementation of comprehensive energy efficiency measures in existing residential buildings in Ukraine and improvement of buildings' energy efficiency would result in reduced total energy consumption by 15.3 Mtoe. This accounts for 60% of the acceptable calculated value of baseline consumption (25 Mtoe).
- In the sector of public and commercial buildings, due to limited statistical information on the stock, the results of the model for assessing energy saving potential in educational institutions, where the energy efficiency potential was estimated at 712.5 Ktoe in 2020.

Costs

- In the residential sector, the total investment required for implementation of comprehensive energy saving solutions is estimated at UAH 670 billion (€60 billion).
- In the public and commercial building sector, the total investment required for implementation of comprehensive energy efficiency measures educational facilities is estimated at UAH 29 billion (€2.6 billion).

Energy performance certification and issuance of energy certificate

Sectors and groups affected

The following groups and sectors are affected:

- owners of buildings undergoing major renovation, when fall under CC3 and CC2 category of consequence, defined in accordance with the Law of Ukraine 'on Regulation of Urban Planning Activities',
- owners of public buildings (the State) with a heated area exceeding 250 m², which are often visited by the public,
- owners of municipal buildings (Municipal authorities) with a heated area exceeding 250 m² (if thermal modernisation is carried out),
- owners of buildings in which thermal modernisation is carried out, for which public support is provided,
- public sector institutions responsible for setting out implementation and quality assurance mechanisms and tool,
- certification commissions responsible for the professional certification/attestation of energy auditors and inspectors,
- training institution,
- urban planning institutions responsible for building permits/compliance control,
- local authorities,
- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- building materials and equipment manufacturers/suppliers,
- software developers/providers,
- the public at large.

Benefits

Energy performance certification is the only tool to quantify energy consumption and identify actions needed for improvement. The energy performance certificate (EPC) has multiple benefits; it serves as:

- an information tool for building owners and tenants, when a building or building unit is sold or rented out,
- a powerful market tool, to create demand for energy efficient products and technologies, by providing recommendations for a cost-effective upgrading of the energy performance,
- an effective instrument for policy making, to map the energy performance of a country's building stock, to monitor the impact of building policies, to be used as an analysis tool for the identification of gaps and barriers in the implementation of energy efficient technologies and to develop targeted policy instruments and incentive programmes,
- Energy performance certification and certificates issue will promote uptake of energy refurbishments.

Currently there is no obligation under the Directive or the Law for building owners to take actions to improve the energy efficiency of their buildings following the recommendations included in the certificates. However, studies conducted in EU Member States indicate that increased awareness in combination with acceptance, by the wide public, of the certificate as a quality document, would encourage the uptake of recommendations. To this end, improved quality of the certification process and training of auditors as well as the operation of an effective quality control mechanism would be of major importance.

Furthermore, given that these conditions are met, it is envisaged that voluntary certification for buildings not falling under CC3 and CC2, and hence the obligation of the Law, will be also promoted and the number of building owners implementing energy efficiency measures will be increased.

Costs

a) **Cost of certification and Energy Certificate issuance on residential building owner (co-owners), housing and construction cooperative, association of co-owners, manager of multi-apartment building**

In EU Member States, the cost of certificate related to the fees of the energy auditor for conducting an audit and certification, is generally set on a market basis with no maximum ceiling. A small number of countries, including Denmark, Croatia, Hungary and Slovenia, have regulated the cost for a certificate (e.g. in Hungary the cost for apartments is set by law at €40 (+VAT) per unit while in Denmark, the cost is capped at €884 for larger single-family buildings)[27]. In general, the audit and certification fee ranges from €20 to €2 000 per building across the EU. This variation can be explained by factors such as quality / comprehensiveness of the certification methodology, variation in labour costs across EU, number of competing actors on the market, cost of software, involvement of trained experts, on-site audits, registration or not in a national EPC database, etc.

While it is positive that market forces have driven down the cost of certificates in most EU Member States, very low costs can be a concern. It calls into question the integrity, purpose and quality of low cost certificates.

In Ukraine, the fees of energy specialists operating in the marketing and conducting audits and inspections of engineering systems are not regulated. An estimate of the cost of certificate issuance to be borne by the owner could be based on the regulated daily fees of construction engineers set at 42 €/day, while the working days vary by building size and complexity.

b) **Cost of certification and EPC issuance on state authorities and municipalities (in compliance with applicable regulations)**

Certification cost for public buildings cannot be left to the market and needs to be established in advance. Considering the variety in size and complexity of public building, an estimate of the certification cost for public buildings resulted at an indicative cost of about 36 450 UAH or €900. The estimate was based on the data and assumptions (considering approximately 27 days of work and taking as a basis the daily fees of construction designers which is regulated at 42 €/day) of previous work performed in the frame of the "Ukraine public buildings energy efficiency" study of 2021, under the Framework agreement to support EIB advisory services.

c) **Cost of qualification of auditors and inspectors of engineering systems**

Qualification and attestation of auditors and inspectors is provided by certification commissions established by higher education institutions or self-regulatory organisations in the field of energy efficiency and published on the relevant websites. As of 2021, 41 qualification commissions carry out professional attestation in the field of energy certification of buildings. Also, special training programmes in the areas of building certification and inspection of engineering systems have been approved in 30 institutions of higher education. The number of specialists certified currently stands at 1 542[28]. In 2019, the Ministry of Communities and Territories Development (MinRegion) estimated that the market in Ukraine needs 5-7 thousand energy auditors[29].

Taking into account the poor condition of the building stock across the country as well as the urgent reconstruction/refurbishment needs of the building stock damaged in war zones, the increased needs for energy certification and, hence, of energy specialists operating in the market, certification commissions would need to review and strengthen their mechanisms of exams and qualification of auditors. An accurate estimate on the cost of such activity in Ukraine cannot be provided as there is no information on fees of candidate auditors/inspectors when apply for getting a qualification certificate and exam; furthermore there is no information available on the existing mechanism administrative costs.

Based on experience from EU countries, an average cost per auditor for training and exams to be borne by the auditor is estimated at of €500[30], this including the administrative costs of the institutions responsible for exams and issuance of qualification certificates. The average administrative cost in EU countries is not known, however, in Greece it is regulated at €100 to be paid by the candidate auditor when applying for a professional qualification.

Using as a basis the case of Greece, assuming that the number of specialists in the market would increase by 4 500 professionals that would apply for a qualification (to meet the average market demand of 6 000 total), this would introduce a cost of €2 250 000, borne by the auditors (including an administrative cost of €450 000).

However, as such development will occur as part of the currently established professional attestation scheme, which would partly or totally reduce the administrative financial impact, the Ukraine Government may decide not to impose this cost on the auditors, reducing thus the final cost borne by the auditors at €1 800 000. These cost estimates should be considered only for indicative purposes.

27 X-tendo: Energy performance certificates – Assessing their status and potential, BPIE 2020.
28 Ukraine – Fifth Annual Report under the Energy Efficiency Directive, July 2021.
29 Energy Efficiency Of Residential Buildings: There Are Successes, But They Are Few | VoxUkraine. https://voxukraine.org/en/energy-efficiency-of-residential-buildings-there-are-successes-but-they-are-few
30 Regulatory Impact Assessment on implementation of Art. 7, 8 and of the EU Directive 2002/91/EC–Scotland.

Energy performance certification of building units/apartments

The Law sets out the obligation of energy certification in whole buildings; no reference is made to individual building units. An amendment needs to be considered to extend the application field and include certification of building units/ apartments. Furthermore, the thermal modernisation of residential building units/apartments is funded under current financing mechanisms in Ukraine, such as "Warm" Loans, EBRD IQ Energy programme (more detailed information on current financing programmes is provided in 3.2.3.11). Energy certification and registration of the energy certificate in the Unified State Electronic System of households/ apartments eligible for funding under these programmes is not possible due to lack of such a provision in the Law.

Sectors and groups affected

The following groups and sectors are affected:

- public sector institutions responsible for the development of state policy in the field of construction and housing and the public sector institutions responsible for implementing the state policy in the areas of efficient use of fuel and energy resources,
- owners of building units/apartments undergoing major renovation, when fall under CC3 and CC2 category of consequence, defined in accordance with the Law of Ukraine 'on Regulation of Urban Planning Activities',
- owners of buildings units/apartments in which thermal modernization is carried out, for which public support is provided,
- public sector institutions responsible for setting out implementation and quality assurance mechanisms and tools,
- institutions responsible for approvals of building permits and compliance control,
- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- building materials and equipment manufacturers/suppliers,
- the public at large.

Benefits

Considering the high percentage of privately-owned houses (93.7%) and the total number of apartments accounting for 19.3 m, the direct benefits deriving from the energy certification and implementation of minimum energy performance requirements, in building units/ apartments are presented below:

a) Ukraine will improve the legislative harmonization with the requirements of the EPBD and, this contributing further to the country's efforts to accelerate accession to the EU,

b) the potential number of building owners to implementing energy efficiency obligations set out on energy certification and information to building owners will increase,

c) energy savings in the building sector will increase.

In the frame of this project, an accurate estimate of the impact of an extended implementation of the energy certification in building units/apartments, in terms of energy savings and costs of implementation, would not be feasible.

The total number of households reached 16.5 million in 2020 in Ukraine, according to the National Statistical Office[31] and nearly 1.5 million homes, representing approximately 10% of households, have been damaged during the war,

Based on the assumptions and outputs of the "National Energy Efficiency Action Plan Through 2020" on the potential energy savings in the residential building sector, a comprehensive energy refurbishment of the existing residential buildings (including energy performance upgrade of apartments in multifamily buildings, to achieve the refurbishment of whole buildings), would result in reduced total energy consumption by 15.3 Mtoe, this representing energy savings of almost 40%.

Costs

a) **Administrative costs**

Such development will potentially occur as part of the internal administrative costs, which would minimise the financial impact.

b) **Costs on building owners**

Considering the average size of urban and rural housing units being in the range of 50 m^2-60 m^2, the working days for audit and energy certificate issuance are estimated at 2-3 days, this resulting in an indicative maximum auditor's fee of approximately €120-150/apartment. This estimate should be considered only for indicative purposes.

If thermal modernization of residential building units/ apartments is considered under national incentive programmes for the thermal modernization of buildings, the cost of certificate issuance would be considered as eligible cost for public support and the financial impact on owners would be eliminated.

31 **Number of Households in Ukraine | Helgi Library.**
https://www.helgilibrary.com/indicators/number-of-households/ukraine/#:~:text=Last%20Updated%3A,of%2010.6%20mil%20in%201960.

Independent control systems – Quality assurance

The provision for independent monitoring of certificates and inspection reports of engineering systems is set out in the Law. However, no obligation is set in the Law on the requirements of Annex II, foreseeing the process of control and the verification of a "statistically significant" percentage of energy certificates and reports issued annually, specifically:

a) validity check of the input data of the building used to issue the energy performance certificate and the results stated in the certificate,

b) check of the input data and verification of the results of the energy performance certificate, including the recommendations made,

c) full check of the input data of the building used to issue the energy performance certificate, full verification of the results stated in the certificate, including the recommendations made, and on-site visit of the building, if possible, to check correspondence between specifications given in the energy performance certificate and the building certified.

Information on the methodology/process of quality control performed is not available. As of June 2021, 8 434 certificates were included in the database and 199 (approx. 2.5%) were checked, out of which 141 certificates were found to not meet the requirements and 58 successfully passed verification[32]. According to other sources, by 2023 the number of certificates increased to over 17 000. The level of quality control percentage is considered medium comparing to the statistical average percentage of controls of annual certificate number issued in other countries, e.g. Denmark 25%, Greece 5%, Romania 10%, France 1%, the Netherlands 2% for residential and 5% of non-residential, and Portugal 0.5-4%[33].

In view of the intense post-war reconstruction activity expected in Ukraine and the need for increased controls of certificates and reports, the central executive authority and/or the expert institutions would need to enhance the mechanism established. Furthermore, the data available on verification of certificates indicate that quality assurance issues need to be reconsidered, this including training of experts, a more efficient exam framework and a more effective (and 'proportional' as per EPBD) penalty system. Experience from EU countries of the EPBD implementation shows that such failures are inevitable in the initial implementation phase. Throughout the years, the countries have strengthened the quality assurance mechanisms and improved the quality of certificates. Currently, training of auditors is not mandatory in most EU countries. However, recent studies and surveys in EU indicate a shift towards the need for mandatory and regularly repeated training.

Sectors and groups affected

- the public sector institutions responsible for the development of state policy in the field of construction and housing and the public sector institutions responsible for implementing the state policy in the areas of efficient use of fuel and energy resources,
- expert institutions or other energy auditors.

Benefits

a) improved quality of certificates will ensure an effective implementation of energy efficiency measures to achieve improved energy efficiency of buildings and contribute to the county's efforts towards green recovery and low-carbon, energy-efficient economy,

b) increased trust and acceptance of the energy certificate on behalf of the society will encourage building owners to implement energy efficiency measures following the recommendations included in the certificates.

Costs

It is anticipated that an independent control mechanism cannot be implemented without attendant costs to approved organisations. Information on current costs is not available. An estimate of additional costs, assuming an increase by 2% of the rate of checks, would initially add administrative costs equivalent to about an additional 2% of overall certificate fees.

Assuming that all 150 000 buildings damaged will undergo refurbishment and be issued with an energy performance certificate, with an average certificate cost for residential buildings of €135/whole building, the additional administrative cost, borne ultimately by building owners through certificate fees, would reach a level of €405 000. These cost estimates should be considered only for indicative purposes.

32 Ukraine – Fifth Annual Report under the Energy Efficiency Directive, July 2021.
33 X-tendo – Energy performance certificates across the EU – National approaches, BPIE 2014.

Building automation and controls

According to Articles 14(4) and 15(4) of the EPBD, where technically and economically feasible, non-residential buildings with an effective rated output for heating systems or systems for combined space heating and ventilation, or systems for air-conditioning or systems for combined air-conditioning and ventilation of over 290 kW are equipped with building automation and control systems by 2025.

No specific obligation is set out in the Law on the installation of automation and controls, further to the prioritisation **"as one of the areas for provision of state support"**. An amendment of the Law needs to be considered to include the specific obligation. Furthermore, a methodology needs to be developed/published to provide for where this is not economically feasible through a payback evaluation.

Sectors and groups affected

- public sector institutions responsible for the development of state policy in the field of construction and housing and the public sector institutions responsible for implementing the state policy in the areas of efficient use of fuel and energy resources,
- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- institutions responsible for approvals of building permits and compliance control,
- building materials and equipment manufacturers/suppliers.

Costs

a) Administrative costs
Such development will potentially occur as part of the internal administrative costs, which would minimise the financial impact.

b) Costs on building owners

The cost of building automation systems shall be defined according to market prices. Indicative costs based on market research of the European market, are estimated at approximately €20 000 for a medium sized office or hotel.

Electromobility

Art. 8 of the EPBD 2018/844 requires the installation of at least one recharging point in new non-residential buildings and non-residential buildings undergoing major renovation, with more than ten parking spaces, and ducting infrastructure, namely conduits for electric cables, in new residential buildings to enable the installation at a later stage of recharging points for electric vehicles.

Regarding the situation in Ukraine, as of January 2023, approximately 84 000 electric vehicles are registered in the country. The number is growing by 5 000 every month, and analysts predict it will triple by 2025[34]. The use of EVs in Ukraine is motivated by tax and customs payments exemptions. On the 23rd March 2023, the Law of Ukraine "On Certain Issues of the Use of Vehicles Equipped with Electric Engines and Amendments to Certain Laws of Ukraine on Overcoming Fuel Dependence and Development of Electric Charging Infrastructure and Electric Vehicles" came into force[35].

The law was developed to implement the Association Agreement between Ukraine and the European Union and to harmonise Ukrainian legislation, in particular, with Directives 2009/33/EC and 2014/94/EU of the European Parliament. However, there is no legislative provision in the Law on Energy Efficiency of Buildings for recharging points in parking spaces.

An amendment of the Law and related bylaws needs to be considered to include the specific obligation, in order to align with the EPBD as well as with the upcoming new EPBD recast provisions aiming at accelerating deployment.

Sectors and groups affected

- public sector institutions responsible for the development of state policy in the field of construction and housing and the public sector institutions responsible for implementing the state policy in the areas of efficient use of fuel and energy resources,
- owners of buildings undergoing major renovation, when fall under CC3 and CC2 category of consequence, defined in accordance with the Law of Ukraine 'on Regulation of Urban Planning Activities',
- owners of public buildings (the State) with a heated area exceeding 250 m², which are often visited by the public,
- owners of municipal buildings (Municipal authorities) with a heated area exceeding 250 m² (if thermal modernisation is carried out),
- owners of buildings in which thermal modernisation is carried out, for which public support is provided,
- institutions responsible for approvals of building permits and compliance control.
- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- building materials and equipment manufacturers/suppliers,
- the public at large.

Costs

a) Administrative costs

Such development will potentially occur as part of the internal administrative costs, which would minimise the financial impact.

b) Costs on building owners

The costs of the EV recharging infrastructure requirements in buildings vary depending on charging mode, the existing infrastructure, building type, size and location. An accurate cost estimate for Ukraine is not feasible in the frame of the current project and shall be defined according to market prices. Experience from other countries[36] indicate that:

- the cost impact on a new apartment block of 100 parking spaces for EV recharging infrastructure is in the order of approx. €100 per apartment for a building with 100 apartments (€10 000 for the whole building)
- the cost impact on a new non-residential building for EV recharging infrastructure with a surface carpark of 100 spaces is approx. €10 000 for the building.

34 Ukraine is experiencing an electric car boom – UkraineInvest. https://ukraineinvest.gov.ua/en/news/20-12-2023/#:~:text=Ukraine%20is%20experiencing%20an%20electric%20car%20boom%2C%20with%20around%2080%2C000,it%20will%20triple%20by%202025.

35 Use of e-vehicles in Ukraine | DLF attorneys-at-law. https://dlf.ua/en/use-of-e-vehicles-in-ukraine/#:~:text=On%2023%20March%202023%2C%20the,Law")%20came%20into%20force.

36 Regulatory Impact Analysis (RIA) – Government of Ireland 2019.

3.2.3.6 Other certification schemes for buildings

Green building certification under international schemes is voluntary in Ukraine. In the frame of corporate social responsibility, there is an increasing interest of Ukrainian construction companies in environmental issues and efficient use of resources. Especially in the office segment, more and more investors and developers are implementing certain green practices on the path to sustainable development.

The most common green certification options are LEED (focus on energy efficiency), BREEAM (focus on environmental friendliness), WELL (emphasis on human health) and Active House. During the past several years, a number of buildings has been certified under LEED and BREEAM standards and the certification of several buildings is currently in progress.

However, the alignment of the country with the EU policy on building certification (EPC) and related directives on the energy performance of buildings would contribute to the efforts of Ukraine to accelerate accession to the EU and would create a common understanding and benchmarking of the existing and new building stock. This would enable close monitoring of the progress at national level and better integration with existing policies or development of financing schemes or national funds. Therefore, putting emphasis on the enhancement of the energy performance certificates system, which serves as the foundation for adopting and implementing EU acquis, would be preferable over investing in international voluntary certifications.

Nevertheless, a better penetration, of international voluntary certification systems, used to identify buildings with high levels of performance (such as LEED and BREEAM) would still be beneficial, however these certifications are quite costly and their activities might be limited to the commercial sector which is also covered by EPCs.

3.2.3.7 Future developments — the new EPBD recast

While Ukraine still needs to take some further steps to fully align with EPBD 2010/31 and 2018/844, new developments in the European policy on the energy efficiency in the building sector need to be taken under consideration. In December 2021, the European Commission published a proposal for a recast Energy Performance of Buildings Directive. The Council adopted its negotiating position in October 2022 and the Parliament in March 2023. The co-legislators reached a provisional agreement in December 2023. Final adoption by the co-legislators and publication is expected in early 2024.

The new EPBD recast, as part of the 'Fit for 55 Package', sets higher performance standards for new buildings and stricter targets to reduce energy consumption in existing buildings. It includes focus on lifecycle greenhouse gas (GHG) emissions, Indoor Environmental Quality (IEQ) and the phase out of fossil fuels.

A forward-looking Regulatory Impact Assessment of the new EPBD recast would not be feasible before the new recast is launched and it is out of the scope of this project. However, Ukraine is advised to consider legislative and regulatory amendments, where appropriate, in view of the new requirements of the recast. Key points of the new EPBD recast (according to the Commission proposal) are summarised in the following text.

Zero-emission buildings

Current standard for new buildings is the nearly zero-energy building (nZEB). The proposal introduces a zero-emission (ZEB) standard for new buildings.

Energy Performance Certificates (EPC)

The recast EPBD sets out to harmonise requirements for the energy performance classes on a harmonised scale from A to G across the EU. Class A will correspond with zero-emission buildings (ZEB) while G is to correspond to the 15% worst performing buildings in the national building stock at the time of the introduction of the scale. Member States are to ensure that the remaining classes (B to F) have an even bandwidth distribution of energy performance indicators among the relevant classes. The EPC shall comply with a template set out in Annex V to the EPBD by end of 2025 and the validity of EPCs in lower classes (D-G) shall be reduced from 10 to 5 years. Furthermore, EPBD requires digital form (Art. 16 to 18; Art. 2 no. 29).

Minimum energy performance standards (MEPs)

The current provisions on major renovation, which offer an opportunity to apply minimum energy performance requirements in place (to ensure minimum renovation depth) are complemented with new EU-level minimum energy performance standards (aiming to trigger an increase in renovation rates) for the worst-performing public (i.e. buildings and building units owned by public bodies) and non-residential buildings. Member States shall ensure that non-residential and public buildings achieve at least Class F by 2027 (European Parliament (EP) proposal: Class E by 2027), and Class E by 2030 (EP: Class D by 2030). Residential buildings shall achieve at least Class F by 2030 (EP: Class E by 2030), Class E by 2033 (EP: Class D by 2033). The focus on the very lowest performing classes of the building stock intends to ensure that efforts focus on buildings with the highest potential for decarbonisation, energy poverty alleviation and extended social and economic benefits.

Deep renovation, staged deep renovation

The recast EPBD introduces a definition of and aims to incentivise deep renovation –as a first step, before 1 January 2030, being a renovation that transforms buildings into ZEBs. Staged deep renovation means a deep renovation carried out in several steps, following the steps set out in a renovation passport as per the requirements of the EPBD.

Renovation passport

The recast EPBD introduces voluntary renovation passports to equip building owners planning a staged renovation of their building. A renovation passport is a document that provides a tailored roadmap for the renovation of a specific building in several steps that will significantly improve its energy performance. The EPBD requires that the renovation passport is issued by a qualified and certified expert, following an on-site visit; that it comprises a renovation roadmap indicating a sequence of renovation steps that build upon each other, with the objective to transform the building into a ZEB by 2050 at the latest; that it indicates the expected benefits in terms of energy savings, savings on energy bills and operational greenhouse gas emission reductions as well as wider benefits related to health and comfort and the improved adaptive capacity of the building to climate change; and that it contains information about potential financial and technical support.

Mobility

The threshold for installation of recharging points is lowered, e.g. for non-residential buildings new or undergoing major renovation if there are five parking spaces the recast EPBD includes the obligation to install at least one recharging point (in the current version: ten parking spaces); as well as introduces the requirement to install pre-cabling (for electric vehicles) for every parking space; and introduces obligations to install bicycle parking spaces (one for every car parking space).

Smart metering, Building Management Systems

There is increased focus on new buildings and renovation projects installing suitable smart meters and building management systems to harvest data on energy performance.

Ban on fossil fuel heating

The proposed recast EPBD includes a legal basis for national bans of boilers based on fossil fuels, allowing Member States to set requirements for heat generators based on greenhouse gas emissions or the type of fuel used. Also, with the intention to avoid that investments in new generations of fossil fuel-based boilers become stranded assets, the recast EPBD includes a requirement (Art. 2 no. 2; Annex III) that a zero zero-emission building (ZEB) does not cause any on-site carbon emissions from fossil fuels.

Databases for energy performance of buildings

Member States shall set up national databases to gather data on the energy performance of the buildings and on the overall energy performance of the national building stock (related to EPCs, inspections, the building renovation passport, the smart readiness indicator and the calculated or metered energy consumption of the buildings covered). Access shall be ensured subject to data protection laws, e.g. access of EPCs shall be granted to owners, tenants, managers, financial institutions for their investment portfolio, prospective tenants or buyers; anonymised aggregated data for the public; and once per year data shall be rendered to the (EU) Building Stock Observatory. The databases shall be interoperable with other administrative databases containing information on buildings, such as the national building cadastre and digital building logbooks (Art. 19 new).

Solar panels

According to the Council draft, Member States shall ensure that new buildings are designed to optimise their solar energy generation potential based on solar irradiance of the site to enable later cost-effective installation of solar technologies. Member States shall ensure deployment of suitable solar energy installations for all non-residential buildings with over 250 m² of floor area by end of 2026, further non-residential buildings undergoing a major or deep renovation by end of 2027, for all new residential buildings by end of 2029. The European Parliament has provided an even tighter timeline for Member States to ensure the deployment of suitable solar energy installations, within 24 months after the date of entry into force of the EPBD, on all new public and new non-residential buildings; by end of 2026, on all existing public and non-residential buildings; by end of 2028, on all new residential buildings and roofed carparks; and by end of 2032, on all buildings undergoing major renovation) [EP draft, 9a new].

3.2.3.8 Summary

Over the last several years, Ukraine has taken many steps to significantly reduce energy consumption, promote energy efficiency and renewable energy, despite the ongoing military aggression of the Russian Federation, the economic crisis of 2014-2015, the COVID-19 pandemic and the invasion in 2022. In the sector of Energy Efficiency of buildings, Ukraine has shown considerable progress towards the establishment of the legal framework for energy efficient building renovation and improvement of the building stock.

The Law on Energy Efficiency of Buildings, transposing the Directive 2010/31/EU (recast) on the Energy Performance of Buildings as amended by the Directive 2018/844, into the national legislative framework, was put in force in June 2017, followed by a series of amendments in 2019, 2021 and 2022. Since 2017, the majority of by-laws to implement the Law were developed and adopted. With the adoption of the law on energy efficiency of buildings in June 2017 and later amendments, Ukraine has increased the alignment of its framework legislation with the EU acquis in this policy area.

In the frame of this project the following tasks were performed:

1ST

in a first stage, a review of the current status of the transposition of the directive in the Ukraine Law, with the aim to highlight main issues that would require further actions to be considered for a full implementation,

2ND

in a second stage, an estimate of the impact of the Law on Energy Efficiency of Buildings in place as well as of the identified amendments/improvements needed, for a full harmonisation with the EPBD.

Note: It is noted that an in-depth analysis of the legislative framework in force and a gap analysis was not feasible within the timeframe of this project.

Legislative compliance issues

Regarding compliance of the Law with the EPBD, only a few remaining issues require further attention:

- The introduction or clarification of energy certification requirements for building units/apartments when these are sold or rented out.

Currently the Law foresees that a copy of an energy certificate is provided, if the building has a valid certificate. There is no obligation set to issue one, if missing.

- The alignment with the EPBD requirement for independent control systems and quality assurance of certificates with the guidelines provided in Annex II.

Currently there is no obligation set on implementing the provisions as in Annex II. Furthermore, there is no information available on the methodology/procedure of quality control established and performed by the assigned institutions.

- The introduction of provision for building automation and controls in non-residential buildings.
- The introduction of provision for Electromobility infrastructure installations.

Regulatory impact assessment

The main outcomes of the work performed on estimating the impact of the Law in place as well as of the identified amendments/improvements for a full harmonisation with the EPBD are summarised below.

1. Direct benefits

By extending the application field and introducing the obligations missing, in full alignment with the EU acquis:

a) Ukraine will meet the requirements of the EPBD and contribute to the country's efforts to accelerate accession to the EU,

b) obligations set out on energy efficiency calculation and implementation of minimum energy performance requirements will promote the issue of energy efficiency in buildings, this contributing to the country's efforts to achieve the national targets for green recovery and the development of a low-carbon energy-efficient economy,

c) energy savings of 40% in energy consumption in households could be achieved, with improving in parallel the quality of living conditions and reducing energy bills. Considering the potential energy savings in public buildings, the total reduction in energy consumption of the whole building stock in the country could reach approximately 55%, with the respective benefits in national economy.

2. Sectors and groups affected

The following groups and sectors are affected:

- professionals of the building sector (developers, contractors, engineers, building designers, energy auditors, inspectors of engineering systems),
- urban planning institutions responsible for approvals of building permits and compliance control,
- certification commissions responsible for the professional certification/attestation of energy auditors and inspectors,
- training institutions,
- owners of buildings undergoing major renovation, when fall under CC3 and CC2 category of consequence, defined in accordance with the Law of Ukraine 'on Regulation of Urban Planning Activities',
- owners of public buildings (the State) with a heated area exceeding 250 m², which are often visited by the public,
- owners of municipal buildings (Municipal authorities) with a heated area exceeding 250 m² (if thermal modernization is carried out),
- owners of buildings in which thermal modernization is carried out, for which public support is provided,
- public sector institutions responsible for setting out implementation and quality assurance mechanisms and tools,
- local authorities,
- building materials and equipment manufacturers/suppliers,
- software developers/providers,
- the public at large.

3. Costs*

a) The costs associated with the energy performance upgrade of the residential buildings (in the case of whole building block) are estimated at €60 billion.

b) The costs associated with the energy performance upgrade of public buildings is estimated at €2.6 billion.

c) The cost of energy certification and energy certificate issuance, borne by residential building owners of apartment type buildings (estimated on the basis of the regulated daily fees for construction engineers in Ukraine and the number of residential apartment buildings throughout the country) would be at the level of €1.3 billion, while including the corresponding cost for public buildings on State authorities and Municipalities, the total cost is estimated at approx. €1.5 billion.

d) The administrative cost for the qualification and attestation of auditors and inspectors required to meet the market needs (based on EU data available) is estimated at €450 000.

e) The additional administrative cost on the institutions for control and quality assurance of energy certificates, associated with the enhancement of the established mechanism, is estimated at €405 000 and is anticipated to be included and borne ultimately by building owners through certificate fees.

f) The administrative cost of introducing a legislative/regulatory amendment on installation of building automation and controls in non-residential buildings, would potentially occur as part of the internal administrative costs, which would minimise the financial impact.

g) The cost on building owners shall be defined according to market prices; an indicative cost, based on EU market research, is estimated at €20 000 for a medium sized office or hotel.

h) The administrative cost of introducing a legislative/regulatory amendment on installation of Electromobility infrastructure will potentially occur as part of the internal administrative costs, which would minimise the financial impact.

i) The cost on building owners shall be defined according to market prices; an indicative cost, based on data from other countries, is estimated at approximately €10 000 for a building with 100 parking spaces.

(*) These cost estimates should be considered only for indicative purposes.

Ukraine has put a lot of effort into aligning its framework legislation on energy efficiency in buildings with the EU acquis in this policy area and is already in a good stage, with a minimum of further effort required toward full alignment. Considering the poor condition of the building stock, combined with the need to rebuild the country after the war, a full implementation would be a powerful mechanism supporting the country to secure the thermal modernization of buildings, in line with the key principles of "Build Back Better" and "Build Back Greener" of Ukraine's post-war reconstruction.

Moreover, ensuring full harmonisation and successful implementation would contribute to the county's efforts towards achieving its energy and climate targets, developing a low-carbon energy-efficient economy and accelerating the process of accession to the EU.

3.2.3.9 Transposition of the EPBD 2010/31 EU and EPBD 2018/44 EU

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
Methodology and minimum energy performance requirements	
• A methodology for calculating the energy performance of buildings in accordance with the common general framework set out in Annex I. • Setting of minimum energy performance requirements for buildings and building units, with a view to achieving cost-optimal levels. • Cost-optimal levels shall be calculated in accordance with the comparative methodology framework referred to in Article 5. • Setting of minimum energy performance requirements for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels.	Article 5 and 6: • A methodology for calculating the energy performance of buildings in accordance with the common general framework set out in Annex I. • Setting of minimum energy performance requirements for buildings and building units, with a view to achieving cost-optimal levels. • Cost-optimal levels shall be calculated in accordance with the comparative methodology framework referred to in Article 5. • Setting of minimum energy performance requirements for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels.
Building automation and controls	
• Lay down requirements to ensure that, where technically and economically feasible, non- residential buildings with an effective rated output for systems for air-conditioning or systems for combined air- conditioning and ventilation of over 290 kW are equipped with building automation and control systems by 2025. • Installation of controls of technical building systems in existing buildings and temperature self-regulating devices for the separate regulation of the temperature in each room in new buildings.	Article 16: • the introduction of automated systems for monitoring and control of engineering systems of buildings is one of the priority areas for the provision of state support. **No specific obligation is set out on the installation of automation and controls**
Nearly zero-energy buildings	
• By 30 June 2021, all new buildings are nearly zero-energy buildings; and after 30 June 2019, new buildings occupied and owned by public authorities are nearly zero-energy buildings.	The concept of nearly zero-energy building is included in the definitions of the Law. **A new order on approval of requirements for nearly-zero energy buildings is under preparation.** **No information on progress is available.**

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
Energy performance certificate	
• An energy performance certificate is issued for: a) buildings or building units which are constructed, sold or rented out to a new tenant; and b) buildings where a total useful floor area over 250 m² is occupied by a public authority and frequently visited by the public.	Article 7: An energy performance certificate shall be issued, in the case of: • constructions (new construction, reconstruction, capital repairs) which due to the class of consequences (as defined under the Law of Ukraine "On Regulation of City Planning Activity") fall under the categories CC3 and CC2. • publicly owned buildings with a heated area of more than 250 m² that are frequently visited by the public. • buildings that receive public support for thermal renovation, and shall achieve an energy class not lower than the energy efficiency defined by the minimum energy performance requirements. **There is no reference on the energy certification of building units.**
Energy performance certificates in real estate market transactions	
• When buildings or building units are constructed, sold or rented out, the energy performance certificate or a copy thereof is shown to the prospective new tenant or buyer and handed over to the buyer or new tenant.	Article 8 • In case sale or lease (rental) of a residential or non-residential premises of a building, the seller or lessor (lessor) shall provide the potential buyer or lessee (lessor) with a copy of the energy certificate (if the building has a valid energy certificate). **No strict obligation for an energy performance certificate in real estate transactions is set out.**
Energy performance certificates in commercial advertisements	
• When buildings / building units having an energy performance certificate are offered for sale or for rent, the energy performance indicator of the energy performance certificate of the building or the building unit, as applicable, is stated in the advertisements in commercial media.	In Article 25.1 of the Law of Ukraine "On Advertising" (The Official Bulletin of the Verkhovna Rada, 2004, No. 8, Article 62; 2009, No. 19, Article 257) a supplement is foreseen: • Part 2: "Advertising of buildings with an energy certificate for sale or lease (rent) must contain an energy efficiency indicator specified in the relevant certificate".

Directive 2010/31/EU	Law on Energy Efficiency of Buildings

Display of energy performance certificates

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
• Display of EPC of public buildings frequently visited by the public in a prominent place visible by the public.	Article 7: • An extract from the energy certificate of a building, containing information about the class and other indicators of energy efficiency of the building, shall be posted in a place accessible to citizens in a building which is frequented by citizens.

Regular inspection of technical systems

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
• Regular inspection of heating systems with boilers over 20 kW and assessment reports. • Boilers over 100 kW shall be inspected at least every 2 years and gas boilers every 4 years. • Regular inspection of AC systems of over 12 kW and inspection reports.	Art. 13: • Engineering systems are inspected on a regular basis. • the reports on the results of the inspection of engineering systems shall be prepared using the Unified State Electronic System in the field of construction. Access to the reports is open and free of charge. In the by-law no 173 of 2018, "On the approval of the Methodology for Inspection of Building Engineering Systems" the regularity of the inspection of systems is defined.

Independent experts

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
• Certification of buildings and the inspection of heating systems and air-conditioning systems are carried out in an independent manner by qualified and/or accredited experts, whether operating in a self-employed capacity or employed by public bodies or private enterprises. • Make available to the public information on training/ accreditations of experts. • Regularly updated lists of qualified and/or accredited experts or regularly updated lists of accredited companies which offer the services of such experts are made available to the public.	Articles 7, 8, 9 and 13: • Energy efficiency certification shall be carried out by an independent energy auditor. • Inspection of engineering systems is carried out by specialists in inspections of engineering systems. • Certification of auditors and inspectors of technical systems is provided by certification commissions established by higher education institutions or self-regulatory organisations in the field of energy efficiency and published on the relevant websites. Qualifications of experts and mandatory exams are defined. • Access to information on energy auditor inspectors of engineering systems is open and free of charge through the portal of the Unified State Electronic System. • The list of higher education institutions and self-regulatory organisations that train persons intending to carry out activities in energy efficiency certification, energy audit of buildings and inspection of technical installations, and information about them shall be placed in the Unified State Electronic System.

Directive 2010/31/EU	Law on Energy Efficiency of Buildings

Independent control systems – Quality assurance

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
• Independent control systems for energy performance certificates and reports on the inspection of heating and air-conditioning systems are established in accordance with Annex II, in order to ensure the quality of energy performance certificates. • The competent authorities or bodies to which the competent authorities have delegated the responsibility for implementing the independent control system shall make a random selection of at least a statistically significant percentage of energy performance certificates and inspection reports issued annually and subject those reports to verification.	Article 14: Independent monitoring of energy certificates and reports on the results of the inspection of technical systems is carried out by: • the central executive authority in charge of developing the state policy in the area of energy. • Expert institutions or other energy auditors. **There is no reference on the requirements of Annex II of the EPBD foreseeing the process of control and the verification of a statistically significant percentage of energy certificates and reports issued annually.** **Furthermore, there is no information available on the methodology/process of quality control performed.**

Information

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
• Take the necessary measures to inform the owners or tenants of buildings or building units of the different methods and practices that serve to enhance energy performance. • Ensure that guidance and training are made available for those responsible for implementing this Directive.	Articles 4 and 10: The central executive authority in charge of shaping the state policy in the field of construction and housing policy and the central executive authority implementing the state policy in the areas of efficient use of fuel and energy resources, are responsible for: • In case sale or lease (rental) of a residential or non-residential premises of a building, the seller or lessor (lessor) shall provide the potential buyer or lessee (lessor) with a copy of the energy certificate (if the building has a valid energy certificate). The central executive authority in charge of shaping the state policy in the field of construction and housing policy and the central executive authority implementing the state policy in the areas of efficient use of fuel and energy resources, are responsible for: • promotion of information technology in the field of energy efficiency. • promotion of public awareness of Ukrainian legislation on energy efficiency, domestic and international experience in this field.

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
Penalties	
Lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive.	Article 9 and 17: In case of repeated violations access of the auditor to the electronic Unified State Electronic System (USES) is restricted automatically. The access of the building energy auditor to the USES shall be restored automatically after the expiry of the period of access restriction. An energy auditor or a specialist in the inspection of systems is civilly liable for improper performance of his duties under the contract and the law. **There is no reference on the energy certification of building units.** In the Code of Ukraine on Administrative Offences, by amendment of Art. 96, monetary fines are imposed in case of failure to display properly an EPC, as well as in case of failure to notify the energy and water supplier of the estimated energy and water consumption reduction that will occur after implementation of thermal modernisation works.
National plans for increasing the number of nearly zero-energy buildings	
Draw up national plans for increasing the number of nearly zero-energy buildings.	Article 15: To progressively improve the energy efficiency of buildings, the Cabinet of Ministers of Ukraine approves a national plan to increase the number of nearly zero-energy buildings, which is made available for information to the Energy Community Secretariat. **The National Plan for Increasing the Number of Buildings with a Near-Zero Level of Energy Consumption was approved by the order of CMU of January 29th, 2020.**
Long Term Renovation Strategy	
The establishment of a Long Term Renovation Strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonised building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings.	Article 15: To progressively improve the energy efficiency of buildings, the Cabinet of Ministers of Ukraine approves a national plan to increase the number of nearly zero-energy buildings, which is made available for information to the Energy Community Secretariat. **The long-term building renovation strategy was drafted and published in September 2022. Revisions will be necessary to factor in the building stock damaged by the Russian war against Ukraine and the increased climate ambitions.**

Directive 2010/31/EU	Law on Energy Efficiency of Buildings
Electromobility	
Installation of at least one recharging point in new non-residential buildings and non-residential buildings undergoing major renovation, with more than ten parking spaces, and ducting infrastructure, namely conduits for electric cables, in new residential buildings to enable the installation at a later stage of recharging points for electric vehicles.	**There is no provision.**
Smart Readiness Indicator	
Precise obligations are expected to be defined in the new EPBD recast	
Databases for energy performance certificates	
When buildings or building units are constructed, sold or rented out, the energy performance certificate or a copy thereof is shown to the prospective new tenant or buyer and handed over to the buyer or new tenant.	Article 8 In case sale or lease (rental) of a residential or non-residential premises of a building, the seller or lessor (lessor) shall provide the potential buyer or lessee (lessor) with a copy of the energy certificate (if the building has a valid energy certificate). **No strict obligation for an energy performance certificate in real estate transactions is set out.**
Building Stock Inventory	
The establishment and operation of a national Building Stock Inventory is not part of the national transposition of the EPBD in the Law of Energy Efficiency of Buildings. It is an obligation under the Energy Efficiency Directive that requires the establishment of a publicly available inventory of heated and/or cooled central government buildings with a total useful floor area over 250 m². Therefore, its implementation impact assessment is not considered under the assessment of the EPBD implementation. However, a mention on the status is made also here as it is considered an indispensable tool for the development of national policies and plans for increasing the number of nearly zero-energy buildings set out in the EPBD. The Ministry of Communities and Territories Development (MinRegion) has developed a form of data collection to create a Ukrainian national database of non-residential buildings. The aim is to provide information about energy efficiency on the municipal and national level for public buildings. Data collection for this project is ongoing. **No further information is available on progress and status of the database.**	

3.2.3.10 List of by-laws

Laws of Ukraine (rada.gov.ua) https://zakon.rada.gov.ua/laws/main/l468359p2?lang=en

1. 2023 – 1068 List of capital repairs that are not subject to the minimum energy efficiency requirements for buildings.
2. 2023 – 884 On Approval of the Procedure for Conducting Professional Training of Persons Intending to Carry Out Activities in Energy Efficiency Certification, Energy Audit of Buildings and Inspection of Technical Installations.
3. 2023 – 698 On Approval of the Procedure for Exchange of Information between Central Executive Authorities, Qualification Centres, Higher Education Institutions and Self-Regulatory Organisations in the Field of Energy Efficiency of Buildings.
4. 2023 – 692 On Approval of the Procedure for Acquiring the Status of a Self-Regulatory Organisation in the Field of Energy Efficiency of Buildings and the Model Charter of a Self-Regulatory Organisation in the Field of Energy Efficiency of Buildings.
5. 2021 – 600 On Approval of the Procedure for Professional Attestation of Persons Intending to Carry Out Energy Efficiency Certification and Inspection of Engineering Systems.
6. 2018 – 276 On Approval of the Procedure for Independent Monitoring of Energy Certificates.
7. 2018 – 274 On Approval of the Procedure for Independent Monitoring of Reports on the Results of Inspection of Engineering Systems.
8. 2018 – 275 On Approval of the Procedure for Reviewing Reports on Inspection of Engineering Systems.
9. 2018 — 605 On Approval of the Procedure for Professional Attestation of Persons Intending to Carry Out Energy Efficiency Certification and Inspection of Engineering Systems.
10. 2018 – 602 On Approval of the Procedure for Exchange of Information between Central Executive Authorities and Attestation Commissions in the Process of Independent Monitoring.
11. 2018 – 172 On Approval of the Procedure for Energy Efficiency Certification and the Form of Energy Certificate.
12. 2018 – 169 On approval of the Methodology for determining the energy efficiency of buildings.
13. 2018 – 170 On Approval of the Methodology for Determining the Economically Feasible Level of Energy Efficiency of Buildings.
14. 2018 – 173 On Approval of the Methodology for Inspection of Building Engineering Systems.
15. 2018 – 171 On Approval of the Procedure for the Application of Calculation Elements of Software for Determining the Energy Efficiency of Buildings.
16. 2018 – 265 On approving the list of industrial and agricultural buildings, energy, transport, communications and defence facilities, and warehouses that are not subject to minimum requirements for energy efficiency of buildings and are not subject to energy efficiency certification.
17. 2017 – 267 On approval of the Identification of buildings frequented by citizens.

3.2.3.11 Funding programmes for improving energy efficiency of buildings

‘Warm’ Loans

Government incentives of a total max. amount of UAH 10 million to improve energy efficiency in households through bank loans, addressing natural persons and associations of co-owners of apartment buildings (ACABs) requiring a majority decision of owners (at least by 75% of the votes according to the apartment area). The programme was launched in November 2014. After the completion of an energy efficiency project funded by a loan the household gets a reimbursement from the state budget. The amount of the reimbursement covers a part of the loan principal. Only loans used for specified energy efficiency measures are reimbursed. Eligible measures/technologies include insulation, windows replacement, boiler replacement, radiators replacement, lighting upgrade, temperature regulators, water meters and individual heating units.

About 190 000 households received about UAH 2.7 billion worth of loans for improving energy efficiency up to 2019. The average cost of a project is about UAH 18 000 for private persons and about UAH 120 000 for ACABs.

EBRD IQ Energy programme

IQ Energy is a programme implemented by international organisations in Ukraine under the management of the EBRD, with a total budget of €90 million to install energy efficient equipment through bank loans in households in apartment buildings or detached houses. The programme started in 2016.

NEFCO energy efficiency programme

IQ Energy is a programme implemented by international organisations in Ukraine under the management of the EBRD, with a total budget of €90 million to install energy efficient equipment through bank loans in households in apartment buildings or detached houses. The programme started in 2016.

Preferential loans from the State Fund for Supporting Youth Housing Construction

The programme provides direct loans from the State Fund for supporting Youth Housing Construction and addresses legal entities (ESCOs) and ACABs. The aim is to fund minor and basic repairs of residential buildings, including energy refurbishment. The programme started in 2012.

3.2.4 Possible funding models for green reconstruction

3.2.4.1 Introduction

In order to assess the cost-effectiveness of different energy performance measures in buildings, the cost-optimal methodology has been introduced by the Energy Performance of Buildings Directive (EPBD) recast. It involves comparing the costs and benefits of different sets of energy performance requirements to identify the most economically viable option.

The implementation of the cost-optimal methodology marked a novel approach in setting minimum energy performance requirements for new and existing buildings. Member States must develop cost-optimal calculations every 5 years to verify and accordingly update the national requirements in force. The steps involved in a cost-optimal calculation are mainly:

1. **Baseline assessment:** establish a baseline scenario representing the current state of the building stock in terms of energy performance.
2. **Identification of measures:** identify a range of possible energy performance measures that could be applied to buildings. These measures could include improvements to insulation, heating, cooling, lighting, etc.
3. **Life-cycle cost analysis:** perform a life-cycle cost analysis for each identified measure. This involves considering not only the initial investment but also the operational and maintenance costs over the lifetime of the measures.
4. **Energy performance calculation:** estimate the energy savings associated with each measure and translate them into monetary terms using appropriate energy prices.
5. **Cost-optimal calculation:** compare the total costs (investment, operation and maintenance) with the energy savings and other benefits achieved by each measure. The goal is to identify the combination of measures that provides the most cost-effective solution.
6. **Sensitivity analysis:** conduct sensitivity analyses to assess the robustness of the results to variations in key parameters and assumptions.
7. **Policy recommendations:** based on the cost-optimal analysis, provide recommendations for energy performance requirements and standards that strike a balance between costs and benefits.

The concept of “cost” is intended as the investment the State is available to make in terms of tax-deductions allowed to private owners to implement the energy rehabilitation of their home, both individual and within apartment-blocks. Different percentages of deduction on the total cost of the interventions have been foreseen in Italy

(from 36% to 110%) for about fifteen years, according to the type of energy saving measure adopted and the amount of energy saved (increasing of building energy-class).

The following considerations focus on the recent measure adopted by the Italian Government in August 2020, the so called “Superbonus 110%”, now concluded after many debates and radically different political positions. It represents an interesting national case study, because this measure has been approved and very appreciated by the European Commission for its effectiveness to pursue EU objectives for the decarbonisation and, at the same time, as a great opportunity to re-launch the national economy after the dark pandemic period.

The methodology applied for the implementation of the measure has certainly known challenges and contradictions that interrupted its anticipated the conclusion of its implementation, so that a strong debate is still present in the Italian Parliament, but the positive impacts partially achieved deserve attention and the measure, revised with proper amendments calibrated on the specific national context, could be also replicated in Ukraine. Further measures are constantly studied in Italy to comply with the international engagements and the lesson learned from “Superbonus 110%” can provide useful hints.

3.2.4.2 Considerations on cost-benefit

On the basis of the surveys conducted in Italy (by ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development) on cost-benefit related to the implementation of energy rehabilitation of buildings, three types of effect must be taken into consideration:

- direct: the additional expenditure in a sector generates production in the sector itself and in all sectors that must be activated to produce semi-finished products, intermediate products and services necessary for the production process;
- indirect: each sector is directly activated and indirectly activates others (a chain of actions and reactions induced by the production of the initial product). For instance, the insulation of houses impacts on the solutions/technologies of heating plants adopted as a consequence, to optimise the energy saving achievable;
- induced activities: direct and indirect production remunerates the labour factor with incomes that feed an expenditure on final consumption of domestically produced consumer goods, which in turn requires greater production.

Among the overall effects of energy-saving investments on buildings, the impact needs to be assessed in terms of:

- economic and financial considerations,
- occupational aspects,
- total reduction of CO_2 emissions into the atmosphere,
- reduction of consumption and bill expenses,
- improvement of the safety of buildings (provided that the energy rehabilitation involves also plant, pipes, etc. and is done in full compliance with regulatory and design provisions).

The economic and financial impact

To assess the economic and financial impact, it is possible to refer to the study of the Italian Foundation of Accountants, which reconstructed the methodology applied by the State General Accounting Office in the estimates of the public finance effects of the financial facilities provided to private sector for building energy rehabilitation.

An alternative estimate of the gross cost for the State and the tax effect induced by the various incentive measures that the State can adopt to encourage energy savings is presented. According to these analyses, the cost to the State budget is the difference between:

- the “gross” cost represented by the lower revenue that flows into the State budget due to deductions from gross income taxes (direct deduction) or the lower revenue that flows into the State budget due to the use of tax credits to offset the tax and social security debts of the supplier or transferee (indirect deduction).
- the induced effect calculated through the higher revenues that flow into the State budget due to the tax and contribution levy on the higher tax bases that are declared compared to the (lower) ones that would have been declared in the absence of a concession which, by incentivizing expenditure for interventions on existing real estate assets, produces incremental effects on the volumes of turnover and income of the chain of companies in the construction sector and suppliers (building materials, fixtures, boilers, etc.).

In other words, instead of giving subsidies to people who want to make energy rehabilitation works, the State renounces a part of the tax revenue coming from the incomes of those citizens, aware that other tax amounts will come from the companies involved in the process, who will increase their turnover (producers and traders of building materials too). Moreover, the State is aware that the obligation to declare officially any trade (materials and man-power) to obtain the tax deduction (asking for evidence of payments and invoices, certified by accountants and accredited auditing institutes), will fully prevent tax evasion, very diffused everywhere in construction world. This last aspect, even if it sounds like a paradox, represents probably one of the main positive factors, due to consolidated illegal practices, really difficult to quantify and to correct in any other manner.

Focussing on “Superbonus 110%”, it is possible summarise that for every euro spent by the State in the form of tax relief for building incentives, 43.3 cents would return to the State coffers for a net cost of 56.7 cents (if the measure is implemented for 5 years at least, not the case in Italy, as explained below). Moreover, the following effects have to considered:

Employment effect

According to the CENSIS report (Centre for Social Investment Studies – socio-economic research institute accredited by the Italian Government), in 2021, after one year of implementation of the policy of “Superbonus subsidies” to energy rehabilitation of buildings, the added value of buildings increased by 21.3% compared to the previous year.

As mentioned above, the obligation to comply with EU commitments on CO_2 emission reduction gave the Italian Government the opportunity to launch a measure to effectively face the deep-rooted custom of “black work” characterising the construction world (including also the employment of undocumented workers paid illegally, without any social security and safety on the job), thus re-activating the construction sector stuck for more than a decade after the 2008 crisis and a very negatively-affecting national economy. The construction sector, as is very well known, is the main engine of the economy. The increase in property value was a happy by-product of the fundamental objective of giving back to the market a lot of buildings recognising a proper value to higher energy class buildings and deeply depreciating the lowest class ones. Of course (following a law adopted very recently by Italian government) the taxation on the added value of rehabilitated buildings has increased a lot if the flat/building is sold in less than ten years after the energy rehabilitation work that enjoyed the Superbonus 110% measure.

Between August 2020 and October 2022, the “Superbonus” had a decisive impact on employment of 900 000 direct and indirect workers. In the January-October 2022 period alone, it was estimated that energy efficiency work in buildings activated 411 000 direct employees (in the construction, technical services and related sectors) and another 225 000 indirect workers. These numbers should be read in the light of a study that estimated an increase of 641 000 jobs in the construction sector and 351 000 jobs in related sectors. This involves people who, in the absence of regular employment, would certainly have been supported by welfare policies. Savings of more than half a billion euros per month or €6 billion per year could be estimated.

Reduction of emissions and savings on energy bills

It is worth mentioning the dossier published by ANCE (National Association of Builders), which shows that 60% of the interventions concerned the most energy-intensive buildings (Classes F and G of the Energy Performance Certificate (EPC)). Almost 90% of the interventions brought the buildings into the best classes (from C to A), an extremely important result for the level of emissions. This is an important figure considering that, according to ENEA's data, 76% of Italian properties are located in the lowest classes (E, F, G) and that 8.6% of households say they are unable to heat their homes adequately.

According to Nomisma (Nationally accredited consulting firm on real economy issues), the energy effect of the Superbonus 110% in 2022 has had a direct impact on the pockets of Italians with a total saving of €29 billion (projections that take as a reference the data updated at the time of the estimate). Those who benefited from the jump in Energy Performance Certificate (EPC) would, in fact, have benefited from a reduction in bill costs of €964 per year.

Of course, this money saving has been created thanks to a huge spending by the Government. But this spending was intended to be exceeded by additional tax revenue to the State that had to be reached (according to the planning done) in the medium-long term if time was given to the positive effects on the national economy to mature and if the process continued for many years. This did not happen in Italy due to the block of the measure (because of political change) that is creating a disaster for construction companies, unemployment and several difficulties for building owners with uncompleted construction work.

3.2.4.3 Quantification of average energy savings per housing unit and CO_2 reduction

A specific study on “Superbonus 110%” effects has been carried out by Gabetti Real estate (Italian company involved in buildings commercialisation and management) after two years of implementation of the measure on 181 apartment-blocks (from a total of 7 322 flats), selected among 671 apartment-blocks belonging to their network and which benefited from the measure. This selection was made choosing a certain number of buildings in each Italian region (several latitudes) proportional to the total number of buildings rehabilitated in each region belonging to Gabetti business network.

Statistics were derived relating to:

- average energy savings and average reduction of CO_2 emissions per housing unit,
- average percentages of thermal transmittance abatement for the various components of the building profit (walls, roofs, floors, windows),
- reduction of gas consumption.

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The reduction of the estimated average energy needs for the apartment-blocks analysed (a total of 1 290 800 square metres of surface insulated) is 53%, while the estimated average energy saving percentage is 46%. These positive values are also confirmed by the average Energy Performance Certificate (EPC) jump, which has been estimated at around 3 classes.

Another positive aspect provided by the analysis is the reduction in gas consumption. Starting from the estimate of the total gas consumption of the apartment-blocks before the intervention, **the estimated reduction of the consumption of gas cubic meters after the intervention is 40%**. The savings in terms of less gas used to heat the home and for the production of hot water also leads to a reduction in **the annual costs of gas use** which, for the 181 buildings in the sample, **is estimated at 43%**. This value (not clearly explained in Gabetti report) should be justified from not only to the reduction of gas usage but also to standing charges and cheaper supply contracts.

Table 1 — Results achieved in Italy in about two years of “Superbonus 110% implementation
(data elaborated on a selection of 181 apartment-blocks)

Average reduction of gas cubic metres per year	Average seasonal efficiency after energy rehabilitation	Gas expenses average reduction per year	Average energy need reduction	Average energy saving	Average CO_2 emissions saving	Average energy class jump of the buildings
40%	94%	43%	53%	46%	51%	3.1

The average seasonal efficiency of the ratio between heat supplied by the boiler and energy consumed also improves. An analysis of the data shows that, from 80% before work started, energy renovation interventions allow an increase in efficiency of up to 94%. Reductions that have a significant impact both in terms of economic savings on bills and apartment-blocks costs, and in terms of increasing the market value of the property. Finally, a third figure that has been obtained is the **saving of CO_2 emissions**, which for the 181 apartment-blocks analysed **is estimated at around 51%.**

3.2.4.4 Projection for the Ukrainian context

Premise

The case study presented here allows an approximate, but concrete, projection to be made of what the full implementation of the EPBD and EED means for Ukraine. The approximation depends on the quality of available data on the share of different buildings types and their condition in terms of envelope insulation and thermal plants efficiency.

Superbonus 110% has been a pilot measure implemented for the first time in Italy that combined the willingness to comply with EU engagements with the need to give a new impulse to the national economy. Of course, it cannot be considered a “perfect solution” for all countries, above all in light of the evolution that the measure saw in Italy and the discussions in the last years at political level. But this aspect cannot be considered relevant and must not affect the evaluation of the results achieved and that potentially could have been obtained through a long-term implementation.

Many corrective elements have to be introduced to tailor a similar measure in a country such as Ukraine, above all considering the reality of a war still ongoing, but for sure it is an experience gained that allows the analysis of pros and cons to be much better than a theoretical exercise based only on feasibility studies.

Moreover, this was the first time that such a comprehensive measure has been implemented in Italy, fully financially supported by the Government without any financial contribution from building owners, instead of specific measures such as boiler and fixture replacement and renewable energy adoption co-financed by the State as done in the past and still being adopted in Italy.

The complete financial support by the Government introduced by Superbonus 110% in Italy took for granted the impossibility of a financial contribution from the citizens (a big error of judgement in the Italian context, to be read as a demagogic move stimulated only by the desire to create political consensus in all social classes), but probably not so far from the conditions in which Ukraine finds and will find itself in light of the tragic consequences of the war. Thus, a case study that starts from the complete lack of financial resources by the population can be an appropriate reference for a potential transposition to Ukrainian context.

The following figure elaborated by NTU (German international consulting firm providing programme management and advisory services for development projects worldwide) in the frame of the agreement to support European Investment Bank (EIB) advisory services, shows the results of the interviews made in 2021 on the make-up of heat supply sources by type.

Figure 2 – Structure of heat supply sources by type,%

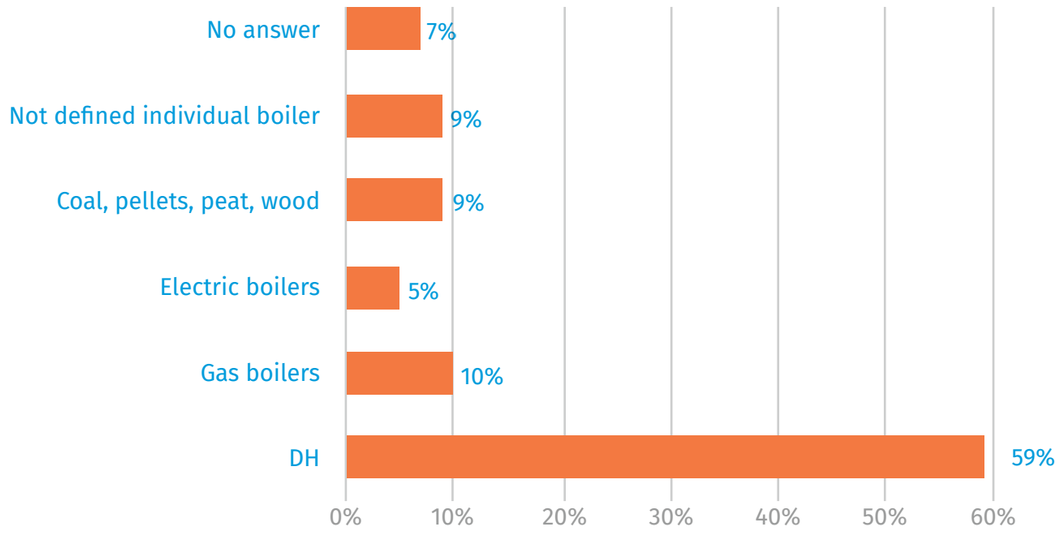

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Table 2 — Results achieved in Italy in about two years of "Superbonus 110% implementation
(data elaborated on a selection of 181 apartment-blocks)

Number of floors	Number of flats per floor	Occupants per apartment	Average (m^2) heated area per flat	Total (m^2) average heated area per building	Average (m^2) surface per building (external walls and roof)	Total occupants
5	8	3	80	3 200	3 500	120

Justifications of the choice

- Due to the recent uncertainties in gas supply and its cost created by the war, many owners of flats in large big apartment-blocks decided to make their apartment independent from district heating plant connection, recently equipping the flat with individual heating systems burning pellets or wood. This was independent of considerations of energy efficiency but simply in order to feel safer in case of gas supply shutdown, a big increase of its cost or (has already happened) destruction by bombing of district heating power plants that power hundreds of apartment-blocks.
- As shown in the above table, the percentage of individual heating systems is much less than district heating and probably referred mainly to isolated houses. It seems that it cannot be a representative sample useful for a wide projection on Ukrainian building stock. Boilers replacement (adoption of condensing boilers) which allows about 15-20% of energy saving, much less than envelop insulation (about 50%) also has to be considered.
- Technical aspect – the energy saving of a condensing boiler is reached only if the flats are provided with distribution plants with large radiant surfaces (e.g. underfloor heating), working with low temperature water (maximum 40° Celsius). This is not the case of distribution plants of Ukrainian flats, designed (in light of the climatic conditions of Ukraine) to work with high temperatures (60°-70°Celsius), temperatures that do not allow the condensation of the fumes and the recovery of heat, thus completely nullifying the investment in a condensing boiler.
- The above-mentioned recent trend regarding the adoption of individual heating system solutions by users detaching their flat from central district heating, makes it difficult to forecast the future beneficiaries of energy efficiency interventions in district heating sub-stations. A projection for Ukraine should be realistic and based on reliable data instead.
- The fewer district heating users there are in the apartments-blocks, the lower the cost-benefit of energy efficiency interventions in the plants will be.

Moreover, it is worth considering the following aspects:

- A large insulation campaign driven by the Government can also take advantage of the various contributions of International Financial Institutions, as e.g. European Investment Bank (EIB), which allowed a €300 million loan to improve the energy efficiency of Ukraine[37]. These contributions can significantly lighten the effort of the State in supporting 100% the energy requalification of real estate assets, and a measure such as the 110% Superbonus implemented in Italy could then become less burdensome for Ukraine (e.g. 60-70% in terms of State contributions).
- The replacement of gas and electric boilers and/or biomass heaters in single houses and apartments already provided with individual heating plants can effectively complement the reaching of EPBD goals, but would require a strong coordination effort for the implementation of an energy auditing system and adequate competences to manage energy diagnosis and implementation of the works, more complex and time consuming than the planning by the Government of a large insulation campaign of the envelopes of big apartments-blocks.

In light of the considerations above, it may be assumed that:

- the insulation of the building envelopes of apartments-blocks is a priority to get a strong impact in a short term of EPBD implementation,
- the contribution to national energy efficiency by the replacement of individual boilers, both gas or biomass fuelled, with more efficient ones would be not so relevant,
- only building envelope insulation can guarantee about 50% reduction of energy need, a jump of three energy classes and an average 51% in CO_2 emissions saving.

37 **The European Investment Bank (EIB) and the Ministry of Communities and Territories Development of Ukraine signed in 2021 a €300 million loan to improve the energy efficiency of some 1 000 public-owned buildings, including schools, cultural centres, kindergartens and hospitals. The loan was signed during the 22nd EU- Ukraine Summit to help the country limit the economic impact of COVID-19 by stimulating faster economic and social growth after the pandemic.**

3.2.4.5
Calculation of CO_2 emissions decrease after envelope insulation of apartment block stock in Ukraine

To obtain an indicative amount of the possible CO_2 emissions decrease per year in Ukraine through the implementation of a wide energy efficiency campaign focussed on the envelope insulation of apartments-blocks stock, based on the results reached in Italy by the implementation of Superbonus 110% initiative, the overall final figures reported by ENEA at national level (focussed on building envelope insulation), updated to December 2022, the end date of the implementation of the measure, can be referred to (Table 3).

Table 3 — Results from ENEA Superbonus 110%, overall final figures after two years

BUILDING ENVELOPE	NUMBER OF INTERVENTIONS	SURFACE, m²	%	ENERGY SAVING GWh/year	%	TOTAL COSTS € bln.	SPECIFIC COST €/m²	%	ENERGY SAVING COST €/kWh/year
Vertical surfaces insulation	222 889	54 288 422	56%	2 900	52%	15.8	290	41%	5.47
Ceilings and roofs insulation	159 727	20 061 112	21%	1 100	21%	5.2	260	14%	4.68
Horizontal surfaces wasting heat	70 356	7 110 114	7%	400	7%	1.7	250	5%	5.03
Fixtures replacement	458 705	8 142 043	8%	1 100	8%	12.5	1 500	33%	10.98
Horizontal surfaces not wasting heat	28 298	4 437 494	5%		5%	1.3	290	3%	
Solar shading – shutters	98 021	1 614 431	2%	90	2%		670	3%	12.11
Solar shading – curtains	81 849	1 322 060	1%	30	1%	0.5	430	1%	19.59
TOTAL	1 119 845	96 975 676	100%	5 600	100%	38.3		100%	

Elaborating a first projection of a potential implementation of a measure for Ukraine with similar characteristics as Superbonus 110% (fully financed by Government), in order to reduce the financial impact of the implementation of the measure, the most effective interventions in terms of cost/benefit can be identified, choosing the interventions with the lowest cost-to-energy ratio (€/kWh/year). This means foreseeing the insulation of vertical and horizontal surfaces and ceilings/roofs, excluding the replacement of fixtures and solar shading.

This priority has also been assumed in the rules established by the Italian Government for Superbonus 110% implementation in apartments-blocks and "mini" apartments-blocks (2-4 units), where the insulation of vertical and horizontal surfaces and ceilings/roofs was considered mandatory "driving interventions" as well as the replacement of centralised heating plants. The replacements of fixtures and individual heating plants (boilers or biomass plants) with other more performing devices was non-mandatory "Driven interventions".

Moreover, general conditions of fixtures/solar shading in apartment-blocks can also be assumed to be already averagely good, because their replacement is technically easy and can even be made by small installation companies directly engaged by single owners/tenants. The walls/roofs insulation requires instead permission, the involvement of specialised construction companies, scaffolding and adoption of specific safety measures, beyond the managing capacities of the single owners/tenants of the flats. In this first projection, energy efficiency interventions on centralised heating plants (district heating sub-station) are also excluded, because of the recent mentioned trend of detaching single flats from the centralised district heating plants.

An average size of apartments-blocks in Ukraine can be assumed as in the following table.

Table 4 — Ukrainian apartment block data

Average heated area per flat (m²)	Number of floors	Number of flats per floor	Occupants per apartment	Total average heated area (m²)	Total occupants
80	5	8	3	3 200	120

The estimation of the total cost of the implementation of a wide insulation campaign fully financed by the Government of all residential apartments-blocks in Ukraine, energy saving achieved, and CO_2 emissions avoided each year is presented in the following table.

Table 5 — Projection for Ukraine (calculation of GWh/year)

Millions of inhabitants (2021)	Population living in apartment-blocks (59%)	Estimation of apartment-blocks	Total heated area of apartment-blocks	Average consumption of apartment-blocks	Estimation of apartment-blocks stock consumption	Total thermal insulation	Energy saving achievable by envelope insulation
	millions	number	m²	kWh/m² year	GWh/year	m²	%
43.8	25.8	215 300	688 962 700	276	190 200	753 553 000	50% [38]
Average cost of insulation per m²	Total investment for thermal insulation of apartment-block	Energy saving	Cost of a thermic kWh considering methane gas for heating systems	Money saving	Tonnes of CO_2 emissions avoided	Cost for each saved tonne of CO_2 emissions	Simplified[39] payback of investment
(Ukrainian costs in €)	stock €M	GWh/year	(1 m³ gas = €0.5) Euro	€M/year		(€)	years
80	60 300	95 100	0.05	4 450	19 490 800	3 090	14

276 kWh/m² per year has been adopted as average consumption of apartment-blocks in Ukraine, in line with NEEAP where it is declared: **"Based on calculation results, total specific energy consumption (energy efficiency indicator) on average in Ukraine constitutes 276 kWh/m² per year of consumed energy and ranges from 145 to 327 kWh/m² per year, depending on the type of building and climate zone in which a building is located").**

The results achieved are coherent with data reported in the National Energy Efficiency Action Plan 2020 (NEEAP) in terms of CO_2 emissions saving (see table below), where a maximum possible energy saving in all the residential sector is theorized by different measures.

Table 4 — Ukrainian apartment block data

No.	Measures	Potential, ktoe		
		Multiple-apartment building	Cottage-type buildings	Total
1	Additional thermal insulation of walls	1 700 000	3 313 000	5 012 000
2	Installation of energy efficient windows	975 000	1 901 000	2 896 000
3	Additional thermal insulation of roof	928 000	1 809 000	2 736 000
4	Installation of energy efficient engineering equipment	1 439 000	2 806 000	4 245 000
5	Replacement/change of indoor lighting	149 000	291 000	440 000
Total		5 190 000	10 120 000	15 310 000

38 A reduced percentage is adopted comparing to energy need reduction of the building calculated in the Italian case study; it is an approximation due to the average colder climate of Ukraine.

39 It is a "simplified payback" because recent EU agreements established a complex calculation of payback made by life cycle analysis of each building material and construction process adopted, not available for Ukraine at the moment.

The total potential energy saving reported, converting ktoe to toe and into GWh (assuming 1 toe = 11 630 kWh) is:

15 310 000 toe x 0.01163 = **178 000 GWh** per year for the whole residential sector.

In light of the choice of giving priority to apartment-blocks and proposing the most effective measure to achieve the maximum energy saving, avoiding the replacement of fixtures or boilers, as above justified, is “thermal insulation of walls and thermal insulation of roofs” and this gives:

(5 012 000 toe + 2 736 000 toe) = 7 748 000 toe x 0.01163 = 90 000 GWh per year.

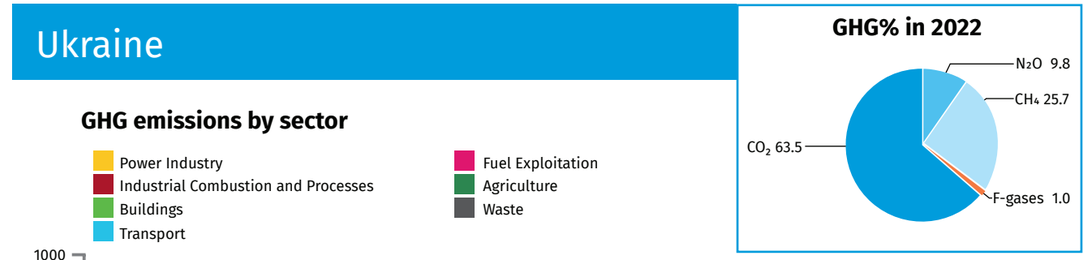
This result is not so far from the 95 100 GWh saved each year, achieved adopting envelope and roofs insulation in the estimated number of apartment-block in Ukraine, according to the assumptions presented below.

Table 7 — Data summary after wide insulation campaign of envelope insulation of residential apartment blocks

INHABITANTS (2021)	POPULATION LIVING IN APARTMENT BLOCKS (59%)	EXTIMATION OF THE NUMBER OF RESIDENTIAL APARTMENT-BLOCKS	TOTAL THERMAL INSULATION	AVERAGE COST per m^2	TOTAL COST OF THERMAL INSULATION	ENERGY SAVING	CO_2 EMISSIONS TONNES YEAR AVOIDED
			m^2	(UAH costs in €)	(€)	(GWh/year)	
43 790 000	25 836 000	215 300	753 523 000	80	60 284 230 000	95 100	19 491 000

Elaborating the data presented in the tables above, it was assumed that the average cost for the thermal insulation of building walls and roofs in Ukraine is about €80 per square metre and the current cost of a cubic metre of methane gas is about €0.5 (estimation made comparing to Italian costs). The cost of methane can, of course vary, depending on market trends, deeply conditioned by the on-going war. Both costs could be subject to a strong decrease in the near future.

Ukraine



From: CHG emissions of all world countries, 2023 JRC Science for Policy Report

Figure 3 — CO_2 emissions for Ukraine

Year	GMG emissions Mt CO_2eq/yr	GMG emissions per capita t CO_2eq/cep/yr	GMG emissions per unit of GDP PPP t CO_2eq/kUSD/yr	Population
2022	208.607	4.836	0.549	43.140 M
2015	301.123	6.743	0.627	44.658 M
2005	444.001	9.469	0.833	46.892 M
1990	952.140	18.501	1.117	51.464 M

The "CHG emissions of all world countries, 2023 Report" published by JRC[40], estimates the total CO_2 emissions for Ukraine as 208 607 000 tonnes. If buildings are considered responsible for about 40% of the total emissions, in Ukraine it may be assumed that the building sector is responsible for 83 442 800 tonnes of the total national emissions (see table below).

Table 8 — Contribution to Ukrainian CO_2 emissions of envelope insulation

CO_2 emissions avoided by envelope insulation of apartment-block stock, tonnes	Total CO_2 emissions of building sector in Ukraine (2023 JRC Science for Policy Report), tonnes	Contribution to building sector emission	Total CO_2 emissions of Ukraine in 2022, tonnes	Contribution to Ukraine total CO_2 emissions
19 491 000	83 442 800	23%	208 607 000	9%

According to the data presented in the figure above, CO_2 emissions avoided by the implementation of a wide insulation campaign limited to residential apartments blocks can give a 23% contribution to CO_2 emissions decreasing in the building sector and about a 9% decrease in Ukrainian 2020 total CO_2 emissions.

The potential extension of a similar measure to the remaining residential building stock of individual houses, representing about 40% of the total (according to NTU data), could almost double the contribution of building sector to CO_2 emissions decreasing, only by envelope insulation of houses, reaching about 20% contribution to the decreasing of total Ukrainian CO_2 emissions.

It is worth referring, as a brief conclusion of the presentation of this Italian case study and its potential transposition in the Ukrainian context, some considerations "ex post", useful to avoid the mistakes that in Italy brought the end of the Superbonus 110% implementation period and consequent positive impacts in medium term.

- The raw materials market must be controlled by the State, to avoid speculation (due to the increased demand) and abnormal prices increases (in Italy, insulation materials price increased by 100% in a few months).
- The implementing rules defined by law have to be clear and simple from the start, avoiding adjustments during the implementation period, thus creating big difficulties in work scheduling by construction companies and confusion amongst professionals responsible for any declaration related to work advancements and accounting.
- The financial contribution cannot be 100% (apart from specific cases as, e.g., the total reconstruction due to the detriments of the on-going war). Even a small (in Ukrainian case) property contribution improves the quality of the works and efficiency in their implementation.
- The monitoring and control by the State on the works have to happen along the path to works conclusion, without representing an "eventual possibility" statistically not probable.
- A clear definition of buildings/families eligible for this measure is crucial, giving priority to low and disadvantaged classes and "residential first houses", to avoid spending public money for energy rehabilitation of second or third houses that, due to the limited use, cannot give a proper contribution to the global energy saving and CO_2 emissions reduction.
- According to the presented data concerning the economic impact of the measure in term of direct and indirect positive effects mentioned in 3.2.4.2, a specific economic study should be elaborated for Ukraine, above all in light of specific economic situation of Ukraine, due to the on-going war.

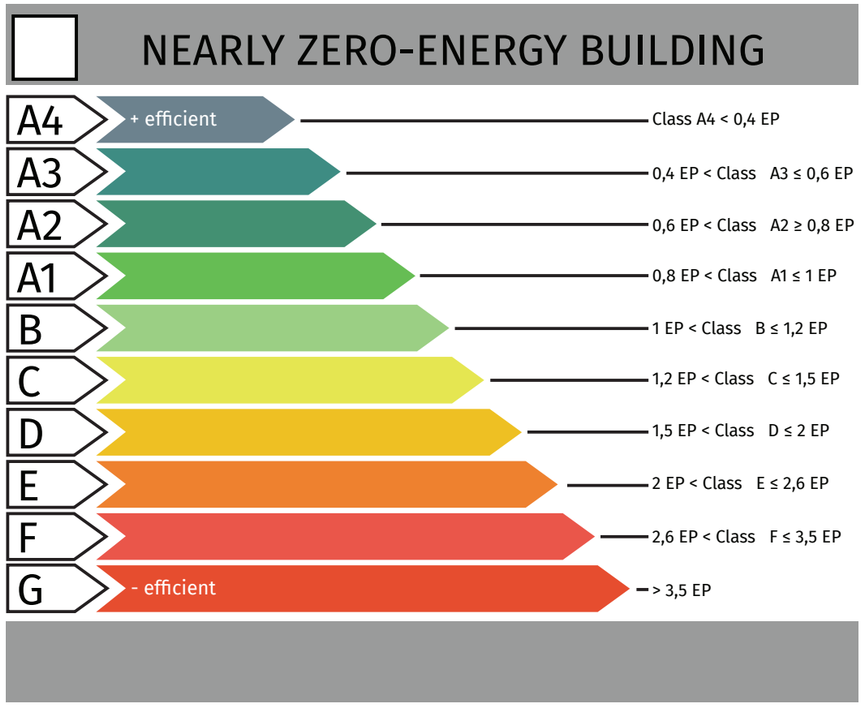
The figure and table below present the new scale of classification of buildings energy performance on the basis of global non-renewable energy performance index EP adopted in EU, and the values of EP compared to kWh/m² per year. Maximum and minimum kWh m² per year values slightly vary according to single country agreements.

40 https://edgar.jrc.ec.europa.eu/report_2023

Table 9 — New scale of classification of building energy performance on the basis of global non-renewable energy performance index EP adapted for each country in EU

ENERGY CLASS	EP min	kWh/m² per year	EP max	Total
A4			0.4	37.2
A3	0.4	37.2	0.6	55.8
A2	0.6	55.8	0.8	74.4
A1	0.8	74.4	1	93.0
B	1.0	93.0	1.2	111.6
C	1.2	111.6	1.5	139.5
D	1.5	139.5	2.0	186.1
E	2.0	186.1	2.6	241.9
F	2.6	241.9	3.5	325.6
G	3.5	325.6		

Figure 4 — New scale of classification of buildings energy performance on the basis of global non-renewable energy performance index EP (for Ukraine lowest class G (3.5 EP) is equivalent to 327 kWh/m² per year)



3.3 Construction products – regulations

3.3.1 Introduction

The main regulatory provision for this sector is the Construction Products Regulation (CPR), EU/305/2011, **https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R0305.** This allows Member States to set national regulations for construction works (see above), covering Energy economy and heat retention, and Sustainable use of natural resources and Hygiene, health and the environment, but does not generally set levels of performance. When Member States do regulate on these topics, this leads to the need for construction product manufacturers to declare certain performance characteristics of their products. This section, however, also consider the Circular Economy, because this concerns construction products.

3.3.2 Construction Products Regulation

The most relevant product characteristics for environmental/energy performance are: thermal conductivity/resistance, product dimensions, air tightness/permeability and performance of certain heating appliances. Content/release of dangerous substances is not directly relevant for environmental performance, but is important for the possible re-use or recycling of products. Sustainable use of resources was not, to any great extent, regulated by Member States when technical specifications were being drafted, so this does not yet feature in these specifications. This situation has now changed, so when CPR technical specifications are revised, they will be required to cover it, which they will do, most likely, by Environmental Product Declarations (EPDs) according to EN 15804+A2.

The CPR is a complex and difficult regulation for non-EU countries to transpose. It requires a fully-developed NQI to respond to the approximately 450 product standards and around 2 500 supporting standards, all of which are compulsory, and it only really works appropriately if there is an underlying system of regulations on construction works. Moreover, the regulation is in the process of being radically revised by the European Commission and, although this revision will strengthen provisions on Sustainable use of natural resources, the full details of the revision have not yet emerged.

Amongst other laws which relate to construction works, Ukraine has two legal provisions related to the EU's CPR. The Law of Ukraine "On Construction (Building) Norms" of the 5th November 2009 deals mainly with who applies construction (building) norms (requirements for buildings and structures) and how, the application of which is mandatory. Article 7-2 of this Law (added in September 2020) transposes basic requirements for construction works from the CPR: Article 7-2(4)(6) mentions energy economy and energy efficiency (heat retention), while Article 7-2(4)(7) deals with sustainable use of natural resources (the same as in the CPR).

There is also the Law of Ukraine "On Making Construction Products Available on the Market" of 2nd September 2020 which came into force on the 1st January 2023. This appears to be in certain aspects a transposition of and in others an approximation to the CPR. It also regulates construction products that do not fall within the CPR; ready-mixed concrete, reinforcing steel for concrete and plastics pipes are notable construction products which, because of an absence of harmonised European Standards, are not covered by the CPR in the EU.

As for transposed harmonised ENs (hENs), their list may be found at the following link: **https://zakon.rada.gov.ua/rada/show/v0153914-20#Text**. There are only 154 hENs in this list (compared with about 450-500 in the EU) but some of them are directly relevant for the thermal performance of buildings, including: windows and doors, panels of concrete and autoclaved aerated concrete, concrete floor and ceiling slabs, sandwich panels, bricks and blocks and, importantly, thermal insulation materials.

The list of hENs (which cover products) does not cover supporting standards, such as test methods these are compulsory but not considered to be 'harmonised' in the meaning of the CPR. There are estimated to be 1 500-2 000 of these in total in the EU, so it might be assumed that there are 500-700 required for 154 hENs in Ukraine.

From the NAAU website, 93 laboratories with valid accreditation certificates testing construction products are listed (there are others with certificates suspended or withdrawn, and there may be other labs who have never been involved with the accreditation process). 11 accredited test labs have thermal performance in their scope (although scopes are not always precise) and, if the Ukrainian law follows CPR principles, these would need to be the equivalent of Notified Bodies (bodies recognised by Member States and the European Commission as competent to perform CPR tasks). From this, it might reasonably be concluded that Ukraine already covers the most crucial construction products from a thermal point of view, although whether is can assess dangerous substances is more difficult to ascertain.

There are a few other regulations which apply to construction products, including REACH and specific dangerous substances regulations, such as formaldehyde and asbestos. These are important, however, only because dangerous substances can hinder the end-of-life possibilities.

It is well beyond the scope of this project to consider a full transposition of the CPR in Ukraine, or the NQI resources that this would bring. Any reconstruction of Ukraine would require product performance characteristics well beyond thermal ones (structural strength, fire performance, etc.). A brief assessment suggests, however that, provided that the transposed hENs are being applied correctly, a lack of data on product performance should not create major problems for a full-scale rebuilding and renovation programme.

3.3.3 Environmental Product Declarations (EPDs)

3.3.3.1 Reasons for and explanation of EPD

Carbon efficiency and sustainability are becoming increasingly important in the construction sector, and are increasingly driving investment and procurement choices. Buildings and construction are responsible for around 39% of the world's annual CO_2 emissions (excluding agriculture). Of this figure, 11% comes from embodied carbon, the emissions from the extraction and manufacture of products. Green building efforts have long focused on cutting operational emissions, such as the energy required to heat, light, or cool a building. But in 2019, the World Green Building Council signalled the need to also drastically reduce embodied carbon, thereby placing a heightened emphasis on the environmental impact of construction products and materials[41].

In their 2019 report, Bringing Embodied Carbon Upfront, the World Green Building Council set two bold targets:

- The raw materials market must be controlled by the State, to avoid speculation (due to the increased demand) and abnormal prices increases (in Italy, insulation materials price increased by 100% in a few months).
- The implementing rules defined by law have to be clear and simple from the start, avoiding adjustments during the implementation period, thus creating big difficulties in work scheduling by construction companies and confusion amongst professionals responsible for any declaration related to work advancements and accounting.

Environmental Product Declarations (EPDs) are the most frequent tool supporting decision-making on construction products. The European Commission is heavily pushing EPDs as a part of its overall 'Green Initiative' and, although they currently remain voluntary, the CPR mentioned above is currently undergoing revision and, because sustainability is emphasised in the new draft, there is a high chance that they will either become compulsory for all construction products or de facto compulsory because specifiers start demanding them.

An EPD provides an independently verified summary of the environmental impact of a product throughout its life-cycle, calculated via a life-cycle assessment (or LCA). The LCA allows an evaluation of a product's effect on the environment over its entire life-cycle to be made, taking into consideration all the steps that lead from material extraction through to manufactured product, and end of life. An EPD does not automatically show that a product is environmentally 'good', but they allow an objective comparison of potentially competing products to be applied when choosing which products to use. As EPDs become more widespread, it is intended that commercial pressure (if there are no regulatory 'drivers') will encourage manufacturers to progressively improve the EPD score of their products.

In creating an EPD, a manufacturer is not necessarily making a claim of low impact, but rather showing a commitment to measure and transparently declare environmental impact in an accessible format. EPDs are the only tool which currently address the end-of-life provisions of construction products, i.e. their ability to be re-used, re-purposed or recycled.

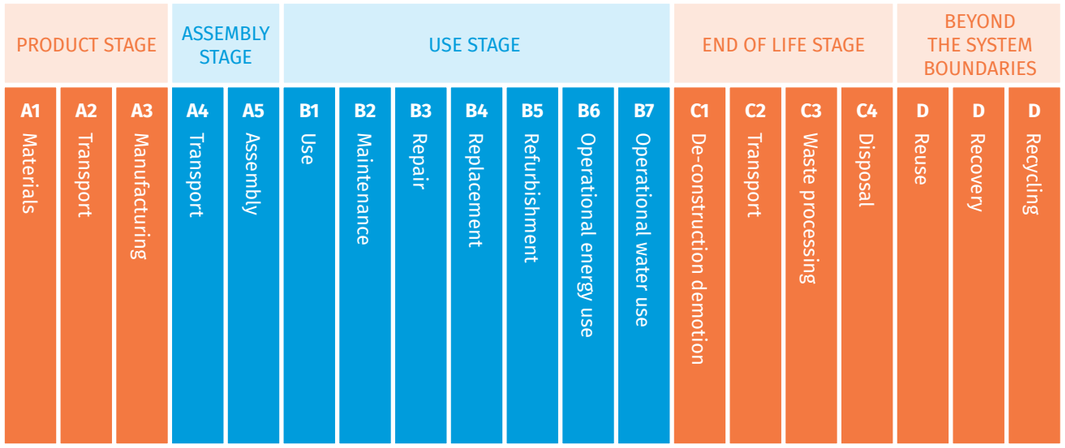
In physical terms, an EPD consists of two key documents, which need to be verified by a third-party certification body:

- the public EPD document, which summarises the findings of the LCA,
- an accompanying private background report (sometimes called an LCA report), which is used to verify the EPD by the appointed third-party verifier (and the program operator, if there is one).

41 https://oneclicklca.drift.click/epd-ebook

The overall objectives of EPDs are to progressively 'decarbonise' building and infrastructure projects, to assist with the development of lower embodied-carbon products and to manage and create corporate or real estate portfolio greenhouse gas reporting. The compulsory and voluntary elements of an EPD are shown in Figure 5:

Figure 5 — Factors used in creating an EPD



Currently, the standards on which EPDs (whether compulsory or optional) are based derive either from international work (ISO) and/or European work (CEN) and are shown in Table 10. An EPD is generally valid for 5 years, unless something relevant changes.

Table 10 — Potential standards used in EPD development

Market	EPD standard	LCA standard	Independent verification standard
EU and EEA	EN 15804+A2 (from July 2022 onwards)	ISO 14040 and ISO 14044	ISO 14025
International	ISO 21930 (compatible with EN 15804+A1, phased out in July 2022)		

After the standard EN 15804 had first been published, the European Commission developed the notion of Product Environmental Footprint (PEF), which has been included in the recent version (Amendment A2) of the standard. PEFs have not proved very popular in the market and, while it is not known yet whether EPDs or PEFs will ultimately prevail, it is to be hoped that the Commission will not opt for a unilateral option which neither has much support nor is used internationally.

Around Europe, various countries are mobilising to address the embodied carbon challenge, and whole-life carbon (WLC) assessments are increasingly being included in building regulations. To comply, developers, architects and project specifiers need to conduct project-level LCAs which include the impacts from the extraction, manufacture and transportation of building materials. As a result, they are starting to prioritise materials which can support the LCA with independently-verified impact data via an EPD. In addition, much of the new legislation includes phased carbon reduction targets. Some examples (others appear likely in the near future) are shown in Table 11.

It is not the aim of this section to describe EPDs in fully detail, but two further elements merit presentation. Table 12 shows the use of EPDs in different building certification schemes, while Figure 6 shows the steps to be taken by a manufacturer to develop an EPD.

Figure 6 — Stages in the creation of an EPD

Table 11 — Examples of legislation on embodied carbon in construction

Country and provision	Expected consequences
DENMARK National strategy for sustainable construction. Carbon calculation requirements expected by 2023 with carbon limit values for all buildings are due in 2025	Carbon calculation required for new build-ings from 2023, and a threshold of 12 kg $CO_2e/m^2/y$ for buildings over 1 000 m^2 by 2023, expanding to all buildings by 2025
FINLAND Maankäyttö-ja rakennuslain (MJR or Reformed Land Use and Building Act) from 2022, building carbon footprint limit values expected by 2025	EPDs will become even more critical as WLC assessments will be required for all new buildings from around 2025, with strict limits on embodied carbon emissions set by building type
SWEDEN Klimat declaration för byggnaderIn (Climate declaration for buildings) from 2022	A climate declaration, including product stage impacts, will be mandatory for all new buildings. It is preferred that EPDs are used for product impact data. Any generic data used must be sourced via the national climate declarations database
FRANCE Réglementation Environnementale 2020 (Environmental Regulation) from 2022	Whole-life carbon measurement will become mandatory for all new buildings with strict limits expected to be brought in by 2024 and gradually reduced, until it reaches a 30-40% reduction by 2030
UK The New London Plan from the Greater London Authority (GLA), in force since 2021	WLC assessments are mandatory for major developments, however the GLA encourages them for all new projects. GLA guidance also makes it clear that impacts are expected to be estimated using EPDs where possible

Table 12 — Use of EPDs in global carbon reduction schemes

Role of EPDs within the scheme	Schemes requiring this use
Documentation: to document that the project has purchased a minimum specified number of products with EPDs	BREEAM (global including Ukraine) Home Quality Mark (UK)
Use in LCA: to enable building level LCA through use of product EPDs	DGNB International (Germany) Levels (Europe-wide)
Buy low-carbon: separate to an LCA, EPDs are used for product comparison to support low carbon choices	Zero Carbon Certification (global) LEED v4 (global) HQE International (global)

3.3.3.2 The consequences of introducing EPDs

Developing an EPD is not itself a particularly expensive activity. They may be developed internally by manufacturers themselves, in which case the only real cost is staff time, or they may be out-sourced to a specialist third party, in which case costs are estimated to be between €9 000 and €25 000. These costs, however, cover the development of an EPD from nothing and generally are only required once every five years, so €1 800 to €5 000 a year. Moreover, for a manufacturer with several similar products in a range, once the first EPD for one product has been developed, the cost of developing subsequent EPDs is likely to be much smaller. Finally, assuming that nothing significant changes with the product, once the EPD has been developed, the only recurring cost is that of registering it once every five years, which is about €1 000 for one EPD, €500 for each subsequent EPD, so between €100 and €200 a year[42].

Total costs for conformity assessment of construction products varies greatly, and for each manufacturer it also depends upon how many products they have in their range. Estimates[43] suggests that conformity amounts to about 0.6% of revenue or 1.3% of turnover on average, and this equates to between about €1 000 and €30 000 a year. The additional cost of preparing and maintaining EPDs is, therefore, small in absolute terms and relatively small as a percentage of other conformity costs.

It is almost impossible to quantify the likely benefits of introducing EPDs, either as a voluntary or regulatory provision, in Ukraine. The number of manufacturers which would obtain them cannot be estimated, and in addition there is no 'performance limit' which products need to achieve. Finally, the high levels of demand in the EU, cited above, from construction products' clients wanting manufacturers to be transparent about the environmental impact and wanting to be supplied with sustainable or green products, might not existing in Ukraine in the short to medium term. EPDs are, however, intended to create market demand so, given their relatively low overall costs, this report recommends that they be introduced. To prevent several possible different changes on the Ukrainian market, however, it might be best for Ukraine to take no immediate action pending the finalisation of the revision of the CPR in the EU which, at the time of drafting this report (early 2024) seems imminent.

There are only few NQI requirements to make EPDs possible in Ukraine, and that is one or more bodies competent to verify EPDs. It is possible that these bodies would need to be Notified Bodies in the EU, and the equivalent in Ukraine. Manufacturers might also need training and assistance in how to draw up EPD.

42 https://www.environdec.com/pricing/pricing2023

43 **Commission Staff Working Document, Impact assessment report accompanying the document Proposal for a Regulation of the European Parliament and of the Council laying down harmonised conditions for the marketing of construction products, , amending Regulation (EU) 2019/1020 and repealing Regulation (EU) 305/2011, SWD(2022) 88 final, Brussels, 30.3.2022.**

3.4 Construction products – regulations

3.4.1 Introduction

The construction sector uses more raw material than any other in the EU, produces the most waste and is responsible for about a quarter of carbon emissions. Change in some areas is coming with, for example, energy efficiency requirements in the UK meaning that, from 2025, new buildings need to generate 75 to 80% less carbon after they are built. But this and similar initiatives in the EU will not address all the environmental impacts the sector is responsible for and it will not help with all the other problems the industry faces, in particular a general shortage of housing and affordability of what new housing is available[44].

One obvious answer, as many are beginning to realise, is a more circular economy. What this means for construction is reducing raw material use through changes to design and a focus on preserving materials and entire buildings at their highest value for as long as possible. It means regenerating, re-using and recycling building materials already in use, at the end of their first life. A circular construction industry would help to provide the housing and infrastructure needed, without the current negative impacts. Many circular measures also offer opportunities to drive down housing costs, increase productivity, relieve supply chain pressures, and improve businesses' profitability. Previous research has shown circular construction business models can increase profitability, improving financial returns by as much as 26% in the UK.

A second report, from the European Environment Agency[45], construction and demolition waste (C&DW) comprises the largest waste stream in the EU in terms of mass (374 million tonnes in the EU in 2016, excluding excavated soil) with apparently high recovery rates. Although this may suggest that the construction sector is highly circular, scrutiny of waste management practices reveals that C&DW recovery is largely based on backfilling operations and low-grade recovery, such as using recycled aggregates in road sub-bases. Nonetheless, circular economy-inspired actions can help achieve waste policy objectives, namely waste prevention and increase both the quantity and the quality of recycling for C&DW while reducing hazardous materials in the waste.

In March 2020, the European Commission, in its Circular Economy Action Plan (CEAP[46]) announced that a Sustainable Products Initiative (SPI) was under preparation with the aim of making products fit for a climate-neutral, resource-efficient and circular economy. The initiative will widen the scope of the Eco-design Directive (EDD) to all products and to provide for the setting of specific requirements linked to a list of aspects set out in the CEAP. These include durability, reusability, the presence of hazardous chemicals; energy and resource efficiency; carbon and environmental footprints, as well as recycled content, while ensuring products' performance and safety. It will aim to improve products sustainability, to give access to sustainability information along the supply chain, to incentivise more sustainable products and business models. For construction products, SPI goals will be mainly realised by means of the Construction Products Regulation[17].

Substantial and accurate data for construction waste in Ukraine do not appear to be available. There will, however, no doubt be a plentiful supply, in particular from the war zone. In the analysis below, though, it is assumed that similar provisions as in the EU could be applied in Ukraine, with broadly similar results.

44 **Circular construction – Building for a greener UK economy. https://green-alliance.org.uk/wp-content/uploads/2023/03/Circular-construction.pdf.**

45 **Construction and demolition waste: challenges and opportunities in a circular economy. https://www.eea.europa.eu/publications/construction-and-demolition-waste-challenges/construction-and-demolition-waste-challenges.**

46 **Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A new Circular Economy Action Plan For a cleaner and more competitive Europe, COM/2020/98 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN.**

3.4.2 Analysis

A circular economy represents a fundamental alternative to the linear 'take-make-consume-dispose' economic model that still predominates. This linear model is based on the assumption that natural resources are always available, abundant, easy to source and cheap to dispose of. However, the linear model is not sustainable, as the world is moving towards (and is in some cases exceeding) planetary boundaries.

The circular economy is restorative in nature, and it aims to maintain the utility of products, components and materials for as long as possible while also retaining their value. It thus minimises the need for new inputs of virgin materials and energy, while reducing environmental pressures linked to resource extraction, emissions and waste management. This goes beyond just waste and requires natural resources to be managed efficiently and sustainably throughout their life cycles.

Circular economy-inspired interventions focus not only on increasing recycling quantitatively but also on:

- keeping materials in the economy as long as possible,
- maintaining their intrinsic value/quality as high as possible,
- reducing hazardous substances in products and waste.

A report from the UN[47] suggests that that material efficiency strategies would reduce natural resource use by 28% and GHG emissions by 72% and yet improve economic growth. This report also suggests that reducing living space by 20% could lead to GHG emission reductions of 73% when emissions savings from recycled building materials used elsewhere in the economy are credited. Interestingly, a report by the Ellen Macarthur Foundation[48] suggests savings of 38% by 2050, indicating one of the problems in getting reliable data in an area which is relatively new and still growing. Despite the potential savings, there are some challenges which a circular economy in construction would pose:

- the need for more skilled labour, capable of saving material and working with repurposed materials (a lack of skilled labour is a perpetual challenge in the construction industry),
- more time required for projects, as materials are disassembled rather than simply being discarded,
- higher costs associated with certification schemes (although in principle a good thing) such as the Leadership in Energy and Environmental Design (LEED) scheme,
- perversely, supply-chain issues because, although one project might not make much difference, if all construction projects start using less new or virgin material, demand will reduce and prices might rise,
- higher quality materials might last longer but will also cost more.

Each of these factors has a tendency to raise, even if marginally, the cost of construction projects, leading to fewer clients deciding to initiate projects, at least until higher prices become normalised.

In the EU, the 2008 Waste Framework Directive set a recovery target of 70% by 2020, where 'recovery' is defined as including all recycling and other recovery operations such as backfilling. Most EU Member States exceeded the 2020 target as early as 2016, they report increasingly high recovery rates and many EU countries have succeeded in establishing markets for recovered C&D materials. This may suggest that the European construction sector is highly circular, as it manages to reintroduce large quantities of its waste into the economy by avoiding disposal options such as incineration and landfilling. However, as a result of building practices in the past and the lack of generation of high-purity materials during demolition, currently the material streams arising from demolition and renovation works are not suitable for reuse or closed-loop recycling. This hampers full implementation of circular economy objectives.

In fact, closer scrutiny of the data reveals that the high recovery of C&DW is based, to a large extent, on backfilling (Figure 7) or on low-grade recovery, e.g. using recycled aggregates from the mineral part of C&DW on applications such as road sub-bases. Moreover, Figure 4 shows that some countries still have very high levels of C&DW sent to landfill, which means that it is effectively lost forever. Therefore, the inherent value of the materials composing C&DW is either lost completely, eroded or qualitative aspects of recycling are not systematically addressed and recycling is not performed in closed loops. The latter would help preserve the value of recycled materials.

47 Hertwich, E., Lifset, R., Pauliuk, S., Heeren, N. "Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future." 2020. A report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya.

48 Reimagining our buildings and spaces for a circular economy. https://www.ellenmacarthurfoundation.org/topics/built-environment/overview#:~:text=Adopting%20a%20circular%20economy%20approach,to%20achieving%20carbon%20emissions%20targets.

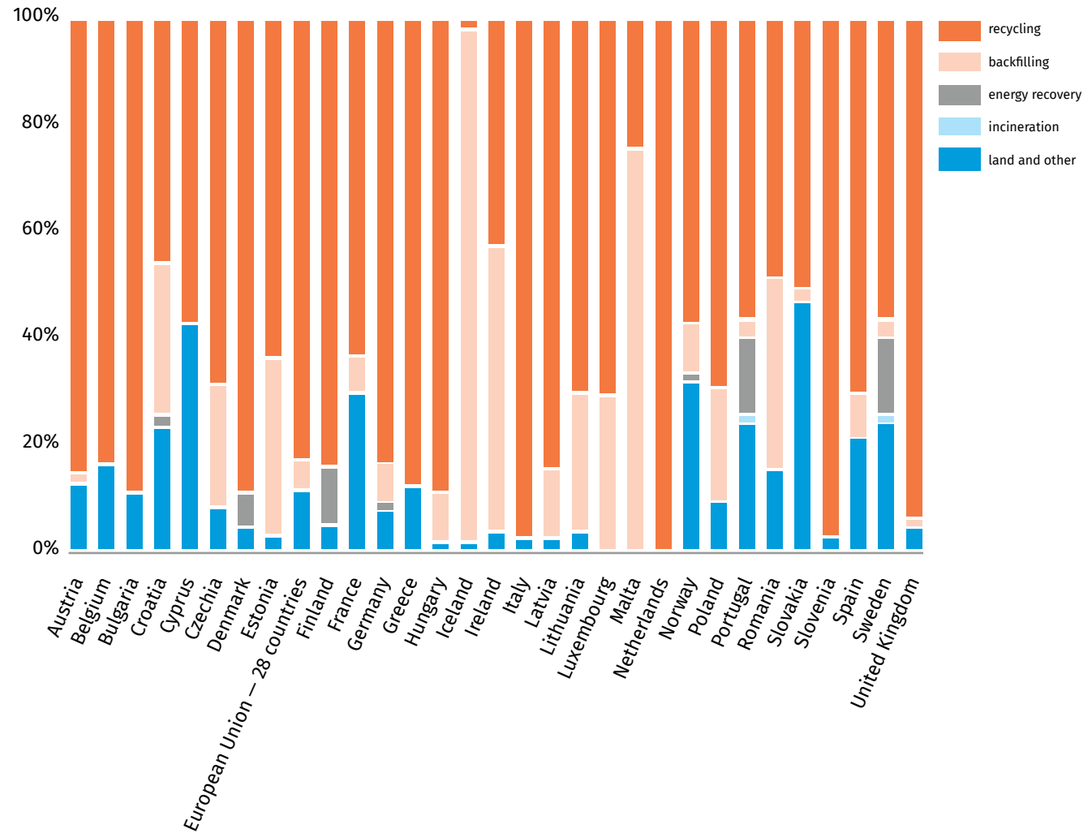


Figure 7 — Treatment of waste from construction and demolition

Closed-loop recycling would result in greater prevention of C&DW (as materials are kept in the economy as long as possible) and in a reduction in the (less circular) recovery of low-grade material. The figure overleaf shows the circular economy for construction products in full detail[49].

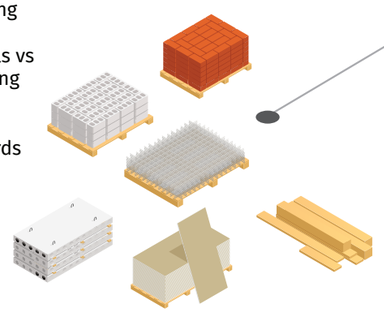
49 https://www.rockfon.co.uk/about-us/blog/2022/circular-economy-in-construction/.

Figure 8 — The circular economy for construction

HIGH-GRADE PRODUCTS WITH HIGH-RECYCLED CONTENT

Materials with high durability used in structural elements

- ⊕ Prolong construction's life span, thus contribute to waste prevention
- ⊕ Creates demand for recycled materials in closed loops, increases quality of recycling
- ⊖ Low price of virgin materials vs high cost of waste processing
- ⊖ Doubts on quality of recyclables, lack of standards



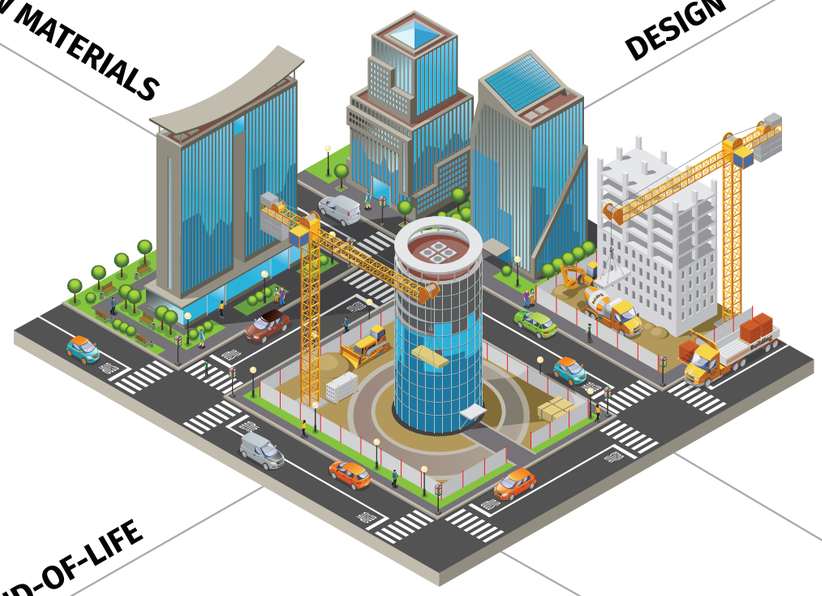
RAW MATERIALS

HIGH-GRADE PRODUCTS WITH HIGH-RECYCLED CONTENT

Design construction products so they are easy to separate into components that can be reused, reassembled, reconfigured, recycled

- ⊕ Re-use in part of waste prevention, separation of components makes recycling easier
- ⊖ Higher complexity of disassembly
- ⊖ Potential conflict with other legislation such as energy efficiency
- ⊖ Lack of knowledge and information
- ⊖ Very long time delay between implementation and results

DESIGN



MATERIAL PASSPORTS

Stats of data describing defined characteristics of materials and components in building products

- ⊕ Facilitates source separation of end-of-life materials, increases recycling quality and closed loops
- ⊖ Information and data management for long time period
- ⊖ Costs of data gathering and storage

CONSTRUCTION

SELECTIVE DEMOLITION

Remove hazardous materials and increase source separation into high-value, pure material fractions

- ⊕ Increase quantity and quality of recycling
- ⊖ More time consuming and potentially more costly demolition
- ⊖ Lack of traceability (limited information on waste material origin and quality)
- ⊖ Complexity of buildings and construction materials

END-OF-LIFE

USE

EXTENSION OF CONSTRUCTION SERVICE LIFE

Renovate, improve maintenance, upgrade, repair, and adapt constructions

- ⊕ Implement of waste prevention
- ⊕ Avoidance of new construction and related environmental impacts
- ⊖ High labour costs
- ⊖ Changes in architectural preferences
- ⊖ Risk from the presence of inferior materials in buildings and degradation of structural building elements
- ⊖ Energy inefficient buildings also extend their life span

Circular construction and demolition — European Environment Agency

There are, however, several reasons (and their solutions) which act as barriers to greater circularity:

Barrier	Opportunity
Virgin material cheaper than secondary material	Create a competitive market for secondary materials; encourage specification of secondary materials in public purchases; 'green taxes' can help make secondary materials price-competitive
Lack of confidence in quality and structural performance of secondary materials	Develop standards for secondary materials allowing them to properly declare their performance
Hazardous and other substances in secondary materials	Develop technology to remove hazardous and other substances; prevent the use of materials containing hazardous substances in all new construction
Unknown composition of waste from older buildings	Use Building Information Modelling (BIM) to track materials and changes (such as maintenance through to demolition)

It is not only hazardous substances which can cause problems. The glass in modern double-glazed window units is often coated for higher thermal performance. This coating can mean that companies will not accept such glass for re-use or recycling[50]. In addition, while aluminium can be infinitely recycled, steel loses some of its strength properties as a result of recycling. Some materials, such as rockwool used for thermal and/or acoustics insulation, can be recycled many times without losing its inherent properties, but to do so may well require plant to allow this recycling.

A study from the Netherlands[51] identified five key opportunities for Dutch construction to become circular by 2050:

- lighter weight construction, meaning fewer tonnes of primary materials used,
- extending the lifetime of buildings so there will be less demolition, and less demand for new construction,
- more and higher value reuse and recycling, including re-use across sectors,
- the use of more renewable materials such as wood and other biobased alternatives,
- design products for disassembly and reuse to make sure that products can be 'mined' from the urban environment and reused.

Finally, mirroring the actions of companies which collect surplus food, Netlet is a Finnish company that collects unused materials from construction sites, checks, processes them and then sells them on. In its first year of operation, NetLet has saved over 1 500 tonnes of surplus building materials, a very small percentage of the waste generated in Finland alone, let alone the EU, but nonetheless a small step in the right direction.

50 Author's own experience, 2023.
51 Assessing all materials consumed for building in the Netherlands, https://www.metabolic.nl/projects/assessing-materials-consumed-for-building-in-the-netherlands/?gad_source=1&gclid=Cj0KCQiA4Y-sBhC6ARIsAGXF1g4ntljPgm3bnO_jSGKgmjQiSKpPMZISWIMA3vLQfCGeofcD_6D1Td0aAla0EALw_wcB

3.4.3 Findings

According to the Ministry of Environmental Protection and Natural Resources, over the course of almost a year and a half of the war, Russians have damaged and destroyed nearly 60 000 objects, of which residential buildings, 48 000, have suffered the most. As of early summer 2023, the amount of construction waste in Ukraine amounted to 0.45 million tonnes, with the regions having the largest accumulation being: Kyiv, Zhytomyr, Sumy, Mykolaiv, Kherson, Chernihiv and Kharkiv. No data are available for Donetsk or Luhansk.

The Kyiv region alone generated 185 thousand tonnes of waste, made up of concrete, brick, facing tiles, ceramics, wood, glass, plastics, insulation materials and asbestos-containing building materials[52]. It is believed that this estimated quantity corresponds solely to war-damaged infrastructure and, although it sounds like a considerable amount, it is only just over 0.1% of the total construction waste generated per year in the EU.

As an indication, it is estimated that one basic two-story family house (approximate heating area of 180 m²), about 500 tonnes of construction waste and garbage can be obtained (bricks 205 tonnes, reinforced concrete 110 tonnes, concrete 125 tonnes, metal 7.5 tonnes, wood 0.5 tonnes, glass 0.3 tonnes). For a five-storey building such as a school or hospital (estimated heating area 4 500 m²) 9 100 tonnes (bricks 4 000 tonnes, reinforced concrete 4 500 tonnes, concrete 650 tonnes, metal 30 tonnes, wood 20 tonnes and glass 20 tonnes).

No data appear to be available covering waste generated by 'normal' construction operations throughout the rest of Ukraine. But, taking data from the EU for similar-sized countries, it might be very roughly estimated to be between 10 and 15 million tonnes a year, maybe more once a major reconstruction and renovation programme gets underway.

Most of this waste was being treated as normal, solid household waste, i.e. was being sent to conventional landfill and therefore 'lost' forever, and by the end of 2022 these landfill sites were in danger of being inundated. Consequently, in September 2022 the government passed a new resolution, No. 1073, On the approval of the Procedure for handling waste generated in connection with the damage (destruction) of buildings and structures as a result of hostilities, acts of terrorism, sabotage or carrying out work to eliminate their consequences and amendments to some resolutions of the Cabinet of Ministers of Ukraine. The new approach provides for the organisation of construction waste by recycling and reuse of waste (if possible), and is based on EU provisions.

Resolution No. 1073 suggests possible ways to reuse construction waste. For example, construction materials based on gypsum can be used as an additive to dry construction mixes, secondary raw materials such as bricks can be reused, and reinforced concrete used for the production of coarse and fine aggregates for concrete).

Most of the communities that faced large-scale destruction now solve the problem of disposal and recycling of construction waste on their own. For the most part, the solution is limited to removing debris and removing the remains of buildings to temporary storage sites. UNDP is already active in Ukraine, with projects in areas such as Chernihiv or Mykolaiv[53]. Amongst other risks, UNDP highlights the risks from unexploded munitions in damaged buildings, the challenge of asbestos (which raises the question of 'relative risk') and the more general issue that Ukraine lacks a history of widespread recycling or the infrastructure to support it. Therefore, a secondary goal is for the local governments working with the UNDP to take recycling and build it into a habit of looking for more environmentally friendly solutions.

One of the best examples of the reuse of construction waste is now a project in Gostomel, which is being implemented by the French company Neo-Eco. At the end of January 2023, the company began work on the first four sites in Gostomel, where they managed to achieve a recycling rate of 90% with only 10% of construction waste taken to landfill. Concrete and bricks were ground to make fine aggregates; wooden doors used to make particleboard panels, plaster used in plasterboard, etc.[54].

The project will build about 450 apartments in new modern urban neighbourhoods, using the recycled construction waste in the construction. It follows Carlos Moreno's concept of the '15-minute city', a residential city in which most daily needs and services such as work, shopping, education, health care, and recreation should be located within walking or cycling distance from anywhere in the city. The downside, though, is that such innovative construction for Ukraine is "much more expensive" than traditional construction"[55] although, unfortunately, "much more" is not quantified.

In addition, the new Waste Management Law entered into force on the 9th July 2022. This law uses the more general term "construction and demolition waste" (rather than the specific term "destruction waste") and it contains instructions for handling such waste. The law proposes that waste recovery operations, including preparation for reuse, are carried out, and also regulates the creation and support of waste management facilities that carry out operations to prepare waste for reuse[28]. It is probably too early to determine whether this law will be widely applied and enforced.

Looking beyond the specific issue of war-damaged infrastructure and its associated C&DW, the whole question of resource efficiency is a vast, complex and relatively new

52 https://visitukraine.today/blog/2126/a-trillion-uah-damage-how-ukraine-plans-to-dispose-of-war-torn-garbage#:~:text=Pollution%20in%20Ukraine%20during%20the%20war&text=Residential%20buildings%20have%20suffered%20the,amounted%20to%20450%20thousand%20tons
53 https://www.undp.org/ukraine/news/environmentally-friendly-method-rebuild-ukraine
54 https://www.property-forum.eu/news/construction-waste-in-ukraine-whats-the-solution/15592
55 https://rubryka.com/en/article/ekologichna-vidbudova-ukrayiny/

subject, but it is just as relevant for the green reconstruction of Ukraine as issues such as energy efficiency. Climate change policies have tended to focus on energy efficiency rather than materials efficiency as a central strategy for GHG emissions reduction. Material efficiency policies have started to emerge, though, through efforts to improve the environmental and resource dimensions of waste management, and this is very relevant for construction, considering that large quantities of energy use and CO_2 emissions associated with the production of construction materials and products. That said, there are no studies, yet, quantifying in any detail the economic effects of a switch from a linear to a circular economy.

High waste recovery rates in the Netherlands, Denmark and Germany following the introduction of landfill bans on recyclable material and high landfill taxes suggest these are effective measures when implemented together. Other regulatory policies that enforce recycling of C&DW have been shown to be effective, including the Japanese Construction Material Recycling Law requiring certain projects to sort and recycle all asphalt concrete, concrete and wood. Eight years after enacting this law, Japan achieved recycling rates of 99.5% for asphalt concrete, 99.3% for concrete and 99.4% for wood.

A less commonly used but effective incentive mechanism are deposit-refund permits, an example of this is Vancouver's Green Demolition Bylaw, which requires a significant demolition deposit at the permit stage that is refunded following completion of demolition. It is well worth noting, though, that the 'effectiveness' measure used for these scheme is recycling/reuse rates and CO_2 emission reductions (both valuable parameters in their own right). To date, there seem to be no detailed studies of the economic consequences, a fact decried by the United Nations Environment Programme report21, a very detailed analysis of the circular economy, and which is considered briefly below.

'Material efficiency', with consequent reduction in energy consumption and CO_2 emissions merits considerable attention from rebuilding funding agencies and others involved in the rebuilding agenda. It is a multi-faceted, cross-cutting subject requiring which, for the moment at least, seems to be based primarily on regulatory 'push'. It also requires a considerable change in 'normal practice' in the construction industry which, in the EU and UK in particular, is generally considered to be very 'conservative'. It may well be that changing 'habits' in the industry is as challenging as changing the regulatory and economic situation.

Material efficiency measures can range from options such as promoting much greater use of timber, not only as a decorative but as a structural material through to reducing the 'mass' of buildings by replacing heavier materials, in particular concrete, by lighter-weight ones and reducing the dimensions of living spaces. All of these can have substantial positive consequences on material production energy usage and CO_2 emissions. The change in skills amongst construction workers from working with concrete to working with structural timber should not, however, be under-estimated. Extension of building lifetimes is not a frequent policy option but is also worth consideration especially for domestic dwellings, where the focus is often on 'minimum purchase price' instead of lifetime costs.

There are various economic and regulatory options which have been tried in various countries. These include a 'virgin material tax' (VMT), often synonymous with a 'raw materials tax', which is a tax on the use of previously unexploited but industrially and commercially important materials including metals, minerals, petrochemicals and timber (this tax is not included on recycled/reused materials); this can be a dedicated one or it can be as simple as VAT.

Equally common are 'Recycled content' requirements, used to refer to the obligation that newly produced products must contain a certain percentage of recycled material. While recycled materials are routinely used in some products within private industrial and commercial operations, the focus here is on legally binding policy and legislation, as opposed to industry-driven initiatives to improve environmental performance. Japan, for example, has a Law for the Promotion of Effective Utilisation of Resources (Ministry of Economy, Trade and Industry, Recycling Promotion Division, 2015) and the Fundamental Plan for Establishing a Sound Material-Cycle Society (Government of Japan, 2018).

Policies for end-of-life management (such as construction and demolition debris reuse and recycling) are widespread but are often focused on landfill diversion. If material efficiency is to lead to climate change mitigation, policy targets need to shift to, or at least include, GHG emission reduction goals or embodied carbon content, as described above in the context of EPDs.

The above analysis has showed that, for Ukraine and in order of increasing importance, as much C&DW as possible needs to kept out of conventional landfill, and experience has shown that 'lost' waste can be reduced to about 10% with savings on energy and large savings on CO_2 emissions, estimated at between 30% and 50% of that used in virgin material production. Waste can be recycled for low-level, low-value uses such as replacing virgin aggregates; this is better than landfill but wastes a great deal of the intrinsic 'value' of the material, The best option, therefore, is reuse, either as such or as replacement material in higher-value products.

There are very limited resource needs in terms of NQI: test laboratories are needed in some cases to assess for hazardous substances (although in the Gostomel projects, testing in Kyiv and France was able to show that the materials were safe), product/material standards specifically for waste-derived products are useful and are being developed in the EU, and some certification capacity may be needed if recycled/reused materials are to be certified.

Outside of NQI, however, there are other resources needed, which include local waste handling sites (some of the benefits are lost if materials are moved from the demolition site to a distant reuse site), equipment is needed to reprocess materials such as grinding concrete and bricks into aggregates and reusing timber in composite panels, and specialist organisations are needed for the safe storage and disposal of materials such as asbestos.

In the circumstances, and given the increasing interest in the circular economy from organisations such as the United Nations, the European Commission and individual governments, it is perhaps surprising that there are so few studies which have attempted to assess the economic consequences of greater circularity, even if the broad view is that it is 'more expensive' than convention construction but without quantify 'more'. It may be that such studies are made difficult by the number of actors and factors involved: building owners, government/local authority agencies, private waste treatment companies, private construction companies reusing materials, training organisation for construction workers and so on.

Regulatory impact assessment is by no means easy (even though it is often favoured by governments, decision-makers and funding agencies) when there are only a few organisations involved and it is relatively easy to identify who are 'funders' and who are 'beneficiaries'. RIA becomes far more challenging, especially the cost-benefit-analysis part of it, when 'funders' can be identified but 'beneficiaries' might be having to pay more and the ultimate beneficiary is 'the planet'.

Where costs rise, such as the initial purchase price of a dwelling, there is a strong case for radical alternatives to address this. For example, there have been some very effective schemes where low-energy consumption products have been supplied to consumer free of charge by utility companies, which then recoup the cost through and almost imperceptible levy on consumers' utility bills over time. Similar inventive schemes might be devised for buildings and other construction infrastructure, through marginally higher rates on dwellings or road-use charging (even if the latter is often unpopular!).

Ultimately, though, perhaps the Circular Economy is a good case of where conventional cost-benefit-analysis is no longer an appropriate tool, whereby decisions are taken only where the CBA analysis results in a 'profit'. It may well be that the paradigm needs to change for CBA towards other social activities, such as public health, schools and the police where the true benefits are extremely difficult to quantify in monetary terms but where they are done because they are the 'right things to do'.

3.5 Construction products – manufacturing

3.3.1 Introduction

Ukraine was once considered an industrial powerhouse. However, in recent years, political and economic instability, combined with the country's inefficient use of energy and high energy prices, exacerbated by the ongoing war, have significantly hindered Ukraine's economic performance and industrial competitiveness.

Determined to fulfil Ukraine's economic potential, in 2015 the government announced its national energy strategy, which outlined the country's long-term energy development priorities with the goal of integration into European energy markets. One key goal is to significantly improve the energy intensity of the national economy by more than 50% by 2035. Such an ambitious target will require a major overhaul of outdated infrastructure and an industrial sector wide prioritisation of energy efficiency. If successful, Ukraine will be well placed to take its rightful place as a major European economy in an unprecedented era of climate change[56].

Concerning energy consumption in the production process of products, some products (in particular cement and reinforcing steel) are particularly energy-intensive. Studies have been done to look at improving these industries and, in the time available for this project, it has only been possible to look at these reports and try to generalise their findings and recommendations to Ukraine. This section therefore gives some very preliminary estimates of energy saving and CO_2 reduction potential, but to arrive at more realistic findings and recommendations, much more in-depth analysis would be required.

Most of the materials used in buildings in the EU are manufactured in industries that are subject to the European Emissions Trading System (EU ETS)[57], established in 2003 through the EU Directive 2003/87. The directive applies now to over 10 000 industrial installations in the EU, including all the larger[58] plants manufacturing steel, aluminium, cement clinker, glass, ceramics, or mineral wool insulation. Moreover, it applies to the six most relevant greenhouse gasses (GHG) emitted by these plants, listed in Annex II of the directive (including carbon dioxide (CO_2) and nitrous oxide (N2O)).

Over time, the EU ETS has been expanded and has now entered its fourth phase (2021-2030) and includes aviation. A new parallel ETS II system is also gradually entering into force to include buildings, road transport and additional sectors (small industry). The EU ETS works on the 'cap and trade' principle. A cap is a limit set on the total amount of greenhouse gases that can be emitted by the installations and aircraft operators covered by the system. The cap is reduced annually in line with the EU's climate target, ensuring that emissions decrease overtime. Emissions are traded so that plants that achieve larger reductions may trade to other plants failing to comply with their own cap. The price of the emissions has changed widely over the years, and now is around 72 €/tonne CO_2[59]. Trading enhances efficiency of the system, allowing reductions of CO_2 to be achieved first where it is easier and cheaper, and only gradually where it is more expensive. Since 2005, the EU ETS has helped bring down emissions from power and industry plants by 37%.

The EU ETS is part of the larger EU Member States effort to become climate neutral by 2050. Several reforms to the ETS have been approved over time, to make this effort more efficient. Among these, a reform establishing a Carbon Border Adjustment Mechanism (CBAM) was adopted through the EU Regulation 2023/956 on 10 May 2023[60]. In fact, as stated in the regulation, while the Union has substantially reduced its domestic greenhouse gas emissions, the greenhouse gas emissions embedded in imports to the Union have been increasing, thereby undermining the Union's efforts to reduce its global greenhouse gas emissions footprint.

Moreover, as long as a significant number of the Union's international partners have policy approaches that do not achieve the same level of climate ambition, there is a risk of carbon leakage. Carbon leakage occurs if, for reasons of costs related to climate policies, businesses in certain industry sectors or subsectors transfer production to other countries or imports from those countries replace equivalent products that are less intensive in terms of greenhouse gas emissions. Some mechanisms embedded in the ETS, like the so-called Free Allocation, were set in place to address the risk of carbon leakage (industries with higher risk of relocation, were granted free emissions).

Now, the CBAM seeks to replace those existing mechanisms by addressing the risk of carbon leakage in a different way, namely by ensuring equivalent carbon pricing for imports and domestic products. The CBAM should ensure that imported products are subject to a regulatory system that applies carbon costs equivalent to those borne under the EU ETS, resulting in a carbon price that is equivalent for imports and domestic products.

This CBAM Regulation should apply to goods imported into the customs territory of the Union from third countries, except where their production has already been subject to the EU ETS through its application to third countries or territories or to a carbon pricing system that is fully linked with the EU ETS[61].

To state it simply, all Ukrainian industrial goods exported in the EU that are covered by Annex I, will be "taxed" for their carbon content, unless Ukraine has a carbon taxation system with the same effectiveness of the EU ETS. The Ukrainian industry will hence be faced to an effort to be greener, if it wants to access competitively the very large EU market. The reconstruction could however also be a good occasion for Ukraine, to adhere to a carbon pricing mechanism compliant to the EU ETS, to green all its construction materials industry, and hence green its reconstruction.

Even without formally adhering to this kind of GHG reduction scheme (though it can be considered that Ukraine will have to do so, to be competitive in its exports to the large EU markets), including some of the EU ETS tools in its national legislation, would allow its industry to be greener.

One of the major achievements of the EU ETS is the Monitoring, Reporting and Verification MRV[62] system that is now in place. This report suggests that Ukraine incorporates, at first as a voluntary activity, this MRV system in its building materials industry. That would shed light in its environmental performance related to GHG emissions. It could be eventually used, during the reconstruction phase, to give priority to the greener industries.

Among the tools that allow EU industries to meet the GHG caps set for them, the use of biomass is growing. The EU ETS Directive allows the emission factor[63] of biomass to be set to zero if RED II[64] criteria are complied with for the biomass. In other words, ETS plants can burn biomass in replacement of fossil fuels, and their use would result, for accounting purposes only, as if they are not emitting CO_2 (in fact they are still emitting CO_2, but this can be considered as being offset during the growth of the biomass itself).

A full explanation of eligible biomass is given in an EU Guidance Document[65]. Two key points that biomass must meet to be recognised to have an emission factor set to zero:

1) it must meet sustainability criteria and
2) GHG savings must be assessed.

Both may be reached through evidence under national or international schemes.

Eligible biomass includes:

- plants and parts of plants,
- biomass wastes, products and residues (e.g. sewage sludge, landfill gas, manure).
- biomass fractions of mixed materials (including waste tyres, municipal and industrial waste),
- fuels whose components and intermediate products have been all produced from biomass (e.g., biodiesel).

While awaiting the reconstruction to start, it would be good to put in place the supply of these streams of biomass, using them for the construction material industry. In the meantime, all the needed tools needed to verify biomass compliance with RED II criteria should be implemented. These includes accreditation of laboratories to ISO standards that measure the content of biomass (e.g. compliance to ISO 21664:2021[66]) and the organisation of certified and traceable biomass supply chains (stating origin, quantity and destination of the biomass).

It is beyond the scope of this project to consider an ETS scheme for Ukraine in general. However, a recent study by the European Central Bank[67] sheds some light and draws some conclusions, that could be seen as more negative than positive. The report finds that the ETS contributed to cut greenhouse gas (GHG) emissions in the EU by 2-2.5 percentage points per year; pricier emissions and more stringent caps accelerated the EU greening process.

However, some carbon leakages (described above) occurred, as declining emissions in regulated industries within the EU were counterbalanced by an intensification elsewhere as EU industries out-source production to non-EU countries. China in particular is often criticised for its high CO_2 emissions, but it needs to be remembered that China has, to a large extent, simply accepted to manufacturer, on its own territory, and export those products which previously would be have been manufactured in the importing countries. Moreover, the ETS burdens companies in EU regulated industries.W

The report also argues that a mild CBAM for Ukraine could be counter-productive, while a strong CBAM could face adverse reaction from other countries claiming that it is an anticompetitive and retaliating in other sectors. Importantly, though, Ukraine will need to comply with the EU ETS as a future condition of accession to the EU, but also because it would face the need to buy certificates to export to the EU, and only exports to non-EU countries (probably not Russia or Belorussia markets that could be closed to Ukraine), would be possible without these.

56 Industrial decarbonisation Accelerator, https://www.industrialenergyaccelerator.org/where-we-work/ukraine/, UNIDO.
57 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en.
58 Thresholds above which the directive applies are stated in Annex 1 of the directive, e.g., plants where combustion units exceed a thermal rated input of 20 MW, production of pig iron or steels in plants with a capacity exceeding 2,5 tonnes per hour or production of aluminium.
59 https://www.eex.com/en/market-data/environmentals/eu-ets-auctions
60 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R0956&qid=1692623128952
61 Countries such as Canada, China, Japan, New Zealand, South Korea, Switzerland and the United States, https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/international-carbon-market_en#:~:text=Besides%20the%20EU%20emissions%20trading,Switzerland%20and%20the%20United%20States.
62 https://climate.ec.europa.eu/sites-0/emission-trading-system-mrv-reporting_en.
63 Emission factor for our purpose means the average emission rate of a greenhouse gas relative to the amount of fuel of material consumed by a process (assuming complete oxidation for combustion and complete conversion for all other chemical reactions).
64 Renewable Energy Directive, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC
65 Guidance document No. 3, Biomass issues, https://climate.ec.europa.eu/system/files/2022-10/gd3_biomass_issues_en.pdf.
66 https://www.iso.org/standard/71313.html.
67 Justus Böning, Virginia Di Nino, Till Folger, Benefits and costs of the ETS in the EU, a lesson learned for the CBAM design, European Central Bank, report No 2764 / January 2023.

3.5.2 Cement

Although difficult to believe but, around the world, cement production alone amounts for about 8% of total production of global CO_2[68] and 15% of all energy used in manufacturing[69]. Cement/concrete is the second most-used material in the world, after water, and its contribution to global CO_2 exceeds that of aviation. If 'cement' were a country, it would be the third greatest emitter of CO_2, behind only the US and China.

Cement is, however, the backbone of the construction industry; when mixed with water, it forms concrete or mortar is widely used in the construction of buildings, roads, dams and bridges. The terms "cement" and "concrete" are often used interchangeably, but it is important to understand that cement is the powder which, when mixed with water, aggregates and possibly other additives, hardens to form concrete or mortar.

The primary component of cement is limestone. To produce cement, limestone and other clay-like materials are heated in a kiln at 1 400 °C and then ground to form a lumpy, solid substance called clinker; clinker is then combined with gypsum to form cement. Cement manufacturing is highly energy- and emissions-intensive because of the extreme heat required to produce it. Producing a tonne of cement generates nearly a tonne of CO_2. Given its high emissions and critical importance to society, cement is an obvious place to look to reduce greenhouse gas emissions.

The production of cement releases greenhouse gas emissions both directly and indirectly: the heating of limestone releases CO_2 directly, while the burning of fossil fuels to heat the kiln indirectly results in CO_2 emissions. The direct emissions from cement occur through a chemical process called calcination. Calcination occurs when limestone, which is made of calcium carbonate, is heated, breaking down into calcium oxide and CO_2. This process accounts for ~50% of all emissions from cement production.

Indirect emissions are produced by burning fossil fuels to heat the kiln. Kilns are usually heated by coal, natural gas or oil, and the combustion of these fuels produces additional CO_2 emissions, and this represents around 40% of emissions. Finally, the electricity used to power additional plant machinery, and the final transportation of cement, represents another source of indirect emissions and account for 5-10% of the industry's emissions.

Indirect emissions from burning fossil fuels to heat the kiln can be reduced by switching to alternative fuels, including biomass and waste-derived fuels such as tyres, sewage sludge and municipal solid wastes. These less carbon-intensive fuels could reduce overall cement emissions by 18-24% from 2006 levels by 2050. Alternatively, efficiency measures can reduce the demand for fuel by addressing the production process itself (such as switching from inefficient wet kilns to dry ones) or through technical and mechanical improvements (such as preventative maintenance to repair kiln leaks). While some estimate that energy efficiency improvements could achieve emission reductions of up to 40%, some industry analyses suggest that producers may have already exhausted this potential. Without additional financial incentives (such as subsidies or a tax on carbon), further breakthroughs could be difficult.

Reducing emissions from the calcination process means looking to a material other than limestone. Blended cement replaces some of the limestone-based clinker with other materials, primarily coal fly ash and blast furnace slag. It could reduce CO_2 emissions by as much as 20%, but its widespread use is limited by other environmental regulations (these substitutes can contain toxic heavy metals); the limited availability of substitute material; and some building code restrictions (blended cement can take longer to set).

68 https://www.cbsnews.com/news/cement-industry-co2-emissions-climate-change-brimstone/#:~:text=Cement%20is%20the%20most%20widely,global%20carbon%20emissions%20from%20aviation.
69 https://www.sciencedirect.com/science/article/pii/S2211467X20300122

Ukraine has 10 cement producers[70] in 2023, although it is not known whether these are all full operational. Ukrcement, the Ukrainian Cement Association, says that its members reported a record 11 Mt of cement production in 2021. Clinker production totalled 8.11 Mt during the same period[71]. These figures may be considered conservative once the war ends and reconstruction starts.

Today, the cement industry of Ukraine has been modernised by mainly replacing 'wet' technology of cement clinker production to 'dry', which contributed substantially to energy use and CO_2 emissions reduction. One producer, CJSC "Ivano-Frankivsk Cement"[72], decided to invest in energy efficiency and researched the potential solutions. The company addressed UKEEP, a credit facility developed by the European Bank for Reconstruction and Development (EBRD), targeting Ukrainian private companies in all sectors, for financing of the project and advisory package.

The project consisted of shifting from the traditional 'wet' production method, which is energy intensive and obsolete by modern standards, to the 'dry' method that requires replacement of the whole production line, construction of new storage, crushing, grinding and feed-in units, as installation of new kiln, pre-heater, cooler and other equipment.

The €80 million investment, where UKEEP financing made up €13.5 million, helped the company to reduce its energy consumption by 50% with the simultaneous 60% expansion of production, allowing repayment of investment in just 9 years. CO_2 emissions reduction as a result of this project reached a significant 3 million tonnes per year. Given that these savings have already been achieved, it can be assumed that Ukrainian cement manufacturers will not return to outdated production processes.

Beyond the savings above, there remain many other larger or smaller potential savings (Table 13). Alireza Mokhtar and Mohsen Nasooti[73] provide a very thorough list, as the following table shows (with ton and $ converted to tonne and €). A full analysis of potential energy and CO_2 savings from Ukrainian cement manufacturing plant was well beyond the scope of this project, and would require a detailed knowledge of the current condition of each plant.

It is unclear exactly which of the energy savings shown below would be feasible for Ukraine, but replacement of carbon-based fuels with biofuels, such as municipal waste (the high temperatures required in cement kilns allow many waste materials to be burnt), is identified as one of the main areas of potential. Single-use plastics, a problem in themselves, are an obvious candidate fuel source, but the biggest stumbling block for wider usage of alternate fuels is turning out to be the cost of transportation. Cement manufacturing is a low margin process which cannot justify the added cost of transporting waste over long distances. It is, in fact, not economically viable to transport waste over 200 km for burning in cement kilns, assuming cement is priced normally as is done now[74]. There is also a need to set up appropriate collection systems if non-recyclable waste is to be used. However, taking this option alone, and assuming 10 Mt of annual cement production, 6 TJ or 1.6 GWh per year. The use of LED lighting also seems like a clear option, with low investment costs and a short payback period, and with the potential to save 3.3 GWh per year.

Unfortunately, the two options with the greatest energy saving potential, low and high temperature heat recovery, which are thermodynamically inefficient, also have rather long pay-back periods and, consequently, may not be economically feasible. It might, however, be possible to use the heat locally for other purposes.

70 https://www.cemnet.com/global-cement-report/country/ukraine
71 https://www.globalcement.com/news/item/13733-update-on-ukraine-february-2022#:~:text=Ukrcement%2C%20the%20Ukrainian%20Cement%20Association,year%20from%209Mt%20in%202020.
72 https://ebrdgeff.com/projects/energy-efficient-wine-storage-2-2/ (ignore the reference to "wine storage").
73 A decision support tool for cement industry to select energy efficiency measures, Energy Strategy Reviews 28 (2020) 100458.
74 https://www.ennomotive.com/cement-manufacturing-emissions/

Table 13 — Potential energy and CO_2 savings in cement production

Measure	Electrical saving kWh/t	Thermal saving GJ/t	Investment cost €/t	Payback period (year)	Installation time (month)
Efficient transport systems (elevator instead of air conveyor)	3.74	0.00	2.8	10.0	3
Raw mill blending systems	3.31	0.00	3.4	10.0	4
Process control vertical mill	1.71	0.00	0.9	2.0	3
High-efficiency roller mills	12.18	0.00	5.1	10.0	18
High-efficiency classifiers	6.12	0.00	2.0	10.0	12
Energy management and process control	4.41	0.00	0.9	10.0	3
High-pressure roller press	19.84	0.00	4.9	1.5	12
High efficiency classifiers in cement (product) mill	4.35	0.00	1.8	10.0	12
Improved grinding media in ball mills	4.41	0.00	0.5	8.0	1
High efficiency motors (applying variable speed drive)	3.31	0.00	0.2	1.0	1
Efficient fans with variable speed drive	7.71	0.00	1.2	2.5	5
Optimisation of compressed air systems	3.31	0.00	0.2	1.0	9
Efficient lighting (LED)	0.33	0.00	0.3	3.0	1
Production of blended cements	(12.12)	2.40	0.7	3.0	2
Use of waste derived fuels (tyres etc.)	0.00	0.66	1.8	1.0	3
Production of low alkali cement	3.09	0.33	0.0	1.0	1
Use of steel slag in kiln process (clinker to cement ratio)	0.00	0.21	0.9	2.0	1
Preheater kiln upgrade to precalciner kiln	0.00	0.47	17.4	5.0	12
Long dry kiln upgrade to preheater/precalciner kiln	0.00	1.54	17.4	10.0	24
Older dry kiln upgrade to multi-stage preheater kiln	0.00	0.99	32.1	10.0	24
Convert to reciprocating grate cooler	(3.31)	0.30	2.7	1.5	12
Kiln combustion system improvements	0.00	0.33	0.9	2.5	2
Optimise heat recovery/ upgrade clinker cooler	(2.20)	0.12	0.2	1.5	2
Seal replacement in the kiln process	0.00	0.01	0.1	0.5	0.5
Low temperature heat recovery for power	30.31	0.00	3.1	3.0	12
High temperature heat recovery for power	24.24	0.00	3.1	3.0	12
Low pressure drop cyclones	2.81	0.00	2.8	10.0	9
Efficient kiln drives motors	2.76	0.00	0.3	3.0	5
Improved refractories material	0.00	0.55	0.3	1.0	1
Kiln shell heat loss reduction	0.00	0.40	0.3	1.0	1
Adjustable speed drive for kiln fan	6.72	0.00	0.2	2.5	5
Selecting raw material with lower friction coefficient	0.11	0.00	0.1	1.0	6
Selecting raw material with lower humidity	0.00	0.11	0.1	1.0	6
Selecting raw material with lower dimension	0.11	0.00	0.1	1.0	1

In 2021, the Ukrainian cement industry emitted 4.2 Mt of C02, from a total of 210 Mt[75]. The Global Cement and Concrete Association (GCCA) has set out a Roadmap[76] to reduce CO_2 emissions by 20% by 2030. This, in the case of Ukraine, would reduce emissions by the order of 1 Mt CO_2. The potential areas for economies are shown in Figure 9:

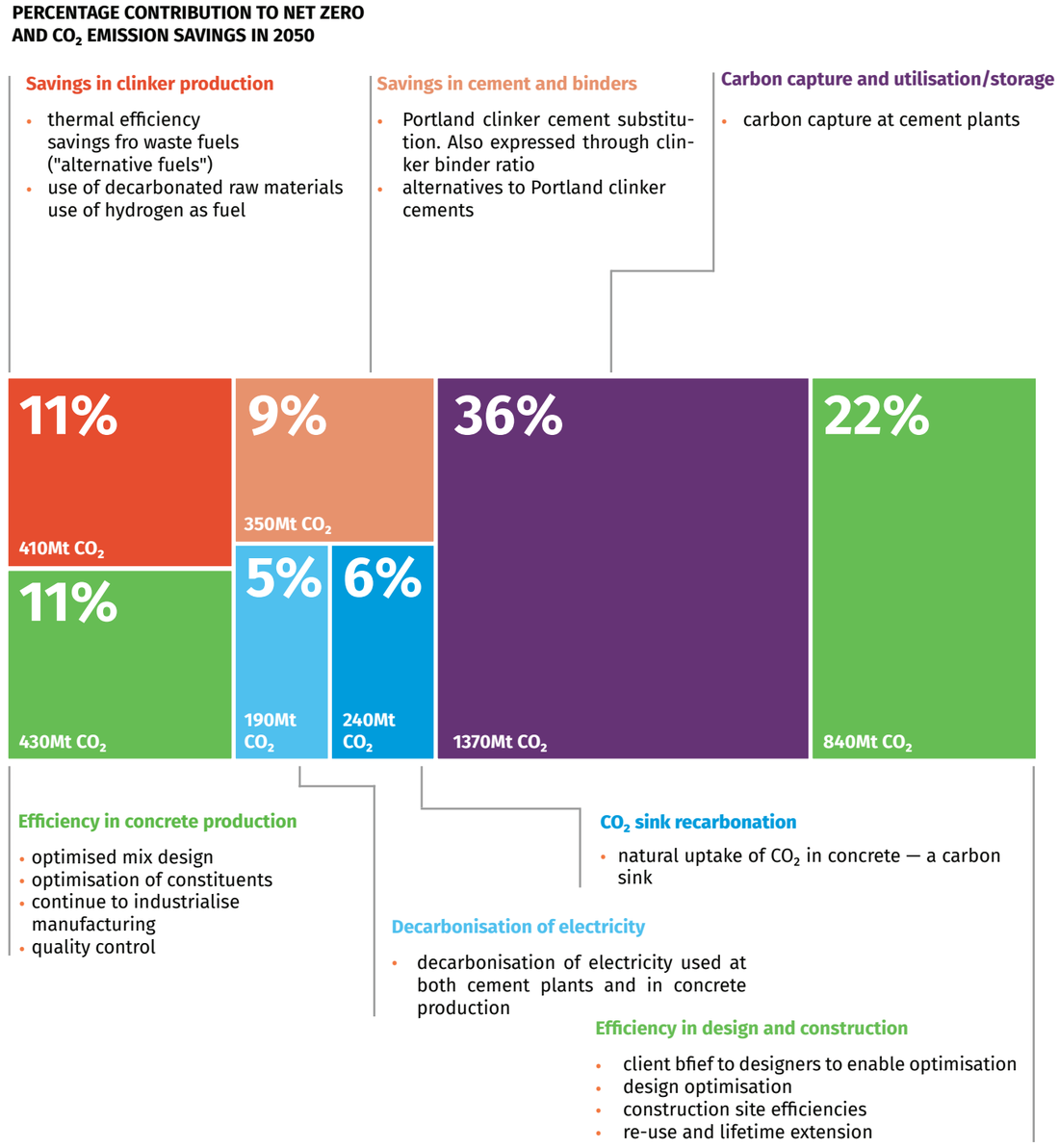


Figure 9 — Potential CO_2 reductions for cement and concrete production

75 https://globalcarbonatlas.org/emissions/carbon-emissions/.
76 https://gccassociation.org/concretefuture/wp-content/uploads/2022/10/GCCA-Concrete-Future-Roadmap-Document-AW-2022.pdf.

Between 2020 and 2030, GCCA proposes accelerated CO_2 reductions through the following actions and initiatives:

- increased clinker substitution, including fly ash, calcined clays, ground granulated blast-furnace slag and ground limestone,
- fossil fuel reductions and increased use of alternative fuels.

One final option which is currently undergoing trials around the world, is carbon capture8. As mentioned earlier, cement produces CO_2 as a by-product, so, unless the CO_2 is captured, stored or utilised, it is not possible to drastically reduce the emissions from the cement plant, CO_2 capture being the easiest part of the process. There are ready solutions available that can capture the emitted CO_2 from the process: oxyfuel combustion, chemical looping, all-electric process heating (especially if generated from renewables), etc. are some of the technologies that are in various stages of development for carbon capture.

However, installing these technologies in a process like cement is not viable in today's economy. The average cost of production of cement is around €60/tonne. With a limited profit margin, investment costs and limited potential for realizing carbon costs, the currently viable selling price for cement is around €80/tonne. Unfortunately, the operation of CO_2 reduction using technologies available today costs roughly €60/tonne of cement produced. A cement manufacturer might, therefore, spend the same cost for preventing CO_2 emission as he spends on producing cement.

This is currently unviable in the present economic scenario for a sustainable cement manufacturer to realise a reasonable return on his investment. The only option would be for the additional cost to be borne somehow, either by some form of State subsidy or by the manufacturer selling his cement, at a premium, as "green cement". This latter, however, is unlikely to succeed, given the construction industry's strong preference for 'lowest cost', if normal cement remains on the market at much lower cost.

In summary, from the available evidence and without a detailed knowledge of the Ukrainian cement industry, this report finds the potential to save of the order of 5 GWh/year energy through two relatively simple measures: using waste as a fuel source and installing LED lighting, and CO_2 emissions reductions of the order of 1 Mt per year by 2030, requiring a total investment of €18 M for waste as fuel and €3 M for LEDs. The investment for fuel is assumed, however, to be the investment required at the cement plant alone, not any costs associated with collecting, transporting and possibly treating the waste.

3.5.3 Steel and aluminium

Steelmaking in Ukraine remains an important industrial sector; it contributed around 12% to GDP and accounted for 23% of Ukrainian goods exports in 2018. In Soviet times, Ukraine produced more than 50 million tonnes annually. That fell to 21-22 million tonnes by 2021 (which might be considered to the last 'normal' year) and, after Russia invaded last year, output fell back dramatically to 6.3 million in 2022. The slump is explained in part by Russia's territorial gains that have led to the loss of control over, or destruction of, giant plants, notably in Mariupol where the Azovstal steelworks was the scene of some of the fiercest fighting of the conflict[77]. Ukraine's total production capacity is now at about 30 Mt/y, because some plants have been lost in non-government-controlled areas of the country.

Ukraine possesses substantial natural reserves of iron ore. Ore mining normally exceeds the demands of domestic steel mills, but extraction costs are high. The Ukrainian iron and steel industry is concentrated in central (Kryvyi Rih), southern (Zaporizhia, Nikopol) and eastern (Dnipro, Donets Basin, Mariupol) regions of Ukraine. There are 14 iron ore mining companies, 15 iron and steel mills, and three ferroalloy plants. Most of iron and steel is produced by large mills with annual capacity of between 4 and 7 million tonnes[78]. It is estimated[21] that 50% of total steel production is used in construction, so this is the figure used in this section.

Steelmaking in Ukraine is based on three main technological routes: The blast furnace and basic oxygen furnace (BF-BOF) integrated route, open-hearth steelmaking (BF-OHF), and recycling mainly scrap steel in Electronic Arc Furnaces (scrap-EAF). The BF-BOF route is dominant in Ukraine, accounting for 70% of crude steel production in 2019, in line with its share in the world market. The outdated OHF technology still accounted for 24% of crude steel with scrap-EAF only accounting for 6%. CO_2 emissions of the Ukrainian steel sector are substantial. Using world average emission intensities of steelmaking technologies, Ukraine's steel industry emitted 48 Mt CO_2 in 2019 (about 17% of Ukraine's total CO_2 emissions, 24 Mt for construction). This estimate is probably low, with emissions higher than the international average[79].

A specific report, undated but probably from 2020-2021[53], studied the Ukrainian steel industry specifically, and it is this report which has been used for the drafting of this section. In general, there are three ways to save energy and reduce CO_2 emissions: optimising production processes (but without hardware changes), retrofitting existing production infrastructure or replacing plants with newer technology. Each of them has specific limitations for Ukrainian producers.

Optimising production processes could involve using coal with a lower sulphur content, pig iron with lower silicon content and an optimal share of scrap metal in the steel production. The quality of Ukrainian domestic coal is also not ideal for this, however. Some adjustments to production processes are likely to be the least-cost method to reduce emissions, but total reductions are limited by the technical potential and other factors such as limited scrap steel availability and the costs of imports.

Retrofitting existing production infrastructure refers to the modernisation of existing equipment without rebuilding entire plants. This includes, for example, the installation of Pulverised Coal Injection (PCI) or Carbon Capture and Storage (CCS) facilities. In the past, Ukrainian companies have invested in retrofits such as PCI, that increase the commercial efficiency of steel making and reduce emissions. This option has potential, but it should be considered that, eventually, the present plants will need to be replaced with completely new technology and costly refits should be avoided if their effect is to limit the replacement of old technologies.

Replacing plants with newer technology is the most expensive avenue but has the potential to substantially reduce or cut emissions and create efficiency gains. Eventually, the present park of BF-BOF and BF-OHF plants could for example be replaced by hydrogen-DRI-EAF plants. The direct-reduced iron (DRI) technology linked with EAF is a complete alternative to other steelmaking technologies. Hydrogen-based DRI-EAF is particularly attractive as it could produce steel without CO_2 emissions if hydrogen is generated using zero-carbon electricity. This and other technologies to fully decarbonise steelmaking are currently operated in pilot projects but are likely to reach commercial maturity in the next decade. The main difficulty for Ukraine's steel sector will be covering the massive investments required in a competitive market environment with low and uncertain margins.

The report proposes several related policy measures, consisting of a "stick" (an increasing CO_2 tax) and "carrots" (support for investment into less emissions-intensive steelmaking and access to discounted credit). It suggests a progressive introduction of a carbon tax on the steel sector, reaching a level of EUR 39/t in 2050. Revenues from the CO_2 tax should be fed back to the steel sector in the form of investment support through a "modernisation fund", modelled on the EU modernisation fund. This fund should provide co-financing of investments that lead to reduced CO_2 emissions and be set up in cooperation with an international bank, ideally the European Investment Bank.

Further, development banks should make credit available at lower rates for investments that lead to reducing CO_2 emissions in steelmaking, because otherwise borrowing costs might a constrain investment. Steelmakers should have the possibility to procure a significant part of their power demand from renewables and, finally, an integrated strategy for a low-carbon steel sector should be created to anchor expectations and ensure consistency of private investments and public policy. Full decarbonisation of the Ukrainian steelmaking sector should be achieved by 2050, in line with the intended decarbonisation of the EU steel sector. This will ensure that Ukraine does not fall behind in this essential technological development, and possibly be locked out of markets because it does not meet environmental/emissions standards or is subjected to high carbon border adjustment taxes.

The report also highlights chronically low investment in the steel industry in Ukraine, which appears to be an important factor for the high cost base because operational costs of older, less efficient plants are higher. Since 2008, capital investment in the steel industry was around €18/t of steel on average, which is a small percentage compared to steel prices around €450/t. More investment would have increased capital costs, but decreased operational costs. The conditions for investment, however, are not very promising, with protectionism limiting exports, low general world steel prices and, in Ukraine, high operating costs. If markets which differentiate between 'clean' and 'dirty' steel can be developed, or if a greater percentage of production could be used on the home market, conditions might improve somewhat.

It is generally acknowledged that decarbonising steel is one of the harder challenges of greening any economy. A key challenge is that CO_2 emissions in the predominant blast furnace process are not due to energy usage but to the chemical process of reducing iron oxide. The figure overleaf summarises the proposals for a total decarbonisation of the Ukrainian steel-manufacturing industry by 2050, 'pushed' by a rising CO_2 emissions tax but where about half of the necessary investments would be covered by revenues from this tax. By the time the tax reaches its peak of €39 /t CO_2, there will be no emissions and, consequently, no producers will be paying the tax. This proposal assumes an ultimate total change to hydrogen-based DRI-EAF (zero carbon cannot be achieved by process improvements or retrofitting), and if recycling efforts can increase the quantity of recycled steel, this will also help.

77 https://www.reuters.com/markets/commodities/ukraines-once-mighty-steel-sector-choked-by-export-blockade-2023-10-26/#:~:text=In%20Soviet%20times%2C%20Ukraine%20produced,hit%206.3%20million%20in%202022.
78 https://en.wikipedia.org/wiki/Metal_production_in_Ukraine.
79 Towards a decarbonisation of Ukraine's steel sector, David Saha, Low Carbon Ukraine and Berlin Economics, https://www.lowcarbonukraine.com/wp-content/uploads/Towards-a-decarbonisation-of-Ukraines-steel-sector.pdf.

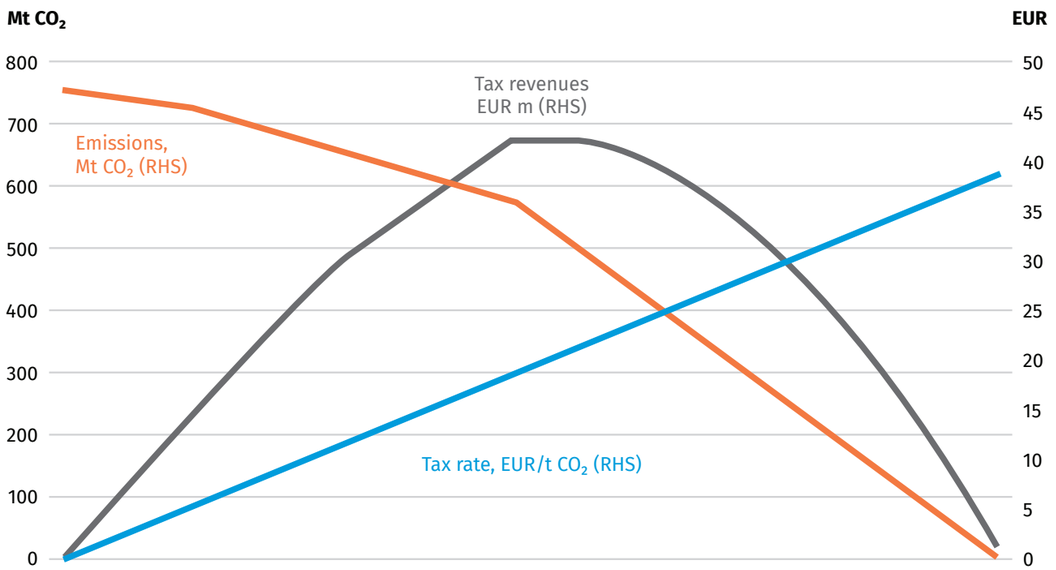


Figure 10 — CO_2 tax rates and emissions, 2021-2050

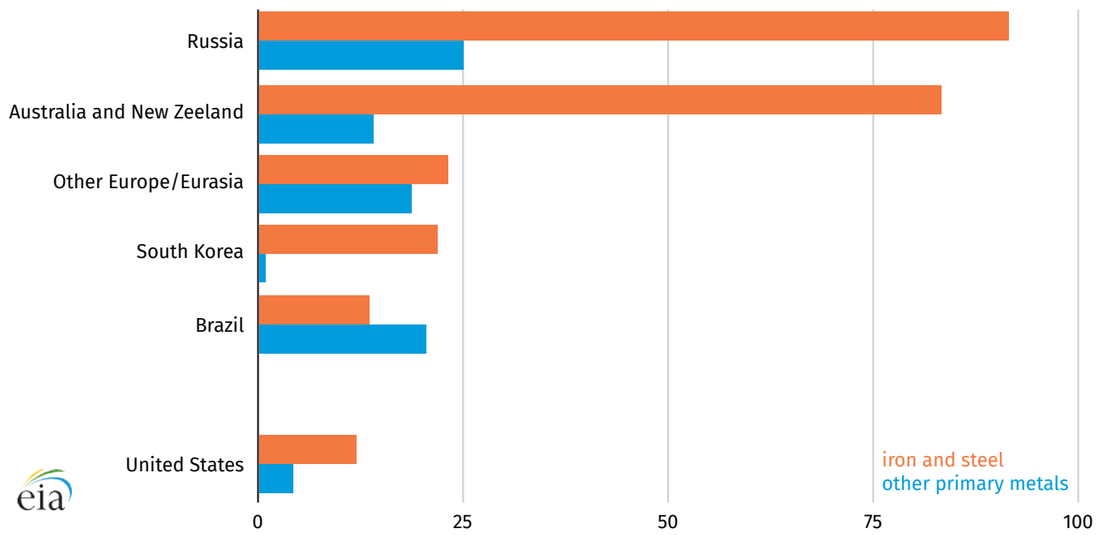


Figure 11 — Basic metal energy intensity per unit of production, 2018

Calculations show that that the operational costs of DRI-EAF steelmaking could be lower than that of the current mix of plants if sufficiently cheap (zero-carbon) electricity is available. The decarbonisation of the steel sector will require zero-carbon electricity at low prices to work. If all current steel plants were replaced by electrically powered hydrogen-based DRI-EAF production facilities, Ukraine would need an additional 52 TWh/y of electricity, from which 40 TWh/y would be required to generate the 1 Mt of hydrogen necessary to reduce the iron ore. While this is an ambitious target, such a build-up of renewables is possible[80], see also the section on renewable energy.

It is estimated that, to meet Ukraine's demand for steel production, investment of about €23 billion would be required. Note, though, that this is total investment in all steel production, 80% of which is exported. The investment required just to decarbonise the steel used for construction in Ukraine would amount to just €2.3 billion.

In summary, and looking more widely than just the Ukrainian construction sector, there are potentially large greening gains (in terms of CO_2 emission reductions) possible, given sufficient investment. A successful incentivisation of investment into efficient, carbon-neutral steelmaking by the combination of CO_2 tax and investment support would save roughly 750 Mt CO_2 emissions by 2030, almost 7 000 Mt by 2050. The investment would not only provide for greener steel production, it would also strengthen the Ukrainian steel sector, allowing it to continue to trade on world markets. Unfortunately, while the analysis in the report used as the basis for this section is thorough, it does not offer any estimations of cost-benefit nor potential energy saving. These, therefore, would require more specific further research.

The consumption of extruded aluminium in construction in Ukraine (extruded aluminium is the major product used in construction) grew from 30.7 million tons in 2020 to 33.4 million tons in 2021. The cost of energy is key in aluminium production because, as one of the most energy-sensitive industries, it accounts for 12% of the global industrial sector's energy use. Aluminium production is also a significant source of CO_2, with world production emitting nearly 270 Mt of CO_2 in 2022 (about 3% of the world's direct industrial CO_2 emissions) and, if indirect emissions from electricity consumption are included, that number jumps to around 1 Gt of CO_2. Assuming that Ukrainian aluminium production continues to use Soviet technology, Figure 11 shows that its energy usage per unit of production is the highest in the world.

80 Energy Strategy 2035. Implementation progress Nov 2019 – Feb 2020, Lower Carbon Ukraine, Quarterly monitoring report, 03/2020.

Aluminium, which is soft, is almost never used in its pure form. Instead, alloys are typically made with magnesium, manganese, copper, and silicon, and may be up to 15 times stronger than pure aluminium. The main advantage of aluminium, however, is that it is infinitely recyclable, without losing its intrinsic properties, and can be recycled between industries, of which packaging, vehicles and construction are the largest[81] [82].

It requires about 17 000 kWh of electricity to produce one tonne of aluminium, this being made up of 500 kWh in bauxite mining, 16 000 kWh in the primary smelting process, and 500 kWh in casting. Aluminium production also requires a large quantity of water, about 7 000 m^3 per tonne (see below). With primary smelting being by far the greatest energy-consuming process, using recycled aluminium can help reduce this, as can switching from fossil fuels to renewables for the generation of the required energy, although renewables have the problem of intermittency. Recycled material can come from within the production plant itself, or externally, and there is a 95% energy saving from using recycled aluminium compared with primary smelting[83].

Globally, internal recycling is around 95%; end-of-life (external) recycling rates are about 75%; figures for internal recycling cannot be found for Ukraine, but external recycling is about 67% except packaging, which is far lower at 37%[84]. Much packaging aluminium goes into foil pouches and multilayer materials that cannot be recycled affordably, suggesting a need to change package design. There is no a priori reason why Ukraine should not aspire to the 75% global external recycling rate nor, indeed, why that figure should not be higher throughout the world.

Two further ways to reduce CO_2 emissions are to change the source of energy from fossil fuels to renewables. Also, nearly all aluminium primary smelting currently uses carbon anodes that release CO_2 as a part of the electrolysis process. These anodes can be replaced by inert anodes made from different materials that do not release CO_2 during electrolysis[85]. Many companies are also exploring carbon capture and storage, and mechanical vapour recompression, which recycles waste heat to improve efficiency. The industry's current pipeline of green projects, however, is likely not enough to achieve this ambitious 95 percent reduction target.

To generate the large, stable loads needed for aluminium production, some producers have turned to hydropower. But this option potentially has limited growth, is regionally specific, and may be impacted by potential droughts.

81 https://www.eia.gov/todayinenergy/detail.php?id=38392#:~:text=Within%20the%20industrial%20sector%2C%20the,and%20other%20intermediate%20metal%20goods.
82 https://www.sciencedirect.com/topics/engineering/aluminum-production#:~:text=About%2017%2C000%20kWh%20of%20electricity,produce%201%20tonne%20of%20aluminium.
83 https://alfed.org.uk/files/Fact%20sheets/3-aluminium-and-sustainability.pdf
84 https://www.treehugger.com/russia-ukraine-war-affects-green-aluminum-5221119.
85 https://www.iea.org/energy-system/industry/aluminium

Nuclear energy, in the form of small modular nuclear reactors, offers promise but is still at an early stage. For many smelters with their own generation ability, the most realistic short- to medium-term option may be retrofitting coal-fired power plants or natural-gas combined cycle plants with carbon capture utilisation and storage[86].

McKinsey and Company[60] report some of the challenges faced by the aluminium industry, and the whole process of cost-benefit-analysis. One of the challenges to aluminium decarbonisation is that the best currently available fossil-fuel-based technology has a net present value greater than the green alternative. Consequently, overcoming these economic obstacles and mitigating potential risks will likely require collaborative action among stakeholders. Banks, investors, policy makers, and end customers can each play an important role.

Aluminium producers will need to retire fossil-fuel-based production and make new investments in low-carbon alternatives, even though these are likely to have a lower return on capital and entail a certain amount of technology and implementation risk. Financial institutions have the capability to mitigate some of these risks and shift cash flows toward green investments.
Given the generally high levels of debt in the aluminium industry, improved interest rates for low-carbon investments and new products such as green loans or bonds used exclusively for climate-friendly projects could be key enablers. Additionally, banks could incorporate climate considerations into their lending decisions, such as those developed by the Centre for Climate-Aligned Finance. Financial partnerships designed to support sustainable investment are already happening, such as the Net-Zero Banking Alliance (NZBA), which brings together banks representing 40% of global banking assets.

Government grants to aluminium producers could potentially help offset some of the costs of green investment, while 'carbon contracts for difference' could bring the operational costs of decarbonised operations in line with those of fossil-fuel-based technology. However, analysis shows that the greatest impact to the economics of decarbonisation could come from carbon pricing, whether through trading schemes or carbon taxes. This could spur investment in green aluminium and enable the economics of the industry's net-zero transition. Aluminium customers (users) also have an important role to play in creating demand and helping shift the industry toward decarbonisation. For example, this could include a 5 to 10% premium for green aluminium or by making firm advance commitments to purchase it.

In summary, and as for steel production, it has proved impossible to identify specific details for the Ukrainian aluminium industry or its state of development. Moreover, there appear to be no reports showing clear cost-benefit-analysis in what is a complex area requiring a holistic approach whereby conventional net-present-value might be an inappropriate form of decision making. Some minimum conclusions can be drawn, however:

1) there are potentially large CO_2 savings from switching away from fossil fuels, and this switch is required to achieve net-zero commitments. Whether this switch is to renewables, which have intermittency challenges, or small-scale nuclear, is not yet clear, but will likely be more expensive than 'simple' improvements in local fossil fuel generation;

2) there are CO_2 saving possible, too, from changing from carbon to inert anodes, and the fact that companies have started doing so gives confidence that it is cost effective;

3) there are huge energy (and CO_2) savings from enhanced aluminium recycling;

4) the policy measures required to bring these changes about are complex and involve multiple actors.

Finally, water consumption has not been considered in other parts of this report, but it is potentially important if climate change starts inducing water shortages. The following table shows the water consumption per tonne of aluminium[87]:

Table 14 — Water consumption per tonne of aluminium

	Electricity generation	Bauxite mining	Primary smelting	Shape casting	Total
Fresh water input (t)	1 066	1.1	7.6	5.5	1 080
Contribution (%)	99	0.1	0.7	0.5	100

As can be seen, it is electricity generation which totally dominates, and could be eliminated by a shift to renewable energy. Within the production process itself, the greatest potential water saving comes from primary smelting. This final part of the analysis, though, does show that greening analysis does need to look beyond energy consumption and CO_2 emissions.

86 Sustainable aluminum: Decarbonizing at a cost that makes sense | McKinsey.
https://www.mckinsey.com/industries/metals-and-mining/our-insights/aluminum-decarbonization-at-a-cost-that-makes-sense
87 https://www.sciencedirect.com/topics/engineering/aluminum-production#:~:text=About%2017%2C000%20kWh%20of%20electricity,produce%201%20tonne%20of%20aluminium.

3.5.4 Concrete

After water, concrete is the most widely used substance on Earth and it is the foundation of modern development, By one calculation, we may have already passed the point where concrete outweighs the combined carbon mass of every tree, bush and shrub on the planet. Our built environment, in these terms, is outgrowing the natural one. When combined with steel, it is the material that ensures our dams do not burst, our tower blocks do not fall, our roads do not buckle and our electricity grid remains connected. But though the problem is bigger than plastic, it is generally seen as less severe, because concrete is not derived from fossil fuels[88].

The strength of concrete can be very necessary and reassuring, and it can resist nature for decades. But, at times, it can suddenly amplify nature's impact. The floods in New Orleans after Hurricane Katrina and Houston after Hurricane Harvey were made more severe because urban and suburban streets could not soak up the rain like a floodplain, and storm drains proved woefully inadequate for the new extremes of a disrupted climate. Earthquakes, too, can reduce incorrectly-designed concrete buildings to rubble in an instant, often with many lives lost, as evidenced by the 2011 Tohoku earthquake and tsunami in Japan.

From an environmental perspective, concrete is not a particularly good product, either! Taking in all stages of production, concrete is said to be responsible for 4-8%of the world's CO_2 emissions although, as discussed above, about half of concrete's CO_2 emissions are created during the manufacture of clinker, the most-energy intensive part of the cement-making process Among materials, only coal, oil and gas are a greater source of greenhouse gases. The large CO_2 emissions are, of course, derived almost entirely from energy used in the production processes of both cement and concrete.

But other environmental impacts are far less well understood. Concrete uses almost one tenth of the world's industrial water use, which can strain supplies for drinking and irrigation. In cities, concrete can add to the 'heat-island' effect by absorbing the warmth of the sun and trapping gases from car exhausts and air-conditioner units.

One of the main problems with concrete is 'inertia'. Political parties the world over need the donations and other support from building firms to get elected, state planners need more projects to maintain economic growth, and construction bosses need more contracts to remain profitable, keep staff employed and political influence high. Hence the self-perpetuating political enthusiasm for environmentally and socially dubious infrastructure projects. Unfortunately, this often leads to corruption of one form or another, with the result being that projects of dubious if any merit are built, which might be 'profitable' for a few but undoubtedly environmentally damaging for the many. Just by way of example, in its push for economic development, it is estimated that China used more concrete in three years than the US used in 100 years!

Unlike cement, for which fairly accurate production figures are widely available, there are no reliable data regarding concrete production at a national level. This may be because a great deal of concrete is produced on construction sites and is not recorded, and also because of the vast numbers of producers of ready-mixed concrete and of precast concrete products in most countries when compared with cement producers; the former may well outnumber the latter by several hundred times. Consequently, it is impossible to give figures for Ukraine, and the only option is to take generic information from the Global Cement and Concrete Association (GCCA). To put the issue into context, though, in 2020 the GCCA estimates that global production of concrete amounted to 4.2 billion tonnes, with a total value of €400 billion.

Figure 6 above, in the Cement section, shows the potential savings in CO_2 emissions for both cement and concrete production combined. It is difficult to disaggregate the two, but it appears that roughly half of total CO_2 emissions can be attributed to cement and the other half to concrete, i.e. about 1 910 million tonnes each. Between 2020 and 2030, GCCA proposes a 25% reduction in CO_2 emission from the concrete industry worldwide (960 Mt), with reductions coming through the following actions and initiatives for concrete production:

- improved efficiency in concrete production,
- improved efficiency in the design of concrete projects and use of concrete during construction, including re-
- cycling,
- investment in technology and innovation,
- carbon capture utilisation and storage (CCUS) technology and infrastructure development.

One of the main changes will be a move away from fossil fuels towards renewables in both industries. Enhanced recycling will help but, as discussed above in the section on Circular Economy, crushing concrete to make aggregates risks losing many of the benefits. One possibility, potentially linked with Building Information Modelling (BIM), is to allow for the reuse of building elements, such as prefabricated wall, ceiling and floor elements.

The use of optimum design, i.e. lighter construction (less concrete) or using alternative materials for non-bearing wall elements, is a simple solution and is likely to be immediately cost-effective. The suite of European Standards in the EN 1990 series of Structural Eurocodes is a good basis for optimum design, although their widespread use would require their design principles to be taught in universities,

88 https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth.

and the computer models which allow them to be used would also need to be available widely throughout Ukraine. Adopting the Eurocodes alone, though, might prove ineffective, because of the many links between Eurocode design principles and provisions and European Standards for individual construction products, in particular concrete elements. It appears that most if not all of the required product standards have already been transposed into Ukrainian standards, but it has not proved possible to assess the extent to which these, or the Eurocodes themselves, are being applied in the country.

Recent experience from the UK is relevant here, especially with reinforced autoclaved aerated concrete or RAAC. RAAC is used to make concrete elements such as walls but in a vacuum. This causes bubbles to form in the concrete, leading to much lighter elements than conventional concrete. Originally believed to be a cheap and effective solution, especially for the construction of public buildings such as schools, serious problems have been encountered during 2023 as it became evident that RAAC elements have come to the end of their 30 year design life and either need replacing or the building demolished. This highlights another option, also mentions in the Circular Economy section above, that extending the lifetime of buildings is as effective at reducing emissions and energy consumption as are improvements in production processes.

CO_2 emissions can in principle be captured after they are produced, through CCUS. Where concrete is made at cement plants, concrete producers can actually use their own product as a sink for CO_2. Through the process of accelerated carbonation, CO_2 penetrates concrete and reacts with calcium hydroxide in the presence of water to form calcium carbonate; the result is stable, long-term CO_2 storage. As a mitigation technology, accelerated carbonation can be achieved by exposing freshly mixed concrete to flue gases with high CO_2 concentrations. This technology, while it is being trialled around the world, is not yet considered to be cost-efficient, although 10 concrete production plants have already started to use carbon capture.

In the longer-term, i.e. 2030-2050, there will still be scope for the further use of alternative fuels to drive down CO_2 emissions, and alternatives to Portland clinker cements may also play a role in decarbonisation, albeit limited, perhaps around a 5% of the market. Clinker substitution will continue but, while supplies of fly ash and ground granulated blast-furnace slag will likely decline (the former because of much reduced coal consumption in power generation, the latter because of changes in steel-making), ground limestone and calcined clay will increase in availability and be deployed as a key tool.

Ultimately, to achieve zero emissions will mean that CO_2 will need to be captured, re-used if possible, or stored. Having established by 2030 the capability and commercial case, and with infrastructure development in place, in should be possible to start the deployment of CCUS at scale. When widely deployed at full scale during cement manufacturing, carbon capture could almost fully eliminate its process emissions. This, in conjunction with biomass and re-carbonation could potentially result in the future delivery of carbon negative concrete. If this is not the case, then a move away from concrete towards other constructions might be the way forward, and this is discussed below.

The GCCA report concludes the public policy will have a crucial role to play in the decarbonisation of the cement and concrete industries. A comprehensive policy framework will need to be developed as a joint endeavour by industry, policy-makers and governments, and will include:

- making it viable to invest in low-carbon cement manufacturing,
- stimulate demand for low-carbon concrete products, including the use of appropriate carbon pricing but avoiding 'carbon leakage', which means that production simply shifts to other countries with lower levels of control,
- create the infrastructure needed for a circular and net zero manufacturing environment.

The GCCA report has considered cement and concrete manufacturing throughout the world, and it has not proved possible to extract data specific for Ukraine nor to provide cost-benefit-analysis or RIA. It is also worth mentioning that, although ready-mixed concrete is the single most used construction material, it has never been regulated at EU level. A European Standard for ready-mixed concrete has existed for many years and is widely used, but the regulation remains at national level. There is an important message here, though, and that is that individual countries are ill-advised to act unilaterally because, unless new provisions are properly applied and enforced, either manufacturers will ignore them or non-green, cheaper, products will be imported from countries with lower control levels. Actions are, therefore, required across all countries which trade together.

3.5.5 Glass

Glass is another relatively high user of energy in its production, mainly in the form of gas to heat furnaces to melt the raw materials (mainly silica) used to make glass. In total, glass manufacturing accounts for about 1% of all industrial energy usage but, of this, it might be estimated that glass used in the construction sector, in the form of flat glass uses mainly in windows and glass wool used in insulation, requires only about one quarter of this total[89].

Ukraine does not, as far as can be known, have any manufacturing plants for either flat glass or glass wool. Consequently, the policy options for glass used in the green reconstruction of Ukrainian infrastructure, will depend, as for other construction materials and products, on the setting of criteria and requirements on the import of greener products from recognised sources. This is likely to have a negative cost-benefit when compared to conventional imports if the purchase price alone is the criterion (as indeed it often is in the construction sector) so, consequently, CBA needs either to be widened to take account of wider environmental costs associated with energy consumption and CO_2 emissions, or policies need to be adopted to identify and address the purchase-price difference. Given the large range of imported construction materials and products, further research would be required for policy advice and consequences to be given in this area.

3.5.6 Plastics

The OECD estimates that global life-cycle emissions of plastics, which includes the production of the material and its disposal, was 1.8 billion tonnes in 2019. This is measured in carbon dioxide equivalents, which accounts for the different warming impacts of different greenhouse gases. Figure 12 shows this, from which it can be seen that production and conversion make up the vast majority of the total, when compared with end-of-life[90].

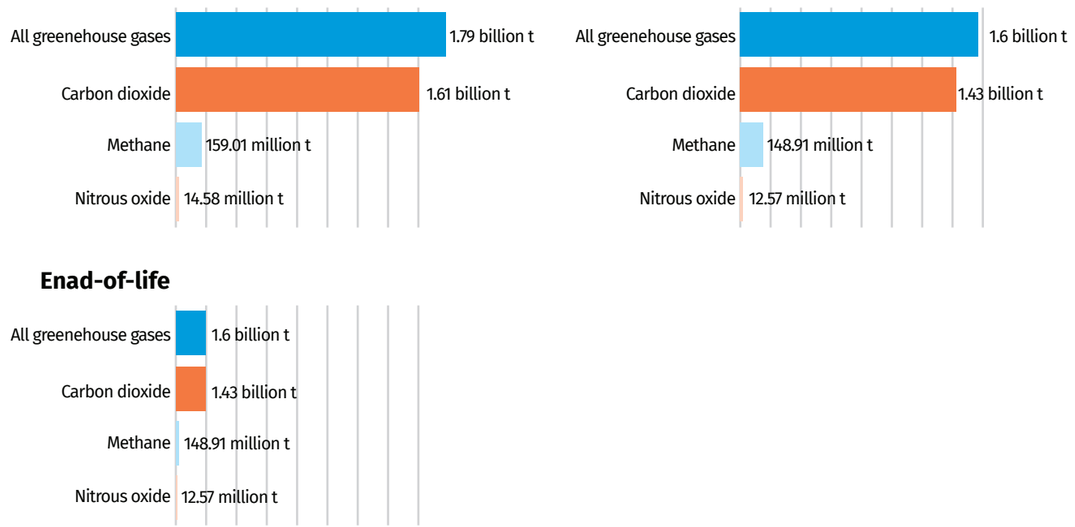


Figure 12 — Global CO_2-equivalent emissions for plastics

89 https://www.eia.gov/todayinenergy/detail.php?id=12631#:~:text=The%20bulk%20of%20energy%20consumed,number%20of%20electrically%2Dpowered%20furnaces.
90 https://ourworldindata.org/ghg-emissions-plastics#:~:text=The%20OECD%20estimates%20that%20the,impacts%20of%20different%20greenhouse%20gases.

It is further estimated[91] that the construction industry consumes 20% of all plastics (and 70% of all polyvinyl chloride (PVC)) produced globally each year. This is increasing exponentially, with global output predicted to double by 2050. It can be assumed, therefore, that plastics used in construction contribute about 0.4 billion tonnes of CO_2 currently, and that this could rise to 0.8 billion tonnes by 2050. This means that plastics used in construction are responsible for about 0.7% of annual global CO_2 emissions. Thanks to their diversity, versatility and inexpensiveness, plastics are used in a vast range of building components, such as windows and doors, internal and external finishes, paints, panels, pipes, cables, floor coverings, membranes and insulation.

Unfortunately, the potential for energy, and therefore CO_2 emissions, savings in the production of plastics is limited, and relates primarily to small efficiency savings from production equipment such as extrusion moulders[92]. Some savings can be made at end-of-life but, as Figure 9 shows, these are only about 10% of total emissions. Ukraine has both plastics manufacturers and plastics recycling companies, but data are not available for production volumes, and recycling rates remain very low.

Plastics highlight, however, one of the dilemmas for the construction industry. They have a much lower carbon footprint than concrete but, set against this, they have substantially lower durability and, importantly, there are potentially important, but currently little-understood, health concerns[65]. Plastic polymers themselves are not a health concern (except for carcinogenic PVC), but these alone are useless in construction applications. The unique properties of construction plastics are the result of the thousands of additives, fillers and reinforcing materials used in their manufacture. Many of these are untested and, of the small percentage that have been scientifically peer-reviewed, many have been found to be toxic, with the potential to cause serious harm to human health and development at manufacture, installation, use or disposal.

An analysis in 2021 identified more than 2 000 additives used in construction industry plastics, of which 25% were classified as EU substances of concern due to their persistence, bioaccumulation or toxicity. Similarly, a further study found up to 88% of chemicals in everyday plastics products, including common construction finishes, leach out into the environment during use. The dilemma, therefore, consists in substituting one environmentally-harmful product such as concrete for an alternative which is somewhat less harmful but might pose health risks, holding out for improvements in concrete production as discussed above, or considering completely different construction products, such as timber (see below) altogether.

91 https://ww3.rics.org/uk/en/journals/built-environment-journal/plastics-construction-materials-health.html#:~:text=The%20construction%20industry%20consumes%2020,PVC)%20produced%20globally%20each%20year.
92 https://www.electrex.it/en/company/about-us/saving-energy-in-the-plastics-industry.html.

3.5.7 Other construction products

The specific construction products considered in the sub-sections above are those considered to currently be the worst from an energy consumption/CO_2 emissions point of view but for which improvement, both in production and through the circular economy, are possible. With the exception of timber which is considered below, improvements in the environmental performance of other construction products involves primarily a shift away from fossil fuel-derived energy sources and towards the use of renewables. Data do not exist, however, at any level, including not at the level of Ukraine as a country, to show what the savings potential or associated costs would be.

3.5.8 Product substitution

It is often considered that changing the materials used in construction, in particular changing concrete, steel and plastics to timber removes the large energy and carbon footprint of the latter with a sustainable material. There are compelling cost and environmental arguments in favour of both, but no one definitive conclusion.

Timber is considered to be a sustainable resource[93]. Unlike other mainstream construction materials, it is renewable. It also generally emits less carbon during production than other resources. The European Standard EN 15804:2012, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products defines a renewable resource is a 'resource that is grown, naturally replenished or cleansed on a human time scale'. It also notes that 'A renewable resource is capable of being exhausted but can last indefinitely with proper stewardship. Examples include trees in forests, grasses in grasslands and fertile soil.' Provided that tree stocks are replenished through replanting and managed sustainably, the timber resource can last indefinitely.

The embodied carbon of a material is the net CO_2 emissions produced during the processes involved in its production and disposal. Carbon dioxide in this context includes all the greenhouse gases brought together into a single quantity referred to as carbon dioxide equivalent (CO_2e). During the production of timber, trees absorb, or sequester, CO_2 from the atmosphere during photosynthesis as they grow. This is stored as carbon in wood, bark and leaf material. The carbon is partly released back into the atmosphere when trees die but, if the area of forest remains constant, there is a net uptake of CO_2. Additional uptake occurs if the area of forest increases, but if the area decreases there is likely to be a net outflow.

If wood is used in timber products, there is a further increase in net uptake as its sequestered carbon continues to be stored for as long as the products remain in use. 1 kg of (oven-dried) wood contains approximately 0.5 kg of carbon, which represents approximately 1.8 kg of absorbed carbon dioxide for each kilogram of construction timber used. Some of this sequestered carbon is offset by the various processes involved in forestry work (e.g. planting, maintenance and harvesting) and in the wood processing activities (e.g., sawing, drying and planing). The larger number of processes involved in more highly engineered products (e.g. plywood, laminated timber and glulam) increases the amount of CO_2 produced. For most timber construction products, though, process emissions are less than the amount sequestered, giving a net negative embodied carbon for the finished product.

It is not generally possible to recycle timber at end-of-life in the true meaning of the word, by reprocessing into a new product with identical properties, as with steel or aluminium. But it can be reused, recycled into lower grade products (e.g. wood particleboard, animal bedding, soil mulches) and used as biomass for energy production where it can substitute fossil fuels.

The total surface area of Ukraine is 606 400 km², of which 97 000 km², or 16%, is forested[94]. If fully clear-cut, this would equate to roughly 2 billion tonnes, or about 3.6 billion m³, of timber. In a major report from the UN Environment Program[95], three main factors are identified as critical for green construction: 1) avoid the extraction of raw materials by promoting the Circular Economy, 2) move the regenerative material use, such as timber and 3) improve methods to decarbonise conventional construction materials. On the face of it, timber would achieve 1) and 2), avoid the need for 3) and is in plentiful supply in Ukraine, as would recycling/reuse of other construction materials.

The UNEP report estimates that the construction industry uses 38% of the world's timber production. Advances in timber building material technologies are making it possible to shift towards large-scale structural timber products, provided that the timber industries continue to innovate and are regulated for sustainable practices. Ensuring that the vast majority of timber is sourced from sustainable

93 https://www.istructe.org/resources/guidance/timber-and-sustainability/
94 https://www.statista.com/statistics/435296/forest-area-ukraine-square-kilometres/#:~:text=In%202021%2C%20the%20total%20amount,the%20observed%20period%20in%202021.
95 https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future?gad_source=1&gclid=CjwKCAiAqNSsBhAvEiwAn_tmxd8VapRVh364d7v9ctrEt3pqdikf3C39V1lndbyq_zOfR1STgSteHhoCPnIQAvD_BwE.

forestry will be crucial for making this a truly sustainable transition, avoiding pitfalls such as lax regulations. Timber certification schemes, requiring responsible forest management, play an essential part in this approach. Certification schemes, such as the 'Forest Stewardship Council' (FSC) and the 'Programme for the Endorsement of Forest Certification' (PEFC) have been in existence since the 1990s in the UK and, if not already in place in Ukraine, would be a good starting point if timber is going to be more widely used in a sustainable fashion in the country. Figure 13 shows the provisions required for a shift towards the inclusion of embodied energy/carbon in design codes:

A key statement from this figure is that "no consensus exists on how to benchmark or baseline the embodied carbon of a building". It is this lack of consensus which allows other positions to enter the debate on moving to alternative construction materials. The following are just three examples of where the continued use of concrete appears to come out better than a switch to timber.

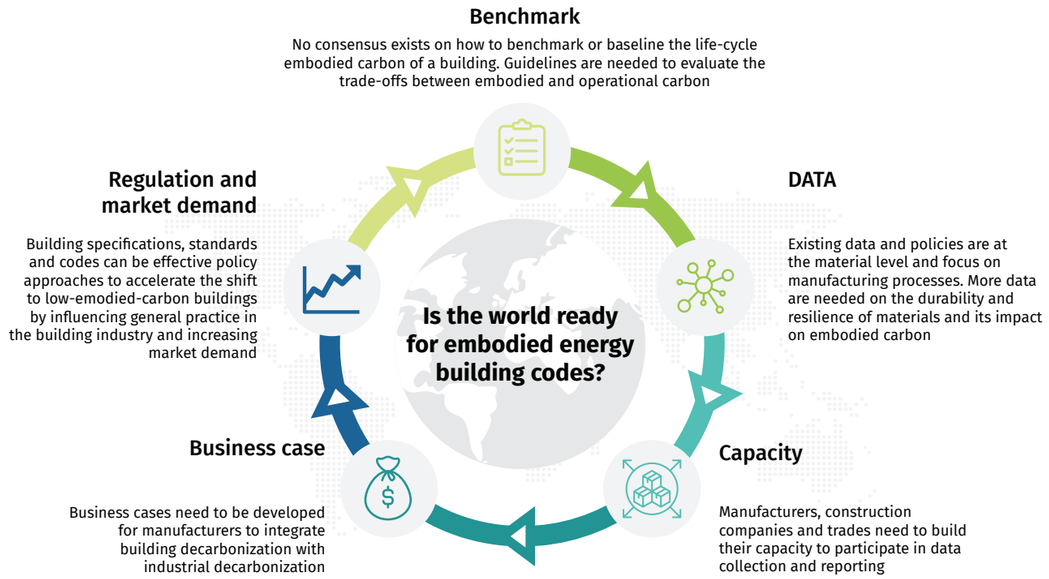


Figure 13 — Factors required for the inclusion of embodied energy in building codes

In a study conducted by Oregon State University[96], it was estimated that mass timber (structural timber) might be 6.5% higher cost than concrete construction. Another study compared the total life cycle cost of mass timber to concrete and found that timber had 26% higher front-end costs, mainly because of mass timber building's construction and utility costs. Weighed against this, it is estimated that mass timber offers a 30% reduction in construction time, especially when elements are pre-fabricated off site.

Further issues raised by the same study show the high risk, even with certified sustainable timber extraction, of substantial loss of biodiversity. While trees can be replanted, they take time to reestablish and, if large quantities are harvested at once to satisfy higher demand, large 'deserts' without wildlife risk being created. Timber also has far lower durability, and is susceptible to mould, rot and insect attack; it is also particularly susceptible to water. The paints, varnishes and other finishes used to increase the durability of timber bring with them the potential health risks associated with plastics (mentioned above), which are widely used in these products.

Finally, the study explores the perception of fire safety. In truth, mass timber, especially when fire retardant treated and combined with sprinkler systems, can have better fire performance than concrete or steel. In a fully-developed fire, timber forms a char layer on its surface and does not burn further; steel tends to buckle while concrete ultimately spalls (crumbles), both of which can lead to structural compromise of a whole building and the need for costly reconstruction, even assuming that the building can be saved. Lack of durability, and perceived fire risks, often lead to higher insurance premiums.

96 https://blog.kryton.com/2023/01/mass-timber-vs-concrete/.

A second study[97] states that "There is much misconception about the ability of timber to perform under harsh conditions; however, the correct choice of product, good design and the help of technology mean that almost any end-use can now have a timber-based solution. However, durable construction timbers take between 15 to 20 years [to grow] and over 25 years respectively to mature. The reduced availability of durable construction timber due to growth maturity years removes timber from true construction cost comparisons". This same study lists that apparent advantages of the three main construction methods (Table 15).

Some of these claims are questionable, particularly thermal efficiency and energy efficiency. Concrete's thermal conductivity is 10 times greater than that of timber, so claims of better efficiency performance for concrete can only be true if the concrete is at least 10 times as thick as the timber. As far as acoustic insulation is concerned, it is considered[98] that "a 320 mm deep wood framed floor performs better for most sound insulation ratings than an eight times heavier 150 mm thick concrete floor, especially if a heavy topping on a resilient layer is added on both".

Factors	Concrete framed	Steel framed	Timber framed
Acoustic insulation	High – this is an inherent property	Poor – additional provision should be made	Poor – additional provision should be made
Fire protection	Provides high level of inherent fire protection	Low levels of resistance, needs additional fire protection finishes	Very low levels of resistance, needs additional fire protection finishes
Thermal insulation	High thermal insulation inherent	Low – additional provision should be made	Medium – additional provision should be made
Vibration performance	High vibration performance	Medium vibration performance	Low vibration performance
Energy efficiency	High energy efficiency	Medium energy efficiency	Medium energy efficiency
Maintenance	Low maintenance	High maintenance	High maintenance
Robustness	Resistance to rusting and does not get corroded by the action of termites	Corrosion of rusting	Termite and rot prone
Insurance	Low insurance	Medium insurance	Low insurance

Table 15 — Claimed performance of three major construction techniques

Table 16 shows the comparative costs of the three construction methods, adjusted to assume that all buildings were constructed at the same (the fourth quarter of 2020).

Table 16 — Average cost of three major construction techniques

Average Cost per m^2			
Construction Type	Existing Cost	Adjusted (4Q 2020) Data	Percentage Drift
Concrete Framed	£ 1,782.54	£ 2,039.94	-31%
Timber Framed	£ 2,149.33	£ 2,375.09	-20%
Steel Framed	£ 3,355.00	£ 2,977.19	0%

97 https://www.uk-bar.org/uploads/documents/originals/135658%20Steel%20Concrete%20Timber%20report%20%20A4%20WEB.pdf.
98 https://www.researchgate.net/publication/235218769_Wood_or_concrete_floor_-_A_comparison_of_direct_sound_insulation#:~:text=This%20figure%20also%20shows%20that,dB%20better%20above%2050%20Hz.

3.6 Appliances used in buildings

3.6.1 Introduction

At the end of 2019, the European Commission announced the European Green Deal, an ambitious package of policy initiatives aimed at making the EU carbon neutral by 2050 and decoupling economic growth from resource consumption. Mineral and metal resource use in energy-using and energy-related products are responsible for large environmental impacts. To improve the environmental performance of appliances, the EU introduced product policies starting in the 1970s that focused on energy efficiency.

The current EU regulatory system consists of two 'framework' documents, a regulation on energy labelling and a directive on eco-design. These two frameworks establish the conditions for setting labelling and eco-design requirements, but they only come into full force on the publication of Implementing Acts, of which there is a series, as shown in Table 17. To date, measures have largely concentrated on energy usage. The European Commission is, however, currently starting to recognise that circularity is as important as energy usage alone. The first EU Action Plan for the Circular Economy announced that future product requirements should include circular economy-relevant requirements.

3.6.2 Analysis

Ukraine has adopted 23 technical regulations covering eco-design, and 11 covering energy labelling for a range of appliances. In 2020, the Ministry of Energy approved additional energy labelling regulations for decentralised heating, commercial refrigerators, residential ventilation systems, solid-fuel boilers, temperature controllers and solar energy installations. Consequently, it appears that all, or almost all, of the EU's package has been brought into Ukrainian law, although it is unclear how many of these provisions are currently being applied by producers in the country, and whether there is any market surveillance control on imported products.

Neither the eco-design nor labelling provisions require the intervention of third party or notified bodies; if a producer has their own test equipment, they are permitted to use this. Nonetheless, a review of the National Accreditation Agency of Ukraine (NAAU)[100] database suggests that there are just two laboratories potentially capable of testing eco-design parameters: **the State Enterprise "All-Ukrainian State Scientific and Production Centre for Standardisation, Metrology, Certification and Consumer Protection (SE "Ukrmetrteststandart") and the Department of Building Physics and Energy Efficiency of the State Enterprise "State Research Institute of Building Structures"** (this latter seems less likely, although the full scopes of accreditation of either body are not available). The database does not indicate whether there are producer laboratories in Ukraine which have never entered the accreditation system.

There are many factors which affect the efficacy of eco-design provisions. These include the number of manufacturers and assemblers of products relative to the number of products imported. If, for a given product area, all products are imported and with none manufactured in Ukraine, the regulations can, in principle, be fully implemented; there are plenty of suppliers of products claiming eco-design compliance. To achieve high levels of conformity amongst imported products, however, requires some market surveillance because, otherwise, the risks of non-conforming, but possibly cheaper, products entering the market are high. Consideration also needs to be given to the level of technological development of any national producers before regulatory requirements are imposed.

The level of application by national producers is also an issue. Some producers complain about the cost of testing in the EU, but this is not generally considered to be a valid complaint; the costs are a very small percentage of the total turnover associated with that model. The complaint becomes more valid when products have to be sent abroad for testing (because there are no test facilities in the country), and where the manufacturer performs quality control tests at a regular frequency on their products.

A second issue is consumer awareness. Most eco-design provisions (but not all) exclude the worst-performing models from the market by setting threshold (lowest acceptable) levels of performance. They still leave, however,

It needs to be observed, though, that the study used results from 13 concrete-framed buildings with costs varying from £1 480 to £3 580/m², 6 steel-framed buildings (£1 980 to £3 440/m²) and just three timber-framed buildings (£1 660 to £3 480/m²). While the figures seem fairly conclusive that steel framing is the most expensive, the figures are not so clear between concrete and timber, and the wide spread of costs imply that other factors beyond simple material cost are also playing a role.

One final report[99] by the Institute of Structural Engineers (IStructE) in the UK considers whether using timber to construct tall buildings makes sense. This is important, because any reconstruction of cities in Ukraine is certainly going to involve multi-storey buildings. The tallest mass timber building is currently believed to be the 24 storey HoHo Tower in Vienna, although the Sumitomo Forestry Co. of Tokyo has announced plans to build a 70-storey timber tower by 2041, and a recently published research paper explores the possibility of an 80-storey tower in Chicago. So the technical possibility certainly exists.

The IStructE report gives some useful guidance, which effectively says that composite buildings, rather than all-timber ones, are probably the optimum approach. Because timber is the weakest of the three main structural materials, it makes sense to use the stronger materials (concrete and steel) where structural loads are highest (which becomes more important as buildings get taller) and use timber for lighter load-bearing uses. In addition, timber is not particularly suitable where spans are large (typical office space requires 9 m x 9 m spans), but cross-laminated timber can be used where spans are smaller, such as in residential units. There are also advantages that of large wood floor and wall panels can be prefabricated off-site, which results in faster construction and quieter job sites, especially in dense urban areas.

The report identifies that some further developments are required, for example to enhance acoustic performance and rain enclosure systems, to improve the performance and viability of tall timber structures. However, the desire from building users to see exposed timber, together with a desire for more sustainable construction should, provided that fears about fire safety can be allayed, help promote the use of timber, even if this comes with a small cost premium. It concludes, however, that designers need to be flexible, and not assume that timber is automatically the best option for every building.

The UNEP report referred to above makes compelling reading as far as strategies and policies are concerned, and also the potential for energy and CO_2 savings, but it contains no information of the possible cost-benefit consequences, either through conventional CBA or more widely through RIA. This highlight the current 'separation' between green aspirations and construction sector/practical realities. The aspirations are all highly laudable, but the realities are that the construction sector is currently dominated by 'least (initial) cost' thinking and until either this situation is changed and/or economic models are developed which allow 'higher cost but green' options to be seen as 'least cost', there may be challenges with the use of alternative materials.

99 https://www.istructe.org/resources/blog/building-tall-with-timber-factors-consideration/?gclid=CjwKCAiAqNSsBhAvEiwAn_tmxX6StNNluF_2NAZVrjVyYs2AaAfpl1OykpFri8X6wV4yISRDMfWeLBoC14AQAvD_BwE.

100 https://naau.org.ua/en/3-reiestr-akreditovanikh-oov.

a wide range of energy efficiency levels, passing from “G” (lowest) to “A” (highest) (or “D” (lowest) to “A+++” (highest) for some products). If consumers opt for the lowest-performing (G) models rather than the highest (A) because of purchase price, the true energy saving benefits will not be achieved.

Some schemes existing in some countries to promote the use of more energy-efficient products. These include higher import duties on lower-performing products (e.g. Algeria) although this requires effective control of the payment of these duties and assumes that the performance declarations are credible, which are not always true) through to electricity generating companies providing low efficiency products to consumers free of charge then reclaiming the cost by a fractional surcharge on customers’ monthly bills (USA). Other schemes, such as government subsidy on the purchase of more efficient products also merit attention but also require that declared performance levels are correct.

Table 17 — List of energy efficient products regulations by product group (non-domestic products excluded)

	Energy labelling legislation	Eco-design legislation
Product groups	Framework Regulation: EU 2017/1369	Framework Directive: 2009/125/EC
Air conditioners	EU No 626/2011	EU No 206/2012 corrected by EU 2023/2048
Domestic ovens and range hoods	EU No 65/2014	EU No 66/2014
Electrical lamps and luminaires	EU 2019/2015	EU 2019/2020 corrected by EU 2023/2048
Household dishwashers	EU 2019/2017 amended by EU 2021/340	EU 2019/2022 amended by EU 2021/341
Household refrigerating appliances	EU 2019/2016 amended by EU 2021/340	EU 2019/2019 amended by EU 2021/341 and by EU 2023/2048
Household tumble dryers	EU No 392/2012*	EU No 932/2012*
Washing machines and washer-dryers	EU 2019/2014 amended by EU 2021/340	EU 2019/2023 amended by EU 2021/341
Local space heaters	EU 2015/1186	EU 2015/1188, EU 2015/1185
Residential ventilation units	EU No 1254/2014	EU No 1253/2014
Solid fuel boilers	EU 2015/1187	EU 2015/1189
Space heaters	EU No 811/2013	EU No 813/2013
Electronic displays and televisions	EU 2019/2013 amended by EU 2021/340	EU 2019/2021 amended by EU 2021/341
Vacuum cleaners		EU No 666/2013
Water heaters inc. storage tanks and heater with solar	EU No 812/2013	EU No 814/2013
Air heating and cooling products	N/A	EU 2016/2281
Computers and computer servers	N/A	EU No 617/2013, EU 2019/424 amended by EU 2021/341
Fans driven by motors	N/A	EU No 327/2011
Simple set-top boxes	N/A	EC No 107/2009*
Power transformers	N/A	EU No 548/2014 amended by EU 2019/1783
Standby and off mode electric power consumption	N/A	EC No 1275 /2008 amended by EU No 801/2013 and EU 2019/2021*
Water pumps	N/A	EU No 547/2012

* To be repealed and replaced in 2025.

3.6.3 Findings

Three studies in particular have looked at the effectiveness of eco-design and energy labelling provisions. Amongst the overall findings, these reports[101], [102] and [103] conclude that:

- it is not possible to make definite estimates of the costs to industry or of the costs to the consumer for the changing of appliances (from lower to higher energy efficiency),
- the benefits in energy savings from the Eco-design Directive were €127 billion in 2020,
- overall, the estimated costs are a small fraction of the expected savings,
- the Eco-design Directive remains a highly relevant policy instrument,
- failure to devote sufficient resources to the implementation of the Eco-design Directive risks undermining the anticipated contribution of this instrument to the achievement of major energy policy and sustainability objectives,
- in many Member States, there is insufficient [market] surveillance conducted and a shortage of testing facilities,
- EU eco-design and labelling measures can be estimated to have saved 10% of the EU27’s primary energy consumption in 2020, and that the total financial savings in consumer spending were estimated at €60 billion,
- between 10 and 25% of products on the EU market are non-compliant with EU eco-design requirements. In some areas, such as air conditioners, non-compliance rates are estimated to be as high as 50%[104], which might prompt the European Commission to raise conformity assessment system requirements, which would have consequences for Ukraine, because test laboratories would then need to be Notified Bodies.

Large cost savings for consumers does not necessarily correlate with a willingness of countries or producers to make the investments to bring them about, and this seems likely to be a factor in Ukraine. Secondly, “failure to devote sufficient resources” remains a valid concern, whether this is by the State or by the private sector. The investment costs of test equipment can, in some cases, be high or extremely high, around €1 million to test fridges, freezers and air conditioners and around €0.6 million to test electric lamps, to take just two possibly extreme examples.

That there is insufficient market surveillance and a shortage of testing facilities remains a valid concern today. The shortage of testing facilities is linked, at least in part, to the investment costs above; the investment is uneconomic for smaller producers and is also uneconomic if made for the purposes of market surveillance (unless a country proposes systematic testing of all models, which would breach EU free-circulation principles).

Finally, the European Commission has published individual assessment studies of the impacts on individual product These broadly reflect the overall findings that EU regulations are cost-effective, lead to energy savings and are effective. It should be highlighted, however, that these relate to the EU which is, in principle at least, a fully-developed economy with a good history of energy saving actions and a fully-developed NQI testing system and market surveillance (although with some limitations as discussed above). The same conclusions might not apply to Ukraine, especially if compliance and/or enforcement levels are even lower than in the UE.

The above indicate the challenges of providing either RIA or CBA in the eco-design area. The lack of information on the number of appliance manufacturers in Ukraine and their technological level is one limitation, as is detailed information on testing facilities and capacity. It can be concluded that, to obtain the cost and energy savings anticipated from eco-design and energy labelling measures, the necessary testing infrastructure needs to be in place, as does adequate market surveillance. In Algeria, for example, it was concluded that 100% market surveillance (although not necessarily 100% testing) would be required for a period, to change the mindset of importers and national manufacturers to make them realise that they could no longer supply non-compliant products.

While the energy saving potential of appliance in Ukraine is difficult to estimate, a simple pro-rata calculation by population might indicate savings of the order of 10 Mtoe per year. Using the same 10% saving witnessed in the EU, and assuming primary energy consumption of 100 Mtoe, the saving would be about 10 Mtoe, an excellent correlation between the two estimates.

101 https://op.europa.eu/en/publication-detail/-/publication/379645c0-eeb7-40eb-adc7-e5a4a502c869.
102 Review and Analysis of Ecodesign Directive Implementing Measures: Product Regulations Shifting from Energy Efficiency towards a Circular Economy, by Robin Barkhausen, Antoine Durand and Katharina Fick, Fraunhofer Institute for Systems and Innovation Research ISI, 76139 Karlsruhe, Germany. Sustainability 2022, 14(16), 10318; https://doi.org/10.3390/su141610318.
103 https://energy.ec.europa.eu/topics/energy-efficiency/energy-label-and-ecodesign/list-energy-efficient-products-regulations-product-group_en.
104 Informal information from APPLIa, the European Electrical Appliances Association, to the author.

It is worth highlighting that there are some exclusions and some overlaps in regulatory provisions in the EU. Gas appliances are covered, both for safety and for efficiency, by the Gas Appliances Regulation, while solid fuel stoves are covered by the Construction Products Regulation. The implications of Ukraine attempting to approximate or transpose either of these complex regulatory instruments and bring them fully into force, covering all of their provisions, are well beyond the scope of this report but would require substantial NQI investment and development.

A search of test laboratories on the NAAU website indicates one test laboratory (accreditation currently suspended) capable of testing gas appliances, the Research and Testing Centre of PJSC "Ukrainian Research and Project Design Institute of Household Mechanical Engineering" and 93 laboratories testing construction products. The CPR also requires inspection and certification bodies, and there are some of these in the NAAU database. It would require a much more detailed evaluation of the market in Ukraine to determine whether the NQI resources are adequate to bring these two legal provisions into force, either just for the purposes of energy efficiency or more generally. Experience from other countries, however, show that it is usually a lack of NQI resources, together with a general lack of awareness and enforcement, combined with manufacturer apathy, which prevents their proper application.

Although impact assessments have been made of gas appliances and construction products in the EU, these cannot be considered to be directly applicable in Ukraine.

3.7 Assessment of the transposition and enforcement of the Renewable Energy Directive (2018/2001/EU) and deployment of renewable energy sources in residential buildings

3.7.1 Background

While the war in Ukraine continues with no clear end in sight, policymakers have begun to address the need for a reconstruction strategy for the country. Ukraine has estimated a cost of €690 billion to rebuild devastated cities and achieve 2032 economic targets. Recent estimates from the World Bank and European Commission place the cost of reconstruction at around €320 billion. A critical and strategically vital component of this rebuild concerns Ukraine's energy sector and infrastructure. Expanding and developing renewable energy generation in the country offers a pathway to secure Ukraine's energy independence and enable greater integration with the European Union.

Ukraine's renewables generation capacity consists mainly of hydro, solar and wind power plants. The country has more than 160 small hydro plants with total installed capacity exceeding 150 MW. Most of Ukraine's solar and wind power plants were commissioned in 2019-21 and are located in the south of the country. More than 1 100 solar installations are in place, ranging from small rooftop installations with capacities of around 25 kW to large plants with capacities of up to 240 MW. Total installed solar capacity is 6.4 GW. Electricity produced from biofuels plays a minor role in Ukraine, with total capacity amounting to only around 0.3 GW.

According to the Institute of Renewable Energy of the National Academy of Sciences of Ukraine, the country possesses a total technical potential of 874 GW for renewable energy sources. This includes approximately 250 GW of offshore wind power. The potential for wind power alone can be expanded from the existing 1.5 GW (as of 2021) to over 100 GW. Renewable gases, particularly biomethane production, have the potential to reach up to 10 billion m^3, equivalent to the import of all fossil gas. Solar generation capacities have the potential to grow up to 71 GW from 7.6 GW in 2021. Recent research indicates that the reconstruction of the economy after the war prioritizing decarbonization will cost only 5% more compared to continued reliance on fossil fuels under the most conservative assumptions.

Despite the invasion, in March 2023, Ukraine set a goal to have 50% of its power from renewable energy sources and 50% from nuclear energy by 2035. Renewable energy promises a more robust energy system for Ukraine in two ways. First, it diversifies energy sources away from fuels like diesel, reducing dependency on vulnerable supply chains. Second, the integration of renewables enables the creation of distributed energy systems, decentralizing the grid and making it more resistant to disruptive events.

In accordance with Decision of the Ministerial Council of the Energy Community D/2021/14/MC-EnC of the 30th November 2021, Ukraine undertook to implement the EU fourth Clean Energy for all Europeans package, in particular to harmonise the national legislation with Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II) by the end of 2022, including the implementation of the guarantees of origin (GOs) of energy used in the EU as a transparent mechanism for confirmation of the origin of energy. Implementing a functional market-based support scheme for renewable energy sources (RES) in accordance with EU Directive 2018/2001 remains a key priority for Ukraine, including for attracting much needed private investment.

3.7.2 Policy initiatives in the RES sector

The field of renewable energy generation is one of the government's key priorities of the state policy of the Ukrainian energy sector and national economy, because of its potential to reduce natural gas dependency and enhance energy security. It is consistent with Ukraine's aspiration to become a full participant in the EU's new climate neutrality policy.

New National Energy Strategy of Ukraine

T**he new National Energy Strategy of Ukraine to 2050 was approved by the Government of Ukraine by Order of the Cabinet of Ministers of Ukraine dated the 21st April 2023, No. 373-p**[105]**.** The new **Energy Strategy** focuses on the development of nuclear and renewable power generation capacity and on the **modernisation and automation of transmission and distribution systems**, in order to achieve carbon neutrality in the energy sector by 2050. Ukraine aims to strengthen energy security and the sustainability of its energy system and wants to join the Unified Energy System of Ukraine (UES) to the European network of electricity transmission system operators (ENTSO-E).

In March 2023, Ukraine's Ministry of Energy announced that the country aimed to increase the share of renewable energy in its power generation to 50% by 2035, while the other 50% of the power mix would be made up by nuclear power, in order to boost energy security. The strategy also aims at increasing the use of carbon-free electricity in end-use sectors. As of end-2021, before the start of the war, nuclear represented 55% of Ukraine's power generation (86 TWh), coal 24% (37 TWh), gas 6% (10 TWh) and renewables 15% (22 TWh, 7% wind and solar, 7% hydro, 1% biomass).

According to the presentation "Ukrainian Energy: from 2023 to 2050" by the Government of Ukraine on the 21st June 2023 at the Ukraine Recovery Conference (URC 2023[106]), in London, further development of RES will be prioritised by Ukraine. By 2050, it is planned to increase electricity production from RES to 525 TWh.

National Economic Strategy until 2030

The National Economic Strategy (NES) until 2030 as approved by the Resolution of the Cabinet of Ministers of Ukraine No. 179 of the 3rd March 2021 sets a strategic target of increasing the share of generation from renewable energy sources in the total electricity production up to 25% by 2030 (as compared to 13.8% in 2021) while an implementation concept of state policy in the field of heat supply sets the target for renewable energy in the heating and cooling sector at 40% by 2035. Achieving the NES target will require attracting at least €9.2 billion in investments.

Ukraine's recovery Plan from July 2022

The National Economic Strategy (NES) until 2030 as approved by the Resolution of the Cabinet of Ministers of Ukraine No. 179 of the 3rd March 2021 sets a strategic target of increasing the share of generation from renewable energy sources in the total electricity production up to 25% by 2030 (as compared to 13.8% in 2021) while an implementation concept of state policy in the field of heat supply sets the target for renewable energy in the heating and cooling sector at 40% by 2035. Achieving the NES target will require attracting at least €9.2 billion in investments.

Draft National Energy and Climate Plan (NECP)

Before the full-scale invasion, Ukraine had developed a draft NECP. The new document will have to be drafted taking into account the impact of the war on Ukraine's energy infrastructure and overall consequences for its energy system, which needs to become more resilient, decentralised, efficient and based on renewables. The NECP should set out concrete policy and measures and become a guiding document for post-war reconstruction in line with Energy Community (an international organisation which brings together the EU and its neighbours to create an integrated pan-European energy market[107]) 2030 targets, taking due account of recommendations from the Energy Community Secretariat to set new ambitious annual targets for RES until 2030.

Ukraine signed new commitments to implement the Paris Climate Agreement at the COP-28 climate summit 2023[108], in particular:

- a commitment to work together to triple the world's installed renewable energy generation capacity to at least 11 000 GW by 2030, taking into consideration different starting points and national circumstances;
- a commitment to work together to collectively double the global average annual rate of energy efficiency improvements from around 2% to over 4% every year until 2030;
- Commit to put the principle of energy efficiency as the "first fuel" at the core of policymaking, planning, and major investment decisions.

To expedite the deployment of renewable energy sources in Ukraine in a coordinated manner and to align with the EU Renewable Energy (RED II) Directive, the State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) has a draft National Renewable Energy Action Plan for the period up to 2030. This plan establishes a new objective to triple the share of energy derived from renewable sources in gross final energy consumption, increasing it from 9% in 2020 to 27% by 2030.

Achieving the goals outlined in the draft National Action Plan will necessitate investments exceeding €20 billion. Specifically:

- €8.4 billion will be allocated towards renewable electricity generation capacities,
- heat and power facilities, as well as biomethane production plants, €11.5 billion,
- an additional €0.3 billion invested in bioethanol and biodiesel production facilities

105 https://zakon.rada.gov.ua/laws/show/373-2023-%D1%80#Text.
106 https://www.urc-international.com/urc-2023-info; https://www.gov.uk/government/topical-events/ukraine-recovery-conference-2023.
107 https://www.energy-community.org/aboutus/whoweare.html
108 https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge

3.7.3 Transposition of the Directive 2018/2001/EU on the promotion of energy from renewable sources (RED II)

The Renewable Energy Directive (2018/2001/EU), RED II, entered into force in the EU in December 2018, as part of the Clean Energy for all Europeans package, aimed at maintaining the EU's status as a global leader in renewables and, more broadly, helping it to meet its emissions reduction commitments under the Paris Agreement.

This directive establishes a common framework for the promotion of energy from renewable sources. It sets a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy by 2030. It lays down rules on financial support for electricity from renewable sources, on self-consumption of such electricity, on the use of energy from renewable sources in the heating and cooling sector and in the transport sector, on regional cooperation between Member States, and between Member States and third countries, on guarantees of origin, on administrative procedures and on information and training. It also establishes sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels.

For ensuring consistent implementation of RED II, the following Commission delegated regulations have been adopted:

- Commission Delegated Regulation (EU) 2021/2003 supplementing Directive (EU) 2018/2001 by establishing the Union renewable development platform,
- Commission Delegated Regulation (EU) 2022/342 supplementing Regulation (EU) 2021/1153 on the specific selection criteria and the details of the process for selecting cross-border projects in the field of renewable energy,
- Commission Delegated Regulation (EU) 2019/807 supplementing Directive (EU) 2018/2001 as regards the determination of high indirect land-use change-risk feedstock for which a significant expansion of the production area into land with high carbon stock is observed and the certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels.

In accordance with Decision of the Ministerial Council of the Energy Community D/2021/14/MC-EnC of 30th November 2021, Ukraine undertook to implement the EU fourth Clean Energy for all Europeans package, in particular to harmonise the national legislation with Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II) by the end of 2022, including the implementation of the guarantees of origin (GOs) of energy used in the EU as a transparent mechanism for confirmation of the origin of energy.

On July 27, 2023, **the Law of Ukraine No. 3220-IX "On Amendments to Certain Laws of Ukraine on the Restoration and Green Transformation of the Energy System of Ukraine"** (hereinafter "the Law"), came into effect. The Law introduces amendments aiming at fostering the deployment of renewable energy and green transition Recommeof Ukraine, most importantly the Law on Alternative Energy Sources and the Law on the Electricity Market.

The principal Ukrainian law governing the field of RES is the **Law on Alternative Energy Sources No. 555-IV dated 20th February 2003** (last amendments: Law of Ukraine on making changes to some laws of Ukraine regarding restoration and "green" transformation of the energy system of Ukraine No. 3220-IX dated June 30, 2023 and Law of Ukraine of November 9, 2023 No. 3460-IX about the Government budget of Ukraine for 2024). The Law defines the legal, economic, ecological and organizational principles of using alternative energy sources and promoting the expansion of their use in the fuel and energy complex.

The **Electricity Market Law of 2016 adopted in June 2017** (came into effect in July 2019, last amendments: Law of Ukraine on making changes to some laws of Ukraine regarding restoration and "green" transformation of the energy system of Ukraine No. 3220-IX dated June 30, 2023 and № 3293-IX of 28.07.2023) is another principal law relating to the energy sector, including RES. The Law aligns Ukraine's national legislation with the European Union's regulation embodied in the Third Energy Package on the European gas and electricity markets liberalizing country's national electricity market. Regarding renewable energy sources for power production the electricity will be bought on the basis of the feed-in tariff regulation.

With respect to renewables, the Electricity Market Law introduces responsibility of the respective producers for hourly imbalances on the day ahead market where they will sell electricity at "green" tariff (GT). It also envisages the possibility of signing preliminary Power Purchase Agreement (PPA) before construction when a producer of electricity from renewables has executed title documents in respective lands, obtained a construction permit or executed a similar document under Ukrainian laws and signed a grid connection agreement.

Law of Ukraine 1391-XIV on Alternative Fuel (last amendment by Law No. 3220-IX dated 30.06.2023) establishes the framework for financial mechanisms to stimulate biofuels and other alternative fuels in order to save energy resources and reduce dependence on imports. It aims at reducing environmental impact by using various kinds of waste as raw material for the production of alternative fuels.

The amendments introduced by the newly adopted Law No. 3220-IX (Green Transformation Law) mainly concern **the support scheme for electricity from renewable energy, renewables self-consumption, and guarantees of origin,** namely:

- setting the legal framework for establishing and maintaining the register of guarantees of origin for electricity produced from renewable energy sources (the requirements of Article 19 Guarantees of origin for energy from renewable sources of RED II);
- introducing the net billing system (self-generation mechanism) to ensure the development of small distributed generation from alternative energy sources by customers and determining the conditions of its operation and its peculiarities;
- providing the legal basis for establishing renewable energy communities in accordance with the Renewable Energy Directive (REDII);
- defining "active customer", their rights and obligations; the operation of an active consumer by the mechanism of self-generation. The Law creates the possibility of selling generation facilities, including those from alternative energy sources, with their connection to the consumer's internal grids;
- introducing of a system for electricity generated from renewable energy sources. The operation of a new market participant, a licensee, a small distribution system operator, which will create power grids and provide connection and distribution services for industrial park participants;
- defining a new market participant, the licensee ("aggregator"), "aggregation", "aggregated group" and "aggregation unit";
- granting the right to export the electricity produced from alternative energy sources to the guaranteed buyer and producers;
- enabling producers generating electricity from renewable energy sources with the feed-in tariff granted to exit the balancing group of the guaranteed buyer, sell electricity in the electricity market on an independent basis and receive the market premium (the Feed-in-Premium mechanism or Contracts for Difference);
- introducing the concept of a special group of customers, specifying additional powers of the State Inspectorate of Ukraine for Energy Supervision as regards this category of customers;
- creating conditions for both public and private investments in renewable energy and overall decentralisation and modernisation of the energy system. New legal provisions also include improving conditions for connecting to grids of the transmission system operator and distribution system operators for decentralised generation and energy storage facilities;
- increasing the flexibility of the auction support model for the production of electricity from alternative energy sources based on the best global practices.

According to the report on the initial assessment of the progress in the implementation of the EU legal acts (EU **acquis**)[109], a draft Law relating to the implementation of individual provisions of RED II as well as a series of draft Resolutions and Orders of the Cabinet of Ministers of Ukraine are to be adopted to implement the provisions of the Law of Ukraine No. 3220-IX "On Amendments to Certain Laws of Ukraine on the Restoration and Green Transformation of the Energy System of Ukraine" and ensuring further alignment with RED II, namely:

- draft Resolution "On approval of the Procedure for issuance, circulation and cancellation of guarantees of origin for electricity produced from renewable energy sources";
- draft Resolution "On Approval of the procedure for disclosing to electricity consumers information about energy sources in the total energy mix of the electricity purchased by an electricity supplier and/or produced at its own generating facilities";
- in pursuance of Articles 21 Renewables self-consumers to 22 Renewable energy communities of Directive (EU) 2018/2001, Resolution "On approval of the state targeted economic programme for promoting the development of small distributed generation from renewable energy sources" as well as a number of the legal and normative acts of the NEURC aimed at the implementation of the self-generation mechanism in accordance with the Law of Ukraine No. 3220-IX;
- in pursuance of Article 3 Binding overall Union target for 2030 of Directive (EU) 2018/2001, Order "On the National Action Plan for the Development of Renewable Energy until 2030" should be adopted. The Ministry of Energy and the SAEE developed the draft Order, agreed with all stakeholders and prepared for submission to the Government. However, it is currently being finalised in terms of its alignment with the objectives and provisions of the Energy Strategy of Ukraine until 2050 and the Law No. 3220-IX, then it will be submitted for consideration by the Government;
- In pursuance of Article 4 Support schemes for energy from renewable sources of Directive (EU) 2018/2001), Resolution "On amending the Resolutions of the Cabinet of Ministers of Ukraine No. 420 of 23 May 2018 and No. 1175 of 27 December 2019", the Order of the Ministry of Energy "On amending the Standard Agreement for conducting electronic auctions for the allocation of support quotas between the auction procuring entity and the electronic platform operator", the NEURC Resolution "On approval of the standard agreement for the service under the market premium mechanism" as well as the NEURC Resolution "On amending the NEURC Resolution No. 641 of 26 April 2019" as regards adding the procedure for concluding the service agreement under the market premium mechanism, the procedure for calculation of the cost of and payment for the service under the market premium mechanism as well as the standard agreement for the service under the market premium mechanism.

109 https://www.kmu.gov.ua/storage/app/sites/1/55-GOEEI/zvit_EN.pdf.

3.7.4 Main issues identified and regulatory impact assessment

Based on the above presented legislative developments in Ukraine towards alignment with the EU acquis in the field of renewable energy, the following findings can be made:

The adoption of Law No. 3220-IX presents an important step towards ensuring compliance with Directive 2018/2021 (RED II).

Guarantees of origin

The RED II provisions are implemented in terms of the implementation of mechanism for issue of guarantees of origin (GOs) for electricity from renewable sources (Article 19 of REDII) (Law of Ukraine No. 3220-IX)), and guarantees of origin for biomethane (on 21 October 2021, the Law of Ukraine No. 1820-IX "On Amending Certain Laws of Ukraine as Regards the Development of Biomethane Production" was adopted). GOs for biogas, green hydrogen and heating and cooling have not been included.

The National Energy and Utilities Regulatory Commission (NEURC) is designated as the issuing body for guarantees of origin from renewable electricity, and the State Agency on Energy Efficiency and Energy Saving (SAEE) as issuing body for GOs from renewable gases. Both institutions are currently exploring registry options and are in the process of drafting secondary legislation. They have to make sure that the registry is accurate, reliable and fraud resistant and comply with the European Energy Certificate System (EECS) and standard EN 16325 as provided by RED II.

Regarding the implementation of the mechanism for issue of GOs a procedure for issuance, transfer and cancellation of GOs for electricity from renewable sources as well as a procedure for disclosing to electricity consumers information about energy sources in the total energy purchased by an electricity supplier and/or produced at its own generating facilities are to be adopted.

Sustainability criteria for biofuels, bioliquids/biomass fuels

Provisions related to sustainability and greenhouse gas emission saving criteria for biofuels, bioliquids, and biomass fuels are still not transposed, and the legal framework is completely non-compliant with REDII.

Self-consumption and energy communities

The Law No. 3220-IX provides the legal basis for establishing renewable energy communities in accordance with REDII while the implementation is still pending. Support to renewable schemes continues to operate under an administratively-determined feed-in tariff. The adoption of Law No. 3220-IX paves the way for market-based support through a feed-in-premium model.

Renewable energy in heating and cooling

Ukraine is working on the development of the solid biofuel market, by establishing an electronic platform for biofuel trading. A program to support households and condominiums to install solar panels and heat pumps is under development, expected to be implemented in 2024. Transposition of Articles 23 and 24 of RED II, on the increase of renewable energy in the heating and cooling sector, including district heating, is needed.

Impact of the Law of Ukraine No. 3220-IX "On Amendments to Certain Laws of Ukraine on the Restoration and Green Transformation of the Energy System of Ukraine"

The newly adopted law creates favourable conditions for the implementation of new projects in the renewable energy sector and balancing capacities, including those connected to consumer grids. The law also outlines changes to the operating conditions of already implemented renewable energy facilities regarding the possibility of selling electricity on market terms.

For the models envisaged by the law to function properly, it is necessary to develop a significant number of bylaws, including license conditions, amendments to market rules and existing codes of transmission and distribution systems which are currently being implemented step by step.

Importantly, the transposition and implementation of the provisions of REDII by adopting relevant laws/by-laws/resolutions/orders will allow Ukrainian businesses and industries to use clean power for decarbonising their production chains and operations, getting better access for exports of more sustainable products to the countries of the European Union. Ukrainian export-oriented industries can get better access to EU markets by switching to renewable energy procurement for their own needs and will be able to supply goods to EU member states without excessive taxation from Carbon Border Adjustment Mechanism (CBAM[110]).

Guarantees of origin will boost incentives to use clean energy with certification of electricity produced from renewable sources, such as solar, wind, biomass, biogas and hydroelectric power plants. This is an effective tool that will avoid additional taxation of Ukrainian goods when imported into EU countries from 2026.

Certificates of origin for RES electricity will enable industries to directly purchase green electricity, facilitating the decarbonization of production chains in line with the GHG protocol (an international system for calculating greenhouse gas emissions).

110 https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en.

In order to expedite the deployment of renewable energy sources in Ukraine in a coordinated manner and to align with the Directive (EU) 2018/2001, the State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) has a draft National Renewable Energy Action Plan (NREAP) for the period up to 2030.

To facilitate the integration of renewable energy facilities into the power system, the construction of new balancing capacities is an imperative. As outlined in the draft National Renewable Energy Action Plan for the period up to 2030, Ukraine will require 1 250 MW of new highly manoeuvrable capacities capable of swift activation, as well as 640 MW of energy storage systems by 2030. The anticipated private investment volume for these initiatives is approximately €2.9 billion.

To regulate these activities, Law No. 2046-IX, "On Amendments to Certain Laws of Ukraine on the Development of Energy Storage Facilities." was adopted on 15.02.2022. This law addresses the regulation of the legal, economic, and organizational framework necessary for the functioning of energy storage facilities within the electricity market. The National Energy and Utilities Regulatory Commission (NEURC) has also made several regulatory amendments to ensure the effective implementation and operation of energy storage facilities in the electricity market, in line with the provisions of the law. On 18 October 2023, the NEURC adopted the Licensing Terms for Aggregation in the Electricity Market under Resolution No. 1909 ("Resolution").

Contracts for difference and improved wholesale market integration

On March 17th, 2023, the President of Ukraine signed the law the "On the Development of Highly Efficient Cogeneration" in Ukraine. This significant legislation grants new powers to SAEE of Ukraine while also aligning with the requirements of Directive 2012/27/EU on energy efficiency, thus ensuring adherence to EU provisions.

Conclusion: The legislative framework of Ukraine is partially compliant with RED II provisions. Considering that RED II provisions are partially transposed, a classic Regulatory Impact Analysis (RIA) is not feasible. Nevertheless, below is a brief impact assessment where Ukrainian legislative framework in RES is aligned with the related EU acquis. It is worth mentioning that in a RIA, different stakeholders' view is an obligatory and very important component.

A. Need for action

What is the problem and why is it a problem at Ukrainian level?

The European Green Deal establishes the objective of becoming climate neutral in 2050 in a manner that contributes to European competitiveness, growth and jobs. This objective requires an emissions reduction target of 55% by 2030 as confirmed by the European Council in

December 2020. This in turn requires significantly higher shares of renewable energy sources in an integrated energy system. The EU target of at least 32% renewable energy by 2030, set in the EU Renewable Energy Directive (RED II) was reconsidered by the revised Directive EU/2023/2413. It sets an overall renewable energy target of at least 42.5% binding at EU level by 2030 but aiming for 45%. The same trend is outlined the Climate Target Plan (CTP), namely the needs to go up to 38-40%, along with new accompanying measures in different sectors in line with the Energy System Integration, the Hydrogen, the Offshore Renewable Energy and the Biodiversity Strategies.

Given the fact that Ukraine was granted EU candidate status in June 2022 and in December 2023, EU leaders decided to open accession negotiations, and considering Ukraine's commitments under the EU Green Deal, the Ukrainian legislative and regulatory framework needs to be further developed to bring it into line with the EU Energy Community acquis.

What should be achieved?

Greater use of energy from renewable sources by 2030, better energy system integration while ensuring protection of biodiversity and climate objectives.

Alignment of the Ukraine's legislative framework and related regulatory structure in the field of RES with the EU Energy Community acquis, including the revised EU Directive /2023/2413.

What are the impacts on SMEs and competitiveness?

Increasing renewable energy use in heating and cooling and in buildings will require building works/renovation, leading to an increase in employment in the sector. Up to 95% of construction, architecture and civil engineering firms are SMEs, so there is a likely positive economic effect on these.

B. Solutions:

- ✔ **Option 1:** No policy change (baseline scenario), no further alignment of the Ukrainian legislative framework with RED II provisions
- ✔ **Option 2:** The Ukrainian legislative framework is aligned with the RED II provisions.

The assumption is made that Option 2 is the preferred scenario.

C. Impact of the preferred option – it is assumed that the preferred option is the alignment of the Ukrainian legislation with the RES-related EU acquis

What are the benefits of the preferred option?

The preferred option effectively help Ukraine increase the share of renewable energy in its power generation to 50% by 2035, thus contributing to reducing GHG emissions by 55% by 2030, as well as to support other European Green Deal objectives. The increased use of energy from renewable sources is crucial to contribute the Ukrainian technological and industrial development and the creation of jobs and growth. The increase in renewable energy would also result in a more secure and integrated energy system less dependent on imports. Renewable solutions for heating and cooling and transport are a main factor to improve air quality in cities. Strengthened sustainability criteria for bioenergy will have positive impacts on biodiversity, the carbon sink and air quality.

Promotion of renewables in electricity through: a promotion of power purchase agreements; cross-border renewable energy pilot projects; specific measures to foster deployment of offshore renewable energy; EU certification scheme and promotion of renewable and low carbon fuels; targeted strengthening of the RED II sustainability criteria for biomass.

An increased climate target for 2030 will require considerable additional investments. However, growing expenditure (due to investments necessary for clean energy transition and the carbon price mark-up) is moderated by increased consumption linked to economic growth. (Within the EU RIA related to the adoption of RED II, as an annual average (2021-2030) and if assessed detached from other "Fit for 55" policies, investment expenditures, excluding transport are estimated to be higher by €13 billion and energy system costs, excluding carbon pricing, higher by €4 billion). In addition, recent research indicates that the reconstruction of the economy after the war prioritizing decarbonization will cost only 5% more compared to continued reliance on fossil fuels under most conservative assumptions.

Other benefits to consider are as follow:

- **Information and training gaps**, especially in the heating and cooling sector will be removed, thus encouraging the deployment of energy from renewable sources. The installers of small-scale biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps shall be certified by an accredited training programme or training provider (RES EU Installer Certification schemes — Average training cost – € 1 001 to €3 000; Ongoing Costs in order to be Certified/ Qualified – Cost of refreshment courses (around €50 yearly); the certification is valid for 3-5 years). The costs for RES EU Installer Certification are insignificant compared to the income that would be realised in the exercise of the professional activity. The list of qualified or certified installers is made available to the public thus raising the confidence of the citizens towards the state measures adopted and protection of their interests.
- **Improvement of the coordination between different authorisation bodies:** providing guidance to applicants throughout their administrative permit application and granting processes by means of an administrative contact point is intended to reduce complexity for project developers and increase efficiency and transparency, including for renewables self-consumers and renewable energy communities.
- **Improved administrative procedures, regulations and codes:** rules concerning authorisation, certification and licensing are objective, transparent and proportionate, do not discriminate between applicants and take fully into account the particularities of individual renewable energy technologies.
- **Reduction of administrative burden/costs:** the simplification of administrative permit granting processes, and clear time-limits for decisions to be taken by the authorities competent for issuing the authorisation for the electricity generation installation on the basis of a completed application, should stimulate a more efficient handling of procedures, thereby reducing administrative costs. In addition, in terms of administrative costs, increase in targets are not likely to create significant impact if it is assumed that monitoring/compliance systems are already in place.
- **Better support the integration of energy from RES into the transmission and distribution grid** and the use of energy storage systems for integrated variable production of energy from RES, in particular as regards the rules regulating dispatch and access to the grid.
- **Positive impact** of the development of the market for energy from renewable sources on regional and local development opportunities, export prospects, social cohesion and employment opportunities, in particular as concerns SMEs and independent energy producers, including renewables self-consumers and renewable energy communities.
- **Better opportunities for establishing economic growth through innovation and a sustainable competitive energy policy,** including. encourage the exchange of best practices in production of energy from renewable sources between local and regional development initiatives and enhance the provision of technical assistance and training programmes, to strengthen regulatory, technical and financial expertise and foster knowledge on funding.
- Empowering jointly acting renewables self-consumers also provides **opportunities for renewable energy communities** to advance energy efficiency at household level and helps fight energy poverty through reduced consumption and lower supply tariffs.
- **Strengthening the role of the citizen** in the energy transition, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, and participate actively in the market.
- **Better protection of consumers of district heating and cooling systems:** consumers should be entitled to disconnect and thus discontinue the heating or cooling service from non-efficient district heating and cooling systems at a whole building level by terminating their contract or, where the contract covers several buildings, by modifying the contract with the district heating or cooling operator. However, it should also be considered that consumers remaining in the district heating system might well suffer, as with fewer consumers, heating system owners might be reluctant to invest in improving their efficiency.
- **Information on support measures is made available** to all relevant actors, such as consumers including low-income, vulnerable consumers, renewables self-consumers, renewable energy communities, builders, installers, architects, suppliers of heating, cooling and electricity equipment and systems, and suppliers of vehicles compatible with the use of renewable energy and of intelligent transport systems.
- **Opportunities for the development of decentralised renewable energy technologies** and storage under non-discriminatory conditions and without hampering the financing of infrastructure investments.
- **Substantial added value of the participation of local citizens and local authorities** in renewable energy projects through renewable energy communities in terms of local acceptance of renewable energy and access to private capital which results in local investment, more choice for consumers and greater participation by citizens in the energy transition. **Such local involvement is crucial in a context of increasing renewable energy capacity.** Measures to allow renewable energy communities to compete on an equal footing with other producers also aim to increase the participation of local citizens in renewable energy projects and therefore increase acceptance of renewable energy.

Will there be significant impacts on national budgets and administrations?

In terms of administrative costs, it can be assumed that increases in targets are not likely to create significant impacts, if implementation units and monitoring/compliance systems are already in place.

3.7.5 Recent EU legislative developments in the field of renewable energy sources (RED III)

Directive (EU) 2018/2001 streamlines the administrative permit-granting procedures for renewable energy plants by introducing rules on the organisation and maximum duration of the administrative part of the permit-granting procedure for renewable energy projects, covering all relevant permits to build, repower and operate renewable energy plants, and for the connection of such plants to the grid.

Given the need to speed up the EU's clean energy transition, the Renewable Energy Directive EU/2018/2001 (RED II) was revised in 2023. The revised Directive EU/2023/2413 (RED III) entered into force in the EU on the 20th November 2023. There is an 18-month period for EU Member States to transpose most of the directive's provisions into national law, with **a shorter deadline of July 2024 for some provisions related to permitting for renewables.**

RED III sets an overall renewable energy target of at least 42.5% binding at EU level by 2030, but aiming for 45%. It stipulates that the renewable energy targets should go hand-in-hand with the complementary decarbonisation efforts on the basis of other non-fossil energy sources towards reaching climate neutrality by 2050.

Directive (EU) 2023/2413 introduces stronger measures so that all possibilities for the further development and uptake of renewables are fully utilised. This is key to achieving the EU's objective of climate neutrality by 2050 and to strengthen Europe's security of energy supply.

In addition to the new headline target to **double the existing share of renewable energy sources,** a strong policy framework will facilitate electrification in different sectors, with **new increased sector-specific targets for renewables in heating and cooling, transport, industry, buildings and district heating/cooling,** but also with a framework promoting electric vehicles and smart recharging.

To support renewables uptake in transport and heating and cooling, the revised directive converts into EU law some of the concepts outlined in **the energy system integration and hydrogen strategies,** published in 2020. These concepts aim at creating an energy-efficient, circular and r**enewable energy system that facilitates renewables-based electrification and promotes the use of renewable fuels,** including hydrogen, in sectors like transport or industry where electrification is not yet a feasible option. **For these hard-to-electrify sectors, the directive sets new binding targets for renewable fuels of non-biological origin.**

As an important bottleneck to the deployment of renewables on the ground, permitting procedures will also be easier and faster both for renewable energy projects (including through shorter approval periods and the creation of 'Renewables acceleration areas') and for the necessary infrastructure projects.

In accordance with Article 3 of Directive (EU) 2023/1791 on energy efficiency and amending Regulation (EU) 2023/955 and in line with Commission Recommendation (EU) 2021/1749(9), Member States should take **an integrated approach by promoting the most energy efficient renewable source for any given sector and application,** as well as by promoting system efficiency, so that the least energy is required for any given economic activity.

Directive EU/2023/2413 revises part of the definitions of RED II (e.g. "energy from renewable sources" or "renewable energy", "gross final consumption of energy") and transposes new ones ("renewables acceleration area", "solar energy equipment", "bidding zone", "innovative renewable energy technology", "renewable energy purchase agreement", "electricity market", etc.). The revised directive amends some part of the RED II provisions and introduces new provisions as follow:

Key amendments introduced to the REDII provisions by RED III:

- calculation of the share of energy from renewable sources,
- administrative procedures, regulations and codes,
- mainstreaming renewable energy in heating and cooling,
- mainstreaming renewable energy in the transport sector,
- specific rules for biofuels, bioliquids and biomass fuels produced from food and feed crops,
- calculation rules with regard to the minimum shares of renewable energy in the transport sector are replaced by Calculation rules in the transport sector and with regard to renewable fuels of non-biological origin regardless of their end use,
- Verification of compliance with the sustainability and greenhouse gas emissions saving criteria.

New key provisions laid down by RED III:

Mainstreaming renewable energy in buildings

Appropriate measures shall be introduced in the national regulations and building codes and, where applicable, in their support schemes, to increase the share of electricity and heating and cooling from renewable sources produced on-site or nearby as well as renewable energy taken from the grid in the building stock.

According to the revised directive's provisions Member States shall ensure that public buildings at national, regional and local level fulfil an exemplary role as regards the share of renewable energy used.

Mapping of areas necessary for national contributions towards the overall Union renewable energy target for 2030

By 21st May 2025, Member States shall carry out a coordinated mapping for the deployment of renewable energy in their territory to identify the domestic potential and the available land surface, sub-surface, sea or inland water areas that are necessary for the installation of renewable energy plants and their related infrastructure, such as grid and storage facilities, including thermal storage, that are required in order to meet at least their national contributions towards the overall Union renewable energy target for 2030.

Renewables acceleration areas

By 21st February 2026, Member States shall ensure that competent authorities adopt one or more plans designating, as a sub-set of the areas referred to in Article 15b(1), renewables acceleration areas for one or more types of renewable energy sources.

Organisation and main principles of the permit-granting procedure

The permit-granting procedure shall cover all relevant administrative permits to build, repower and operate renewable energy plants, including those combining different renewable energy sources, heat pumps, and co-located energy storage, including power and thermal facilities, as well as assets necessary for the connection of such plants, heat pumps and storage to the grid, and to integrate renewable energy into heating and cooling networks, including grid-connection permits and, where required, environmental assessments. The procedure shall comprise all administrative stages from the acknowledgment of the completeness of the permit application to the notification of the final decision on the outcome of the permit-granting procedure by the relevant competent authority or authorities.

- permit-granting procedure in renewables acceleration areas,
- permit-granting procedure outside renewables acceleration areas,
- accelerating the permit-granting procedure for repowering,
- permit-granting procedure for the installation of solar energy equipment.

The permit-granting procedure for the installation of solar energy equipment and co-located energy storage, including building-integrated solar installations, in existing or future artificial structures, with the exclusion of artificial water surfaces, shall not exceed three months, provided that the primary aim of such artificial structures is not solar energy production or energy storage.

Member States shall ensure that the permit-granting procedure for the installation of solar energy equipment with a capacity of 100 kW or less, including for renewables self-consumers and renewable energy communities, shall not exceed one month.

Permit-granting procedure for the installation of heat pumps

The permit-granting procedure for the installation of heat pumps below 50 MW shall not exceed one month. However, in the case of ground source heat pumps, the permit-granting procedure shall not exceed three months.

Unless there are justified safety concerns, unless further works are needed for grid connections or unless there is technical incompatibility of the system components, Member States shall ensure that connections to the transmission or distribution grid shall be permitted within two weeks of the notification to the relevant entity for:

A) heat pumps of up to 12 kW electrical capacity and
B) heat pumps of up to 50 kW electrical capacity installed by renewables self-consumers, provided that the electrical capacity of a renewables self-consumer's renewable electricity generation installation amounts to at least 60% of the electrical capacity of the heat pump.

Overriding public interest

It shall be ensured that certification schemes or equivalent qualification schemes are available for installers and designers of all forms of renewable heating and cooling systems in buildings, industry and agriculture, for installers of solar photovoltaic systems, including energy storage, and for installers of recharging points enabling demand response.

- Facilitating system integration of renewable electricity
- Mainstreaming renewable energy in industry
- Conditions for reduction of the target for the use of renewable fuels of non-biological origin in the industry sector
- Increase of renewable energy and reduction of greenhouse gas intensity in the transport sector
- Calculation rules in the transport sector and with regard to renewable fuels of non-biological origin regardless of their end use
- Greenhouse gas emissions saving criteria for renewable fuels of non-biological origin and recycled carbon fuels
- Union database

RED II also amends Regulation (EU) 2018/1999 8 on the Governance of the Energy Union and Climate Action.

Conclusions and recommendations:

- Given that RED II provisions are partially transposed into the Ukrainian legislation, Ukraine's RES legislative framework will need further developments to be fully aligned with RED II taking into account the revised Directive EU/2023/2413 (RED III). Regarding the latter, it would be meaningful to review the currently prepared drafts laws/ regulations/administrative provisions from the point of view of the revised provisions of RED II, as well as the new provisions laid down by the revised Directive.
- Considering, on the one hand, that a draft law has been prepared to ensure the implementation of the provisions of RED II, incl. a series of related resolutions and orders, and, on the other hand, that a revised Directive has been adopted (RED III), it would be relevant to carry out an in-depth analysis of the key aspects of RED III to see which provisions can be transposed through the already prepared legislative projects and how the alignment of Ukrainian national legislation with related EU acquis will be ensured in the future. The involvement of all interested parties (public authorities, economic operators, stakeholders) should be guaranteed.
- In parallel with further development of the RES legislative framework of Ukraine to align it with that of the EU in the field, it is necessary to take steps to establish/ reorganise the administrative structures, if needed and build/strengthen the administrative capacity and competences for the smooth implementation of the new legislation.
- In addition, development of certification schemes for installers and designers of all forms of renewable heating and cooling systems in buildings, industry and agriculture, for installers of solar photovoltaic systems, including energy storage, and for installers of recharging points enabling demand response is to consider.
- Conduct campaigns to raise citizens' awareness of the state policy, legislative framework and supporting measures available, incl. the benefits of investing in the RES integration (solar photovoltaic panels and/or heat pumps) in the residential sector (apartments buildings/ houses).
- Raise visibility and awareness among municipalities, and support and build capacity of all relevant stakeholders.
- The alignment of the Ukrainian legal and regulatory framework in the RES sector with the related EU acquis will have a positive impact on the economy growth and sustainability, the meeting relevant Ukraine's commitments, the improvement of the investment environment, the creation of jobs and the potential improvement of quality of life.

3.7.6 RES in the residential buildings sector

For this task, a review and analysis of various groups of the most up-to-date available data for the housing stock (including building typology, destroyed/heavily damaged buildings), energy consumption in the household sector, status of district heating systems, number of population of Ukraine, installed RES capacities (operational and destroyed), legislative framework and related initiatives, implemented projects in EU member states and in Ukraine for integration of RES in residential and public buildings, etc. Some assumptions are also made.

In the context of the EU's energy policy and legislative framework, including energy targets for 2030 and by 2050, as well as Ukraine's commitments in the sector, options for retrofitting the country's old heating system and buildings by installing heat pumps and solar PV panels (including storage devices) is considered. Within the timeframe of the current assignment it was not feasible to perform a deeper analysis and estimations. However, the outputs made it possible to outline a general trend and draw related conclusions and recommendations.

Around 40% of Ukrainian households rely on district heating companies (DHCs) for the provision of hot water and heating (The Oxford Institute for Energy Studies, 2016[111]). Nearly 55% of final energy consumption in the residential sector is used for space heating. Almost 60% of natural gas in Ukraine and 97% of RES and wastes (waste heat, biomass) is consumed for space heating.

Moreover, the district heating system in Ukraine was built during Soviet times and approximately 70% of the heating networks are obsolete and their deterioration causes bursts and frequent power outages in cold months. Due to the latter, this system has a low energy efficiency, high losses, elevated CO_2 emissions and increased energy costs impacting residents and businesses. These systems require 250-400 kWh per m^2 per year[112], compared to less than half that in Scandinavia (150 kWh) and one quarter the amount in buildings with energy efficiency measures (60-80 kWh). This implies that the old systems will have to be replaced in the near future. The war in Ukraine has highlighted the shortcomings of district heating systems and severely shaken the already low public confidence in them.

Revitalisation of Ukraine's district heating system would be possible with a complete renewal of fixed assets based on heat supply from renewable sources and the abandonment of natural gas as the main fuel. The cities alone cannot cope with this work due to lack of financial resources and proper understanding. This modernisation will require large investments, which will inevitably increase the already high tariffs. It is a vicious circle; the high cost of modernising district heating in the face of a long-term decline in demand for heat puts investment in the sector in question.

This is a crisis that needs to be addressed. Ukraine can be encouraged to overcome the crisis by the example of the EU, where the transition from boilers to heat pumps has become the basis of a plan for the transition to renewable heating and cooling; the REPower EU plan. Ukraine needs its own plan to get rid of gas dependence; REPower UA.

According to Kyiv School of Economics[113], the largest shares of the total amount of damage belong to the housing fund and infrastructure (72%). Since the beginning of the war against Ukraine, at least 15 300 apartments, 115 900 private houses, 1 991 shops, 44 social centres, 1 118 education institutions, 593 pharmacies, 188 100 private cars, 9 500 buses, 492 trams and trolleybuses, 978 healthcare facilities, 511 administrative facilities have been damaged, destroyed or seized.

Over 499 100 residential units are estimated to be completely destroyed, 788 000 units have suffered moderate damage and 285 000 have minor damage; 2 800 educational institutions were partially damaged and 454 were completely destroyed, both cases amounting to 10% of the total education institutions affected across all levels of education; 1 570 of public health facilities[114] incurred damage or destruction amounting to 15.6% of total public health facilities . Recent new estimates of the Military administration of Ukraine (August 2023) provides the following data regarding the damage to Ukraine's housing stock:

Among all sectors, the housing stock suffered the greatest losses. Thus, the damage was estimated at €42 billion. It should be noted that about €0.9 billion of this amount is the damage incurred by residential buildings as a result of the explosion of the Kakhovka Dam, i.e., flooding and partial destruction.

As of June 2023, according to preliminary estimates by the military administration of Ukraine, the total number of destroyed (or partially damaged) housing stock reached 167 200, including:

147 800
private houses

19 100
apartment buildings

350
dormitories

111 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/07/The-Ukrainian-residential-gas-sector-a-market-untapped-NG-109.pdf.
112 https://keepwarmeurope.eu/countries-in-focus/ukraine/english/.
113 https://kse.ua/about-the-school/news/due-to-the-last-estimates-damage-caused-to-ukraine-s-infrastructure-during-the-war-is-114-5-bln/.
114 Second Ukraine Rapid Damage and Needs Assessment, RDNA, as of February 24, 2023).

The most severe damage was sustained in the settlements located (or located) on the front line, in particular: Mariupol, Kharkiv, Chernihiv, Sievierodonetsk, Rubizhne, Bakhmut, Marynka, Lysychansk, Popasna, Izyum and Volnovakha. In some of these cities, 90% of the housing stock was destroyed, and some of them have no surviving buildings at all. In addition, these estimates do not consider the 37 000 buildings that were flooded after the attack on the Kakhovka Dam.

The ongoing attacks on the energy infrastructure underline the benefits of a gradual transition to a more decentralised energy system to strengthen its resilience. This transition is considered as a key pillar both to reduce the vulnerability to attacks in the short and medium term as well as to build a modern and green energy system in the medium to long term.

An important proviso is that assessed damage is not the same as the cost of reconstruction and recovery needs. According to an UN report of June 2023 "Rebuilding Ukraine with a Resilient, Carbon-Neutral Energy System"[115], renewables could power almost 80% of Ukraine's economy by 2050. It is assumed that rebuilding of dwellings will be made with an average pre-war rate, i.e. about 10 million m² annually. The study assumes reaching 1.5 rooms per person in 2060 (132 m² per household in urban private buildings, 119 m² in rural private buildings and 65 m² in multi-apartment buildings); the total floor area of (inhabited) housing stock is supposed to decrease after 2050. New buildings that meet high standards of energy performance and constructed after 2023 will constitute 27% of total housing stock by 2050.

Opportunities for residential buildings sector in terms of integration of RES

Housing is the sector that has sustained the greatest damage, at over 800 000 units and nearly €46 billion in replacement cost alone. It is also likely the sector with the greatest capacity for improvement in relation to energy. In regions with particularly high damage: Donetska, Luhanska, Kharkivska, and Kyivska, energy efficiency measures can be targeted particularly effectively. Donetska is also the region with by the highest level of damage to district heating. Once this area is no longer under Russian control, it could become a demonstration site for energy efficient buildings employing advanced heating systems (via heat pumps).

The analysis of costs and benefits in the implementation of various projects for the reconstruction/retrofitting of buildings in the EU using renewable energy sources, as well as similar projects in Ukraine, recently implemented or in implementation, show the general trend of benefits relative to the investments made for the replacement of old heating and cooling systems in residential and public buildings sector. The results of such projects prove that the most energy efficient solution is the installation of a heat pump and a hybrid solar system:

"Solar Powers Heat 2023", SolarPower Europe[116] revealing how solar PV and heat pumps empower households to reduce gas use and save on energy bills. When installed together, solar PV and heat pump saved households in Germany, Spain, and Italy between 62% and 84% on annual energy bills in 2022. Europeans with solar PV + heat pumps can expect to continue to save up to 76% on monthly bills in the years to come. New modelling shows that solar PV and heat pumps are compatible year-round. Solar PV can meet up to 63% of heat pump electricity needs annually.

Data highlight savings made by German, Spanish, and Italian households using three different technologies: solar PV, heat pumps, and solar PV + heat pumps combined. The savings are compared to the price that an average family household would pay by sourcing all its electricity from the grid, and a gas boiler for heating. While all technologies provide significant savings in all three countries, the combination of solar PV and heat pumps resulted in the highest savings of up to 84%, during the energy crises in 2022. Households saved up to €3 700 on their energy bills in 2022 with solar PV + heat pumps.

In all three countries, solar PV and heat pumps dramatically reduced households' electricity and heating energy expenses. Households that relied fully on electricity from the grid and used gas for all their heating, suffered from high energy price crisis.

Overall, solar-powered households avoided major energy costs (electricity from the grid, and gas for heating) in 2022, while receiving payments for the excess solar PV electricity they produced. For example, this resulted in savings of up to 64% in Italy.

Greenpeace projects for reconstruction of Ukraine

- Hospital in Horenka (part of Greenpeace CEE's "Greening the reconstruction of Ukraine by building city level partnerships" project,[117]): the most energy-efficient solution was to install a heat pump and a hybrid solar power system. Due to the solar plant, the hospital will become an electricity producer and can cover up to 60% of its needs. Since January 2023, a heat pump with a capacity of 20 kW, a solar power plant with a capacity of 12 kW and a battery with a capacity of 8 kWh have been operating there.

  The reconstruction cost of the heating system and installation of solar panels in Horenka amounted to about €56 000. These costs will be fully repaid in 6-7 years due to savings on energy and electricity production by the outpatient clinic itself.

- Hospital in Shepetivka (preparation for reconstruction started in May 2023)[118]

  The plan involves changing the heating system (at the moment the hospital runs on coal, which adds to air pollution in the area) and walls and roof insulation and possibly add a solar system as well. This particular project can be a showcase for getting rid of coal and changing it for a better, efficient and sustainable heating system for other schools and hospitals in Ukraine, which are still running on coal. The municipality is ready to start the reconstruction process once they have the missing fundings.

  The project proposal estimates the following resources are needed: the heat pump heating system €152 000; solar system (photovoltaic) €60 000; replacement of the roof with insulation €100 000; the insulation of the walls €100 000.

  It is considered that the green reconstruction of Horenka hospital can set a standard for the sustainable reconstruction of Ukraine, and that the future of post-war Ukraine belongs to renewable energy and modern energy-efficient technologies.

  According to preliminary estimates, Horenka hospital can reduce heating costs by at least 80% (almost €7 500) only by using the heat pump.

- The **Low Carbon Ukraine Project** is funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK). Within the project a study for assessing how a cost-optimal mix of solar PV panels, battery systems and diesel generators can mitigate power outages using the example of one Ukrainian school in Kyiv was carried out. In February 2023 a report on the results and conclusions was published: "Keeping the lights on in times of grid outages, solar PV panels, battery storage systems and diesel generators"[119].

  This study compares several alternative options for supplying uninterrupted electricity to a Ukrainian school and focusses on a school building. However, general conclusions remain valid for other types of similar public, commercial or residential consumers. The distributed energy sources considered in the analysis are solar PV panels, battery storage systems and diesel generators. The study was aimed to find a cost-optimal mix of these technologies to meet electricity demand of one representative school in Kyiv.

- Falling battery and PV panel prices have been a consistent trend throughout the last decade (with reductions of more than 80%) allowing these technologies to become cost competitive vis-à-vis traditional fossil fuel-based technologies. Overall, solar PV panels have higher capital costs than the generators, especially when combined with battery storage systems. However, running cost are very low and the expected lifetime for PV panels is quite long (20-25 years) when compared to diesel generators (typically about 8-10 years).

The recovery period in Ukraine should be based on development of decentralised renewable energy projects and reduce dependence on large power generating facility, like nuclear energy. Households, organisations and communities should be able to produce and manage their own energy. The installation of solar PV panels, heat pumps and proper insulation should be prioritised. Nearly Zero-Energy Buildings should be the new standard for all new buildings already from 2023. Ukraine has the historic chance to take the path to climate-friendly, independent energy with the best modern technologies.

The sector of residential buildings in Ukraine uses twice as much energy per square metre, and sometimes even three times more, as residential buildings in the EU. Now there is a historical opportunity to change this, and it would be senseless to restore and rebuild the housing stock, as well as public buildings, according to the same standards as before the war. More than two-third of Ukrainians are urbanites living in apartment buildings with central heating, water and power supply, September 2023.

Ukraine's housing is composed primarily of buildings with poor insulation and low energy efficiency. Buildings in Ukraine are responsible for nearly 40% of final energy consumption. In the residential sector, 54% of final energy consumption is devoted to space heating or cooling. The situation is aggravated by the share of natural gas in residential energy supply (48% versus 32% for the EU), making Ukraine dependent on imported fossil fuels. As a result of the ongoing war, Ukraine has endured enormous damage to the economy and public well-being in terms of social infrastructure. Ukraine has a chance to rebuild public and residential buildings according to new principles of green construction (**Prerequisites for post-war rebuilding of Ukraine's housing and construction sector**[120].

115 https://unece.org/sites/default/files/2023-07/EN_Rebuilding%20Ukraine%20with%20a%20Resilient%20Carbon-Neutral%20Energy%20System_V8.pdf.
116 https://www.solarpowereurope.org/insights/thematic-reports/solar-powers-heat-2023-2.
117 https://www.greenreconstruction.com/horenka-en.
118 https://www.greenreconstruction.com/project/shepetivka.
119 https://www.lowcarbonukraine.com.
120 https://ukraineinvest.gov.ua/en/news/08-11-22/.

Building typology for Ukraine

It is estimated that about 66% of residential buildings in Ukraine are older than 50 years (National Action Plan on Energy Efficiency, 2014), and almost 80% of the stock is inefficient (National Energy Efficiency Fund of Ukraine) in terms of energy consumption. The total area of residential buildings stock in Ukraine is about 968 million m², 60% of these areas is located in urban settlements (**State Statistics Service of Ukraine, Residential Stock in Ukraine**). The average household size in Ukraine 2010-2021 is reported to be 2.58 persons in 2021, remaining on approximately the same level over the past decade. The average number of persons living in Ukrainian households was higher than the EU-27 mean, which stood at 2.3 persons in 2020[121].

A realistic cost-benefit assessment related to retrofit/renovation of old multi-apartment (multi-ownership) buildings aiming at electricity savings and phasing out the old heating system (gas or coal-based) by integration of solar PV plants or solar PV panels in combination with thermo-pumps or thermo-pumps is difficult to be carried out within the current project timeframe as it requires a combination of multiple data (incl. their permanent update) and assumptions as well as corresponding final decisions. The following elements need to be properly identified and assessed, and related decisions to be taken:

- baseline assessment establishing a baseline scenario representing the current state of the building stock in terms of RES capacity,
- identification of a range of possible energy efficiency of facilities measures using RES that could be applied to such type of buildings,
- life-cycle cost analysis covering the investment, operating and maintenance parameters of the selected system (solar PV panels, hybrid system solar PV panels + thermo-pump, thermo-pump; system with or without energy storage device, needs of space/land outside apartment buildings for RES installations, etc.);
- estimation of the energy savings associated with each one of the RES systems to use and conversion into monetary terms using appropriate energy prices;
- cost-optimal calculation for comparing the total costs (investment, operation and maintenance) with the energy savings and other benefits achieved by each RES system. In general terms, the goal is to identify the combination of measures that provides the most cost-effective solution;
- Government policies and mechanisms, e.g. tax reduction, state financial support.

When assessing the investments needed for installing RES in the retrofitting/renovation of buildings in the residential and public sector, the following aspects should be taken into account:

- number of completely destroyed and heavily damaged buildings (residential and public), which implies their new construction,
- number of currently available old residential and public buildings requiring retrofitting/renovation of their heating and cooling systems.

The Ukraine 2023 population is estimated at 36 744 600 people at mid-2023.

The majority of the old residential buildings[122] in Ukraine are of 5 floors or less with heated area of 4 368 m² and heated space of 12 230 m³. Based on these figures it can be assumed that there are approximately 3 apartments of 65 m² per floor. If it is considered an average of 5 entrances per building, it gives 70 apartments.

Regarding ownership, Ukraine's housing stock is 93.7% privately-owned, 4.9% municipally-owned and 1.4% state-owned. Apartment type residential houses account for nearly all housing stock (98.1%). The share of hostels and residential premises in non-residential buildings in the total housing stock constitutes 1.9% (20.4 million m²).

High-energy consumption in Ukraine is a financial burden for the State, the enterprises and the population. Local authorities suffer for the high-energy costs that make up the second largest item of expenditure in the municipal budget, only after staffing.

Solar PV systems

Solar PV systems are one of the most popular renewable energy technologies. They provide a constant flow of free renewable electricity all year round, which can help to drastically reduce energy bills. If it is assumed that an average apartment (65 m²) of three people in Ukraine consumes approximately 2.70 MWh/month (32.4 MWh/year) of electricity (space heating/cooling, lighting and appliances, cooking and other end-uses), a building of 70 apartments will consume 2 268 MWh of electricity, which can be provided by a solar PV panel system with 0.6 MW installed capacity. The estimated investment is approx. €300 000 per average apartment building with 0.6 MW installed solar capacity. If it is assumed that approximately 200 000 apartment buildings are to be retrofitted by integration of solar PV systems, the total estimated RE capacity will be approx. 120 GW, while the total investments to bring it about would be approx. € 60 billion.

121 https://www.statista.com/statistics/1264408/average-size-of-households-in-ukraine/.
122 http://building-typology.com.ua/.

Currently, the price of electricity for household consumers is 2.64 UAH/KWh, including VAT (approximately 0.065 €/KWh). The costs of one household for one year will amount to approximately €2 106. Within the above-mentioned scenario, the pay-back period of the investment is 2-3 years. For multi-family and multi-story buildings, the provision of electrical energy from solar photovoltaic plants would be a more flexible and cost-effective model than installing photovoltaics on the building's rooftop.

Ukraine enjoys favourable conditions for harnessing solar energy. The average annual solar radiation received on a 1 m² surface ranges from 1 070 kWh/m² in the northern part of Ukraine to 1 400 kWh/m² and higher in the southern regions. The destruction of considerable housing, especially in the south, where solar potential is highest might create opportunities to assess potential for rooftop solar to be included in building plans. Because roof space and building orientation are central to rooftop installations, such projects can be much more promising on new builds than for retrofits.

Solar energy is experiencing significant growth in Ukraine, even amidst the ongoing war. Many households and critical infrastructure facilities are installing solar power plants to ensure backup power supply during outages. Notably, small systems with batteries have gained prominence since the war began.

Ukraine has successfully installed 7.6 GW of solar power, and this number is expected to grow continuously. Solar energy offers a valuable opportunity to restore lost generating capacity resulting from the war in a quick and cost-effective manner. Moreover, Ukraine currently boasts 45 000 registered home photovoltaic systems, and according to the Solar Energy Association, the market potential for such systems extends to at least one million households.

Recognising the importance of distributed generation for ensuring energy security, it is crucial to stimulate the development of this market. Therefore, efforts should be made to encourage and support the growth of distributed generation, as it represents a pivotal element in guaranteeing the energy security of the state.

The implementation of RES projects for modernization/retrofitting of old building stock in Ukraine may face different challenges related to legal, management and administrative obstacles, especially in multi-owner buildings:

- Many apartment buildings have physical constraints on solar installation, including rooftop obstructions, competition for roof space, overshadowing, outdated wiring installations and structural issues, as well as access requirements that can significantly increase installation costs.
- Need of assessment of the condition of the building structure and whether the roofs are suitable for the installation of solar PV panels.
- Willingness of citizens to pay for renovation of multi-flat buildings and to share the costs of renovation.
- Identification of the main barriers and problems hampering energy renovation in the selected type of buildings such as:
  - ✔ organisational barriers of renovation linked to reaching common agreement on renovation between apartment owners and one body is necessary to take all responsibility for organizational issues linked to the renovation of multi-flat buildings,
  - ✔ economic barriers of energy renovation linked with the reluctance to take out loans and the low income of the households,
  - ✔ governmental support for energy renovation is not enough to generate initiatives for the renovation of multi-flat buildings,
  - ✔ willingness of citizens to pay for renovation by monthly energy bills have a higher acceptance among households than paying the total costs of renovation upfront before it starts,
  - ✔ low-income households are not able to pay for renovations and higher income households are willing to share the costs with them in order to hasten the renovation processes.

Renewable Energy Systems adoption in multi-owned buildings (MOBs) is inferior due to ownership disagreements and social disputes. The multiple ownership of the RES in common properties of MOBs develops energy and benefit allocation concerns among the apartment owners. Optimum arrangements for installing solar PV depends on the specific characteristics of buildings, households, electricity loads and financial arrangements; there is no "one size fits all" solution. In the context of the above-mentioned more evaluations and analysis will be needed.

Heat pumps

Heat pumps are key to producing renewable heating and cooling from ambient energy, including from wastewater treatment plants and geothermal energy. Heat pumps also allow the use of waste heat and cold. Although the installation of heat pumps in new buildings is conventional, the replacement of existing heating systems with heat pumps is more challenging but extremely important. Heat pumps have topped 20% of the small-scale heat generators market in the EU.

Heat pumps are a greener alternative for individual heating than solid fuel or gas-fired furnaces because they can use the energy produced from renewable energy sources, for instance, photovoltaic panels. The International Energy Agency's report **The Future of Heat Pumps**, which presents the prospects for heat pumps, identifies key opportunities to accelerate their deployment, as well as key obstacles and policy solutions, could also serve as a roadmap for modernising Ukraine's heat supply.

Heat consumers in Ukraine are heterogeneous and can be understood by dividing them into clusters based on common interests[123]. Most heat consumers live in private houses, both in cities and rural areas. For them, district heating systems are not popular, and gas and solid fuel boilers are the basis of heat supply. However, this cluster consumes the most natural gas, about 8 billion m³. About 7.5 million households belong to this cluster. Another 6.2 bcm is consumed by urban district heating systems (over 200 000 multi-storey buildings) and about 0.8 billion m³ is consumed by the public sector (120 000 buildings). Estimates of the number of buildings are approximate and need to be clarified.

The simplest solutions for switching from gas to renewable heating and cooling will be for the low-rise building cluster. Approximately 4 million households out of 7.5 million already have air conditioners, and replacing them with heat pumps will provide heating, air conditioning and hot water to these buildings. Regarding the integration of heat pumps, Ukraine may benefit from the UK experience, where the government has adopted a programme to replace 26 million gas boilers in existing buildings with heat pumps. The budget of this programme for 8 years is €135 billion; it is easy to understand how the problem of decarbonisation will be solved in the country.

The installation of solar PV panels to provide heat pumps with electricity will allow the basic energy supply of buildings to be provided by renewable sources. The centralised power system will remain a backup source for buildings during peak loads.

A simplified model of the efficiency of replacing gas boilers with heat pumps[124]

Natural gas consumption in Ukraine's low-rise housing sector is currently around 8 billion cubic metres per year. Approximately 7 billion cubic metres could be saved by switching to renewable energy sources, which in turn will reduce CO_2 emissions by approximately 14 322 000 tonnes. Installing 7 million heat pumps instead of gas boilers and air conditioners will cost about €18-23 billion, and if solar panels are added to the house kit, the cost will increase by another €23 billion. A scheme under which the natural gas saved over 20 years will be sold on foreign markets, and households will not need budget and tariff subsidies, would need to be created. Another source of funding for such projects is the proceeds from the sale of greenhouse gas emission rights when the natural gas is abandoned.

The sale of CO_2 emission rights, which Ukraine will have in excess in this case, can significantly replenish the state budget of Ukraine. In 2021, the volume of trading in the global CO_2 emission permit markets increased by 164% (a record €760 billion compared to 2020). Ukraine can receive up to €12 billion for the sale of rights (average price of 1 000 m³ of CO_2= €46).

Based on the data provided in various war damage assessment reports, residential buildings in the war zone are either completely destroyed or severely damaged (with compromised construction), either of which will require them to be rebuilt. The same applies to public buildings. The new buildings will have to meet high standards for zero-energy. In this regard, the new buildings should ensure a gradual transition to renewable heating, cooling and hot water supply and the phasing out the use of gas boilers. The use of rooftop solar power plants for new building for all types should be mandatory. The role of municipalities in these cases will be of great importance.

The following aspects should be considered regarding the integration of heat pumps in apartment buildings:

- Replacing boilers with heat pumps can present a challenge due to the high temperature requirements of many existing radiator systems; heat pumps operate more efficiently with lower flow temperatures.
- When planning a heat pump installation in an apartment building, it is crucial to ensure that its capacity is matched precisely to the heating load of the building. The capacity can either be provided by a single larger heat pump or by a several heat pumps with lower capacity interconnected in a cascade.
- Due to a lack of financial incentives, heat pump-related flexibility schemes are not attractive for consumers yet. Due to their heterogeneous composition, it is difficult for Communities of Apartment Owners (CAOs) to finance replacing their heating system. The availability of state subsidies is a fundamental factor in consumers' decision-making regarding the installation of a heat pump.
- To ensure the necessary acceptance among consumers, the provision of comprehensive and comprehensible information about energy performance-related renovation measures and heat pump technology is essential.
- The decision-making and planning process for a heating system change is a particular issue for CAOs, primarily due to its lengthiness and the lack of knowledge of the stakeholders involved. Accordingly, information should be bundled and made available comprehensively, and best practices should be communicated more widely.
- It would be advisable for the heating transition to make the installation of a heat pump a privileged measure under the Ukrainian energy-related legislation.

123 Association "Energy Efficient Cities of Ukraine", https://enefcities.org.ua.
124 https://enefcities.org.ua.

As a result of the experience gained in the EU and globally, the following key aspects should be taken into account in the process of policy development and decision-making related to the deployment of renewable energy sources in the heating sector:

- Economic barriers for the decarbonisation of heating in buildings result mainly from the investment in energy efficiency and renewable energy technologies as well as the operation costs. High investment costs as compared to fossil heating equipment act as a barrier for all the considered technologies, including the investments by building owners in end-use equipment as well as infrastructure investments (e.g. district heating grids).
- The impact on the electricity system is a barrier in all decarbonisation pathways relying on heat production that involves electricity consumption. This includes decentralised heat pumps, large-scale heat pumps for district heating. At the same time, these technologies provide also benefits in form of flexibility options for the electricity system.
- Resource availability is a key barrier in most pathways and covers the availability of the energy carriers, the availability of heat sources and the availability of space (particularly strong barrier for large-scale solar thermal as well as RES-E installations).
- Regulatory barriers and licensing are particularly pronounced for technologies with currently low deployment, where codes and standards as well as licencing procedures have not yet been developed (particularly for hydrogen). For district heating, regulatory barriers include the planning and licensing for heat production facilities as well as third-party access to heating grids.
- The suitability of the building stock poses a barrier for the deployment of most renewable heating technologies: For heat pumps as well as for RES-based district heating, an efficient deployment requires low-temperature heating systems. For solar thermal installations, rooftops may be unsuitable for the installation.
- End-user and investor barriers cover a variety of barriers for investments in decarbonisation technologies. Such barriers include a lack of access to capital, imperfect information, bounded rationality and split incentives.
- The most effective way of aligning investments in building components and heating systems to the objective of decarbonisation is by establishing a strong regulatory framework to restrict the use of technologies that are not consistent with the objective.

To address the economic barriers, economic policy instruments shall facilitate an affordable transition and provide a level playing field for renewable technologies. Key economic instruments include subsidies and preferential loans for investments in renewable heating technologies as well as energy and carbon pricing.

As the transformation of the heating sector has impacts on key infrastructure (district heating, gas grid and electricity grid), approaches for heat planning and citizen involvement are needed to coordinate the expansion, modernisation and decommissioning of such infrastructure.

Recommendations

- Develop short-term retrofitting programmes and related investment plans for gradual switching the energy supply of residential and public buildings to renewable heat and electricity sources (hybrid systems of solar PV panels and heat pumps) for ensuring the necessary energy security and independence:
  - ✔ for public buildings (primarily hospitals, schools): transition to heat pumps in combination with rooftop solar power plants;
  - ✔ for multi-storey (multi-apartment) buildings: transition to heat pumps in combination with solar power plant.
  - ✔ for cottage and low-rise buildings: heat pumps in combination with rooftop solar power plants.
- Regarding centralised electricity, heat and gas supply systems which are considered the most vulnerable, develop short-term strategies and related action plans for ensuring the transition of such buildings to autonomous and decentralised sources of heat and electricity from renewable sources (hybrid systems of solar PV panels and heat pumps).
- Develop policies and related regulatory measures for gradual elimination of energy poverty taking into account that in the period up to 2030, tariffs for system electricity and natural gas are expected to rise sharply in Ukraine. The transition to renewables in this period will reduce the burden on the household budgets.
- All new buildings to be constructed with zero CO_2 emissions (thermal insulation, heat pumps and solar/wind power plants).

3.7.7 RES in the residential buildings sector

3.7.7.1 Introduction

This section should be read together with 3.5) of this report.

3.7.7.2 RES projects in the cement industry[125]

For a cement plant, two options can be considered:

1. Reconstruction and modernization of an existing cement plant

The reconstruction and modernization of a plant with a capacity of 1 million tonnes of cement per year, including construction and/or upgrading of a waste processing plant will provide for the use of Solid Recovered Fuel/Refuse-Derived Fuel (SRF/RDF) for the furnace, thereby removing 90% of traditional petroleum coke fuel. Such an investment is expected to amount to €200-250 million.

Through the implementation of such a project, a 90% replacement of the petroleum coke fuel used and a 60% reduction in fuel costs will be achieved. The expected environmental effect is related to the reduction of carbon emissions, the utilisation of household waste, old car tyres and combustible waste from other industries, stimulation of the separate collection of waste.

2. Construction of a new cement plant

The cost of a new cement plant using dry process cement manufacturing process with a capacity of 1 million tonnes per year amounts to €650 000 000. In this case, the same effect is achieved with the difference that the payback period of the investment will be longer. The choice between the two options also depends on whether there is a suitable/existing cement plant to be reconstructed and modernised after assessing its condition.

3.7.7.3 RES in the steel industry

According to SteelRadar, Ukraine's steel production has significantly decreased. Steel production in Ukraine has experienced a significant decline in 2023. The country's steel market showed a 23% decrease in the first 8 months of the year. Steel production, which was 14 813 million tonnes in the January-August period of 2022, decreased to 11 406 million tonnes in the same period of 2023. Crude steel production fell from 5 186 million tonnes in 2022 to 4 032 million tonnes, a decrease of 22.3% in the same period of 2023. Rolled steel production also decreased from 4 477 million tonnes to 3 466 million tonnes, a decrease of 23.9% in the 8-month period. Pig iron production decreased from 5 150 million tonnes in the January-August period of 2022 to 3 908 million tonnes, a decrease of 24.1%. Rolled steel production also decreased from 4 477 million tonnes to 3 466 million tonnes, a decrease of 23.9% in the 8-month period. Pig iron production decreased from 5 150 million tonnes in the January-August period of 2022 to 3 908 million tonnes, a decrease of 24.1%.

A Coalition for the Green Transition of Ukraine was created in London with the participation of Metinvest and the Government (June 2023). The coalition brings together equipment producers, consumers, financial institutions, government and other stakeholders. The main goal of the association is to restore Ukrainian industry through an ecological, green transformation of steel production. This will help support the national economy and population, while at the same time becoming a driver for supporting the EU's decarbonisation agenda.

The Metinvest group joined the government's platform on the green recovery of the steel sector of Ukraine.

Manufacture of rebar

The construction of a new plant for the production of reinforcing steels for concrete (rebar) should be based on the short technological cycle including the production of electric arc furnace steel; continuous steel casting and a hot rolling mill for concrete iron with a wide assortment of sizes (e.g. Φ8 mm to Φ40 mm). Green hydrogen, or hydrogen made using renewable energy, could be used for powering electric arc furnaces. The capacity of the plant can be determined by the expected needs and the real possibilities of the construction industry for medium-term periods. Such a production process eliminates blast furnaces, respectively the use of coke, which are a source of severe environmental pollution. The modern layout of such productions provides for the use of tunnel heating furnaces between continuous casting and hot rolling, which reduces the cost of natural gas by 40% per tonne of production.

125 www.holcim.com.

3.8 Urban transport

3.8.1 Introduction

The whole area of transportation is important for any greening of Ukraine. Ukraine's energy use is concentrated in the residential, industry and transport sectors, which were responsible for over 80% of total final energy consumption in 2019. The industry and residential sectors accounted for over 60%, with iron and steel production alone representing over half of all industrial use and around 17% of total final consumption. Transport accounted for a further 20% of total final consumption in 2019. With total energy consumption in 2019 of 46 Mtoe (540 TWh), the contribution of transport was 110 TWh. Efforts to maximise energy demand restraint are therefore likely to be most successful if they target these highest-consuming sectors, of which transport is clearly one5.

20% is perhaps a somewhat low value, and is reported to be higher in other countries. It seems likely that, in Ukraine, this comes about because of the relatively poor (i.e. higher) energy consumption of the buildings and industry sectors rather than because of a good (i.e. lower) consumption of the transport sector.

The transport sector dominated consumption of oil products in 2019, accounting for 80%. Road transport accounted for nearly all the sector's consumption and was alone responsible for 77% of Ukraine's total oil product use in 2019. This means that rail and air transport together contributed less than one quarter of total transport energy consumption, or 25 000 GWh. For this reason, while not ignoring potential savings in these two sub-sectors (and noting, in addition, that reductions in road transport might lead to raised usage of rail transport but for very little increase in energy used in rail transport), these two sectors are not considered in this report.

Unlike the buildings and industry sectors, reductions of energy consumption in transport do not come from increasing the energy efficiency of vehicles currently in circulation (this is not generally possible). Instead, they come primarily but removing inefficient vehicles, either by financial incentives and restrictions on the import of lower efficiency vehicles, or by the substitution of fossil fuel powered vehicles by electric vehicles.

It is not generally possible to consider urban transportation separately from total transportation, primarily because data do not exist to identify urban journeys separately from all journeys. Having said that, the substitution of fossil fuel amongst delivery fleets (e.g. buses, taxis and goods-delivery) is identified in some reports as being an appropriate and cost-effective route for introducing electric vehicles. In addition, any calculation of cost-benefit-analysis of changes to transportation require both more detailed baseline data and calculation models which are not generally available. Consequently, it has not proved possible to perform such analysis. Instead, this report identifies how these calculations might be performed in the future, and the input data which would be required and, instead, tries to draw other, more general, cost-benefit findings from other reports.

3.8.2 Analysis

3.8.2.1 General considerations

1. As of 2021, Ukraine's car fleet has about 7.4 million vehicles and 1.7 million commercial vehicles. However, due to the lack of a mandatory roadworthiness test for private cars, these figures should be interpreted with caution; the official system of state registration does not take into account properly disposed or obsolete vehicles. Used cars make up a significant part of Ukraine's fleet: according to various estimates, there are between 400 000 and 2 million of them. Although their number among newly registered vehicles has been declining recently, they still account for 40% of new registrations[126].
2. A significant problem of the transport sector of Ukraine is the age of its fleet. Objective and comprehensive data on this are difficult to obtain, as are emissions of pollutants from mobile sources. However, the report of the Global Fuel Economy Initiative in Ukraine (2018) indicates that the average age of the Ukrainian fleet was about 19 years (as of 2015). Unfortunately, these data do not highlight the categories of vehicles (trucks, cars, buses), but the age of the fleet is an indicator of its low efficiency in terms of CO_2 emissions and other pollutants.

126 https://brdo.com.ua/en/news/vidnovlennya-transportnogo-sektoru-ukrayiny-yak-zrobyty-jogo-zelenym/.

With regard to the electrification of the fleet, in recent years in Ukraine there has been an increase in sales of electric vehicles, which was facilitated by stimulating public policy measures. In 2016, the duty on electric vehicles was abolished, and in 2018 the excise tax and VAT on imports of electric vehicles were abolished. In 2014 only 62 electric cars were sold (0.07% of total sales), in 2016, 1 148 electric cars (1,5%), in 2019, 7 012 (7,2%). Currently, Ukraine is the 12th European country in respect of the total number of electric vehicles and demonstrates one of the highest rates of electrification of the fleet.

Ukraine has relatively strict standards for permissible environmental pollution for new vehicles. As of January 2016, only vehicles that met the Euro-5 standard were allowed to be registered. However, the introduction of the Euro-6 standard, which was planned for 2018, was postponed first to 2020, and recently postponed until 2025. For used cars, in 2018 Ukraine lowered the standard to Euro-2, which harms the environmental efficiency of the entire fleet. It should also be borne in mind that the Euro standard primarily limits its emissions of various pollutants, but does not provide for any restrictions on GHG emissions. Ukraine does not have its own standard to limit these emissions, and one needs to be implemented.

In the transport sector, Ukraine pledged to introduce EU standards for fuel quality, fuel efficiency and fuel emissions under its 2014 Association Agreement (see below). A key achievement has been implementation of the Euro 5 fuel quality standard. The Euro 5 fuel quality standard introduced a maximum sulphur content of 10 ppm in gasoline and diesel, and this has been obligatory for fuels marketed in Ukraine since the beginning of 2018. European fuel economy standards for light- and heavy-duty vehicles are set to increase significantly in the next decade, which suggests that the EU policy framework will continue to provide a sound foundation for Ukraine to gradually increase demand restraint and energy efficiency in the transport sector.

Options proposed by the International Energy Agency[127], include incentives to reduce the mass of many vehicles and increase fuel taxation. Higher fuel prices are correlated to lower fuel consumption. European countries, as well as Japan and Korea, where high fuel taxes are levied, have the world's lowest specific fuel consumption. In comparison, low fuel taxes in Canada, Australia and the United States correspond with above-average fuel consumption. Higher fuel taxes could therefore encourage the uptake of more fuel-efficient vehicles.

One of the most widespread regulatory instruments to incentivise rapid adoption of efficient technologies is average fuel economy standards. Although these did not successfully reduce fuel consumption in the EU between 2017 and 2019, once the new EU 2020 target came into force, average CO_2 emissions per km dropped by 12% within a single year (the same as between 2010 and 2019).

In addition, 'feebate' schemes, such as introduced in France in 2008, can be used to impose a fee on the purchase of vehicles for which CO_2 emissions (g CO_2/km) exceed a defined level, and subsidise the purchase of vehicles with emissions below a specified level. Although feebates directly target CO_2 emissions performance, they indirectly affect vehicle mass and size, as larger and heavier vehicles tend to be less fuel-efficient.

Increasing taxes applied to the purchase of large, heavy cars can disincentivise the sale of larger and heavier vehicles, which itself is linked to poor performance. By way of comparison, the world record vehicle efficieny, at an average speed of 10 MPH (16 KPH, faster than the average speed in most cities) is an astonishing 14 573 MPG (6 200 km/l, albeit using an extremely light, ultra-high efficiency vehicle), and as early as 1973 a modified commercial car achieved 376 MPG (160 km/l)[128]. These figures are worth taking into consideration because, currently, the development of electric vehicles and hybrids is primarily in the drive system, while the same underlying issue, that of moving 1-2 tonnes of vehicle in order to move 100 kg of person, remains largely unaddressed (by way of comparison, the average fuel consumption of cars is currently around 40 MPG (17 km/l).

The whole subject of lighter vehicles is well covered[129] in the report from the United Nations Environment Programme already cited above in the context of Circular Economy. Specifically, material efficiency strategies could reduce emissions from the material cycle of passenger cars in 2050 by up to 70% in G7 countries and 50 to 60% in China and India. The largest savings would come from a change in patterns of vehicle use (ride-sharing and car-sharing) and a shift towards more intensive use and trip-appropriate smaller cars. A more detailed analysis of these aspects is, however, beyond the remit of this project.

Changing one heavy, inefficient, mode of transport, ICE, to another heavy, inefficient but reduced CO_2 emission form of transport does not resolve the fundamental mass issue, where something in the region of 15 to 30 times the amount of power needed to move the person is used to move the vehicle. While it is argued that using (heavy) electric vehicles is 'green' if powered by renewable energy, it must be remembered that if these vehicles are themselves very inefficient, they are using power which might better be used for other purposes. In this respect, things like electric scooters and electric bicycle, where the person is much heavier than the means of transport, is much to be preferred, especially for shorter, urban trips.

Since 1955, Norway has implemented a one-off registration (purchase) tax on internal combustion engine (ICE) light-duty vehicles based on vehicle kerb mass, as well as CO_2 and NOx emissions. More recently, France imposed a tax on vehicles weighing over 1 800 kg, while battery electric vehicles and plug-in hybrids remain exempt. Cities and discourage SUV and large vehicle usage by implementing measures than make ownership less appealing. Parking fees can be based on vehicle size or mass (by way of comparison, a modern Mini weighs about 1.2 tonnes) and/or more parking spaces can be reserved for smaller cars. For example, Berlin is considering charging SUV owners as much as €550 for city parking permits (five times the cost for a small call), and in Vancouver, Canada, owners of a 2023 large ICE SUV or pick-up truck may be charged €725 annually for a residential parking permit.

While electric vehicles (EV) in principle offer advantages of ICEs, especially when charges by renewable energy, they are unlikely to be the universal solution for Ukraine. Their purchase price remains high, at around €45 000 for a typical car, insurance and maintenance costs remain relatively high, and the performance of second-hand vehicle is low. Many countries, including Ukraine, do not have the charging infrastructure in place, either, to make widescale adoption of electric vehicles in the short term feasible.

Less frequently considered is the effect of cold weather on EV performance; In 2020, the Norwegian Automobile Federation tested 20 BEVs in real-world winter conditions, and found that, on average, the range dropped by around 20%, a scenario which will be all too familiar to fleet operators. The winter weather also slows down the speed at which a BEV can be charged and, although fleets can take actions to reduce the negative effect of the cooler conditions, such slowing cannot be eliminated[130] and it is exacerbated when battery power needs to be used to heat the vehicle. Finally, one further issue which is not currently being very widely considered is that of how to treat batteries at the end of their useful lives.

Interestingly, the conversion of bus or trolley-bus lines (of which Ukraine has many) into tramlines is often considered to be both cost effective and environmentally friendly. One report, however[131], shows the opposite, the change from bus to tram led both to an increase in overall CO_2 emissions and had a negative overall value. It cannot be imagined that the specific details of this one small conversion are relevant for any location in Ukraine. But it does show that any decision for conversion needs careful consideration on a case-by-case basis.

Trolleybuses themselves, of which Ukrainian cities have about 40, do not suffer the same issues as trams. The EBRD has been making loans for the upgrading of various trolleybus systems under the Ukraine Public Transport Framework ("UPTF") consisting of municipal-guaranteed loans to public transport companies in Ukraine to facilitate critical improvements in public transport infrastructure in a number of cities across Ukraine. These projects include: Zhytomyr, 100 km west of Kyiv, with an investment of 9 million from the EBRD ordinary capital resources and a loan of €1 million from the Clean Technology Fund; Khmelnytskyi in the west of the country, €10.6 million with other funding; and Poltava, 300 km south-west of Kyiv, €10. These projects come within the €250 million Ukraine Public Transport Framework II[132].

The projects listed above (only a selection of the most recent) all have an Environmental and Social Summary categorisation of B and an Expected Transition Impact ETI score of 60. The former has A to C categorisation, where B is identified as "its potential environmental and/or social impacts are typically site-specific, and/or readily identified and addressed through effective mitigation measures[133]" while ETIs are described as "ETI scoring reflects both the intrinsic value of a project and its contextual value. Selected TI objectives all carry a number that enters the calculation of the score, but such a score is then adjusted to reflect country context and support of Bank-wide strategic initiatives. Strategic relevance is defined by compliance/fit of the project with Country Strategies priorities and the use of financing instruments that are specifically supported by the Bank (equity and local currency lending). ETI is scored between 0 and 100. Most projects fall between 60 and 70 and are considered to have a Good Transition Impact. Projects between 70 and 80 are strong projects; there are only several cases per year, deemed excellent, that receive a score higher than 90[134]".

It has not proved possible to identify how either of these two parameters were calculated nor exactly what the results means. The projects seem mainly to concern the upgrading of existing trolleybus systems and change certain management elements. Consequently, the benefits may be more social than environmental. The fact that the parties concerned consider such projects to be viable investments, however, suggest that they are economically viable and may be worth expanding to other cities. This report cannot draw this as a definitive conclusion, for lack of information, but can suggest that this is an area worthy of more detailed research.

Given the high level of emissions on the roads and the level of congestion in the cities of Ukraine, the system of "congestion payments" should be considered as a solution to these problems[135]. These have proved successful (although sometimes contentious because they are not always considered to be fair, especially if they are 'flat rate', taking no account of time in the zone, and concentrate on just one criterion, emissions, not others such as fuel consumption) in cities throughout the EU and UK. The potential system could be implemented in Ukrainian cities with a population of over 500 thousand people (Kyiv, Kharkiv, Odesa, Dnipro, Donetsk, Zaporizhia, Lviv, Kryvyi Rih). Together, these eight cities have 9.4 million inhabitants, which is almost a quarter of Ukraine's population.

127 https://www.iea.org/energy-system/transport/cars-and-vans.
128 https://www.drive.com.au/caradvice/this-humble-ute-claimed-an-astonishing-world-record-for-fuel-efficiency-in-1973/.
129 Hertwich, E., Lifset, R., Pauliuk, S., Heeren, N. "Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future." 2020. A report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya.
130 https://www.fleetnews.co.uk/electric-fleet/policy/how-the-cold-affects-evs-and-what-to-do-about-it#:~:text=Drivers%20should%20try%20to%20make,the%20impacts%20of%20the%20cold.
131 Substituting a Tramway to a Bus Line in Paris: Costs and Benefits. Working Paper – January 2011 (10.1), Remy Prud'homme, Martin Koning and Pierre Kopp. https://sorbonne.pierrekopp.com/downloads/2011%20T3%20revised%20version%202011.pdf.
132 https://www.ebrd.com/work-with-us/projects/psd/ukraine-public-transport-framework-2.html.
133 https://www.ebrd.com/news/publications/policies/environmental-and-social-policy-esp.html.
134 https://www.ebrd.com/what-we-do/economic-research-and-data/transition-impact.html#:~:text=ETI%20is%20scored%20between%200,a%20score%20higher%20than%2090.
135 https://brdo.com.ua/en/news/vidnovlennya-transportnogo-sektoru-ukrayiny-yak-zrobyty-jogo-zelenym/.

There are different models of road congestion charges in the world: the London model charges drivers a daily fee for using the city's roads regardless of when they enter the area, while the Stockholm model provides different fees for road use at different times of the day. As highlighted above, to ensure that systems are widely judged to be fair, they need to recognise vehicles with low levels of harmful emissions, buses, vehicles owned by non-residents of the city, etc. The congestion charge model, which includes benefits for greener cars (such as hybrids and electric cars), may in particular help to upgrade Ukraine's fleet and thus increase the overall energy efficiency of the transport sector. In order for "congestion pay" to work as an effective solution to transport problems and not become a tax burden for the population, however, urban residents must be offered alternative types of quality public transport.

The costs of implementing such a system vary greatly from city to city and are therefore difficult to predict. However, international experience has shown that "congestion pay" is a long-term, cost-effective municipal solution that pays off within a few years of implementation. At the same time, the system will help reduce traffic, and at the same time will be a source of funds for the local budget to improve public transport.

Table 18 — EU legislation relevant for transport

Type approval Regulation 2018/858[136] (*)
Clean Vehicles Directive (CVE) (2019/1161)[137], amending Direct 2009/33/EC
Clean Vehicles Directive 2009/33/EC[138]
Roadworthiness Directive 2014/45/EU[139]
Roadside inspection Directive 2014/47/EU[140]
Vehicle registration Directive 1999/37/EC[141]
Directive on end-of-life vehicles 2000/53/EC[142] (**)
Euro standards for road vehicles (**), Regulations (EC) No 715/2007[143], (EC) No 595/2009[144]
Carbon emission regulations (**), Regulation (EU) 2019/631[145]
Road infrastructure charging Directive 1999/62/EC[146]
E-tolling interoperability Directive (EU) 2019/520[147]
Alternative Fuels Infrastructure Directive 2014/94/EU[148]
Energy Taxation Directive 2003/96/EC (**)[149]

(*) Legislation added as part of the revision of Annex I to the Treaty establishing the Transport Community (Decision No 2021/05 of the Regional Steering Committee of the Transport Community).

(**) Regulations not included in Annex I to the Treaty establishing the Transport Community.

136 Regulation on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC.
137 https://eur-lex.europa.eu/eli/dir/2019/1161/oj.
138 Directive on the promotion of clean and energy-efficient road transport vehicles.
139 Directive on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC. This is being revised by the European Commission.
140 Directive on the technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Union and repealing Directive 2000/30/EC.
141 Council Directive on the registration documents for vehicles.
142 Directive that sets out specific rules and regulations for the management and disposal of vehicles at the end of their life cycle. This Directive is currently being revised by the European Commission.
143 Euro 6 standards for light passenger and commercial vehicles.
144 Euros VI standards for heavy duty vehicles.
145 Regulation (EU) 2019/631 setting CO_2 emission performance standards for new passenger cars and vans. As part of the Fit for 55 package, the European Commission proposed a revised regulation on carbon standards for both light duty and heavy duty vehicles.
146 Directive on the charging of heavy goods vehicles for the use of certain infrastructures.
147 Directive on the interoperability of electronic road toll systems and facilitating cross-border exchange of information on the failure to pay road fees in the Union.
148 Directive ensuring a minimum deployment of alternative fuel infrastructure. As part of the Fit for 55 package, the European Commission proposed a new Regulation on alternative fuels infrastructure, repealing the previous Directive.
149 Directive establishing the framework for the taxation of energy products and electricity.

3.8.2.2 The EU legislative framework

The EU has a series of legislative provisions related to transport in general. Some of these have been proposed as being relevant for Ukraine in a recent draft report[150], and the whole package has been analysed, in the context of the Western Balkans, in another report[151]. The Western Balkans country are members of the Transport Community, an international organisation which is working on integrating Western Balkans' transport markets into the EU by assisting the six Western Balkans partners in adopting and implementing the EU legislation in the transport field[152]. Ukraine is an observing participant to this community, and a Joint Statement of November 2022 called for a more systematic involvement of Ukraine in Community work. Relevant EU legislation is shown in Table 18 above and some provisions are reviewed below.

Clean Vehicles Directive (CVE) (2019/1161) — ensures that a minimum percentage of public procurement contracts for road vehicles are for clean and energy-efficient vehicles.

Alternative Fuels Infrastructure Directive (AFID) (2014/94/EU) — promotes the deployment of alternative fuels infrastructure, such as electric vehicle charging stations and hydrogen refuelling stations. This is in parallel to the Energy Performance of Buildings Directive, which also provides for charging points.

CO_2 Emissions Performance Standards for Cars and Vans (Regulation (EU) 2019/631) — sets CO_2 emissions targets for new cars and vans, and encourages the uptake of zero- and low-emission vehicles.

It does not follow automatically that all the legislation cited in Table 3 should be transposed in Ukraine, nor that, if Ukraine decides to regulate in a particular area, it is appropriate for the new regulations to be technically and functionally the same as the corresponding provisions in the EU. There would be a need to evaluate each legislative area in detail, especially with regard to the Ukrainian NQI's capacity to implement it, and also with regard to Ukraine's capacity to enforce it; new legislation which is not enforced will have no effect on the energy efficiency of transport in the country.

It is also worth noting that the Transport Community has objectives beyond those of energy efficiency and CO_2 emissions reduction. This is not to criticise its work, but simply to underline that some of the legislation in Table 3 may not be relevant for sustainability or energy efficiency. Where the Community does concentrate on these two areas, its activities are fully relevant, as its website says[153] :

"We are actively engaged in promoting alternative fuel infrastructure deployment, reduced vehicle emissions, climate proofing of transport infrastructure, sustainable urban mobility as well as digitalisation of transport sector. By advocating for sustainable practices and embracing digitalisation in the transport sector, we strive to create a future-proof transportation system. We strongly believe in collaboration, working closely with EU and Regional authorities, private sector stakeholders, and international organisations to achieve our objectives. Moreover, our efforts align with climate neutrality goals, as we prioritise minimizing carbon emissions and promoting the usage of clean energy sources in transport."

Without considering legislation specifically, it may be proposed that to ensure sustainability of Ukrainian transport, there are certain key policy areas:

- enforcement and governance of vehicle inspection and registration, aimed primarily at improving the energy efficiency of the existing vehicle stock and ensuring that new and second-hand vehicles entering the national market are energy efficient;
- taxation reforms, fuel excise duty, motor vehicle tax and environmental tax, aimed at setting financial incentives to encourage more energy-efficient vehicles and reducing the number of single-use vehicle trips, as well as potentially raising revenue for further sustainability initiatives;
- E-mobility strategy and governance, ensuring that the rollout of electric vehicles and associated charging infrastructure are appropriate and safe.

Regular vehicle inspections contribute to reducing transport emissions (as well as ensuring vehicle safety). The situation in Ukraine with these inspections, in principle governed by the Ukrainian law "On Road Traffic" is unusual. Until 2011, they were mandatory for all vehicles (annual or bi-annual depending on the use of the vehicle). The inspections were carried out in designated centres but without enough of them to meet demand. This resulted in queues and bribes and, ultimately, one could just purchase an inspection certificate without having undergone an actual inspection. As a result, the system did not achieve any of its goals.

In 2011, an amendment to the law cancelled such inspections for vehicles that are used for private purposes (this was widely applauded). Vehicles for commercial use are still subject to such inspections in the following way:

- every two years – trucks with capacity of up to 3.5 tonnes,
- every two years – passenger cars used for commercial purposes more than two years old,
- annually – trucks with capacity of over 3.5 tonnes,
- annually – taxis, whatever the age,
- twice a year – buses and special vehicles for transportation of dangerous cargoes whatever the age.

150 Roadmap for the development of a National Guiding Framework of Standards and Technical Regulations for the Green Reconstruction of Ukraine, Nigel Croft, UNIDO, 2023.
151 Policy instruments for managing road vehicle emissions in the Western Balkans, Activity 4 – Road vehicle emission management roadmap in North Macedonia, Report for: World Bank, 19/05/2023.
152 https://www.transport-community.org/about-us/.
153 https://www.transport-community.org/sustainable-and-smart-mobility/.

In April 2021 the government made public the draft law that would return mandatory inspections for all vehicles. In December 2022 the government tried to push this draft law through Parliament, amongst other things citing that mandatory inspections are a requirement of the EU. However, the political backlash among the population and, consequently, MPs was so strong that the government backtracked and declared that the issue of returning mandatory inspections for all vehicles would be revisited only after the end of the martial law.

Assuming that legislation was enacted to re-introduce regular inspections of private vehicles, there are two different measurement methods for CO_2 emissions: the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) and the New European Driving Cycle (NECD) for vehicles produced from 2022. If CO_2 emissions are linked to vehicle tax, it is important to recognise that there are differences between the two, roughly 21% higher CO_2 emissions under WLTP compared to NEDC.

On taxation and incentives, there is a relatively new Law of Ukraine "On Certain Issues of the Use of Vehicles Driven by Electric Engines and on Amending Certain Laws of Ukraine to Overcome Fuel Dependency and to Develop Electro-Charging Infrastructure and Electric Vehicles" of the 24th February 2023 (which came into force on 23rd March 2023). This law introduces a classification of various electric vehicles, provides for charging stations (including requirements for town-planning and development activities).

It also introduces amendments to six laws of Ukraine to facilitate the use of electric vehicles and the construction of charging stations, and contains provisions for gradual transition to and procurement of electric buses in municipalities of different sizes with established deadlines (the deadline being 2036 when all municipal buses used in cities and towns shall be electric or equipped with internal combustion engines operating exclusively on condensed natural gas (NG-methane), liquified natural gas (LNG-methane), bio-gas or hydrogen. Municipalities are entitled to move the deadline earlier or later, but no more than two years later than the deadline established by this Law. While this law is certainly a step in the right direction, unless municipalities widely opt for electric or bio-gas vehicles, there might be little CO_2 emissions reduction from a change of fuel from petrol/diesel to gas (although there may well be reductions in pollution from a switch to cleaner fuel).

For a long time, Ukraine tried to stimulate the importation of the cars of no more than 10 years of age, by imposing higher import duties for older cars. However, due to the lower prices for cars in Europe than in Ukraine and the low general well-being of the population, Ukrainians tended to import older (and cheaper in Europe) cars using a temporary regime. Then the government held several campaigns to legalise those cars, which essentially defeated its efforts to stimulate higher efficiency, but more expensive cars.

Ultimately, when the war started and the military needed a lot of used SUVs (whose life-spans in combat are really short), a veritable influx of used cars took place. At the moment, it appears that the efforts to stimulate higher-efficiency and newer cars have largely collapsed due to the above-described factors. Given that the government is doing its utmost to facilitate and stimulate the import of certain goods (used cars for the frontline or electric power equipment to compensate for the damaged and bombed-out energy infrastructure), it is unlikely that the efforts at higher efficiency of vehicles will be renewed before the end of the war.

Finally, the Energy Performance of Buildings Directive requires (Article 8.2) that:

> "With regard to new non-residential buildings and non-residential buildings undergoing major renovation, with more than ten parking spaces, Member States shall ensure the installation of at least one recharging point... and ducting infrastructure, namely conduits for electric cables, for at least one in every five parking spaces to enable the installation at a later stage of recharging points for electric vehicles where:
>
> (a) the car park is located inside the building, and, for major renovations, renovation measures include the car park or the electrical infrastructure of the building; or
>
> (b) the car park is physically adjacent to the building, and, for major renovations, renovation measures include the car park or the electrical infrastructure of the car park."

While Ukraine has a version of the EPD, it is not clear whether this contains the above requirements for charging infrastructure, nor how this relates to the Ukrainian law mentioned above.

3.8.3 Findings

Greenhouse gas emissions from transport in Ukraine fell from 112 Megatonnes CO_2 equivalent (Mt CO_2-eq) in 1990 to 35 Mt CO_2-eq in 2017, but their share in overall emissions remained about constant. The Ukrainian transport sector emitted about 10% of all GHG emission, but accounted for 71% of total Ukrainian oil consumption in 2018, a year which might be considered representative of the pre-war period. The contribution of different modes of transport to total emissions from the sector is shown in Figure 14, where it can be seen that road transport dominates.

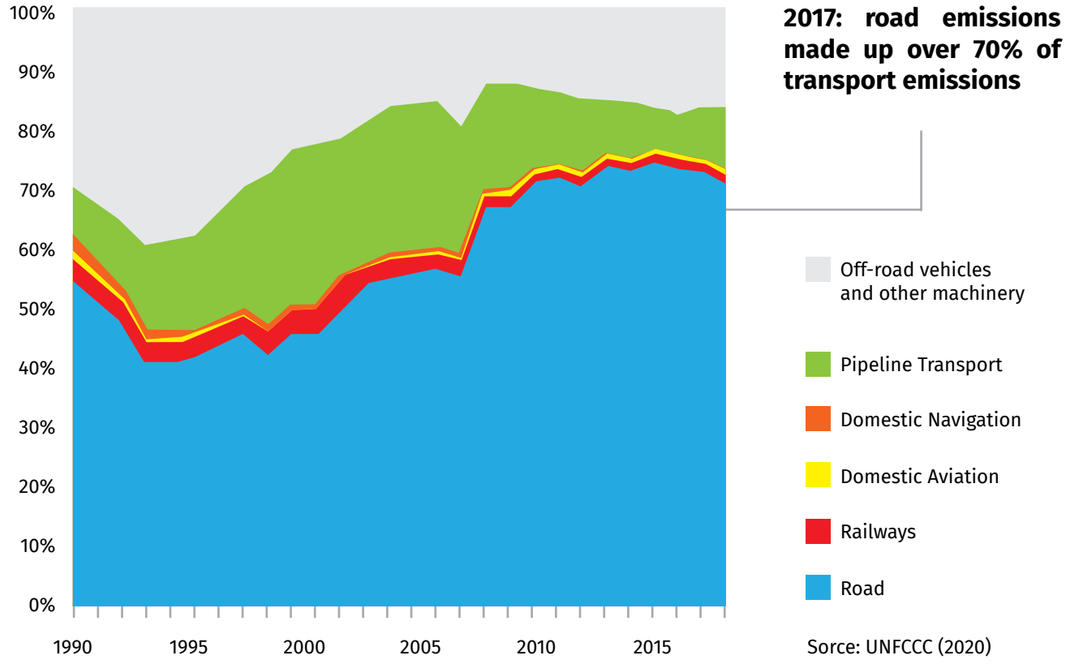
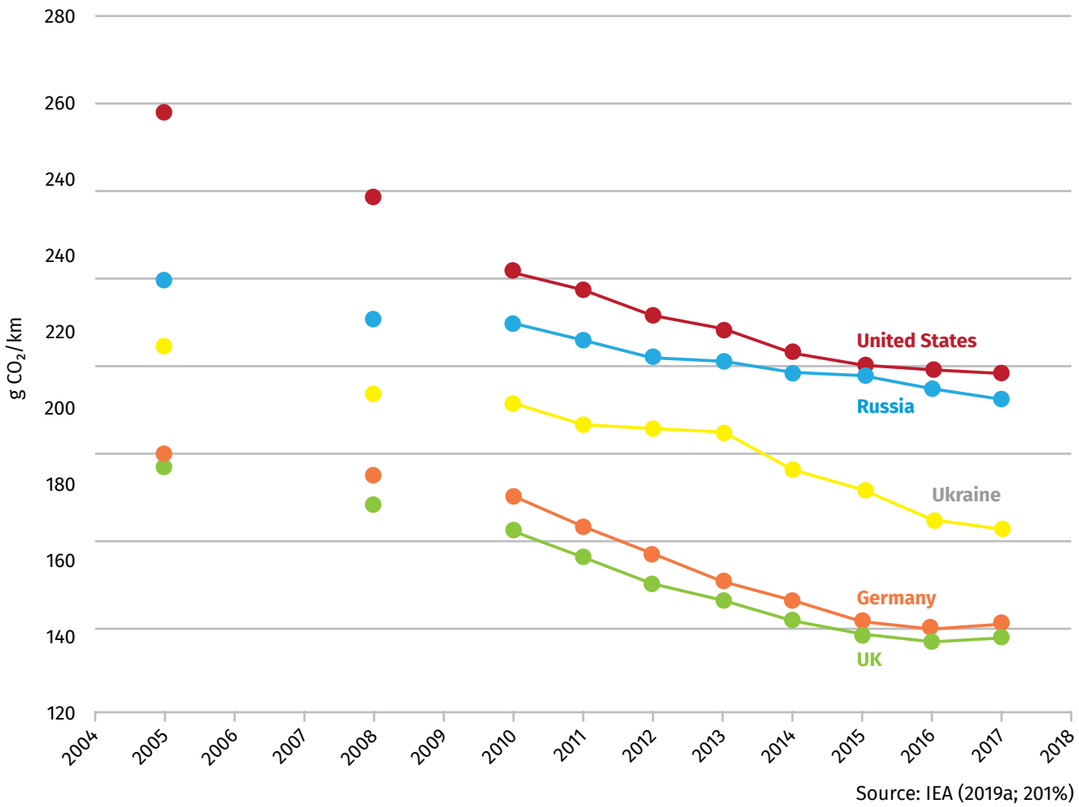


Figure 14 — Percentage of total transport emission by transport type

CO_2 emissions of newly registered cars in Ukraine are reasonable; better than Russia and the US but poorer than the UK and Germany, for example (Figure 15).

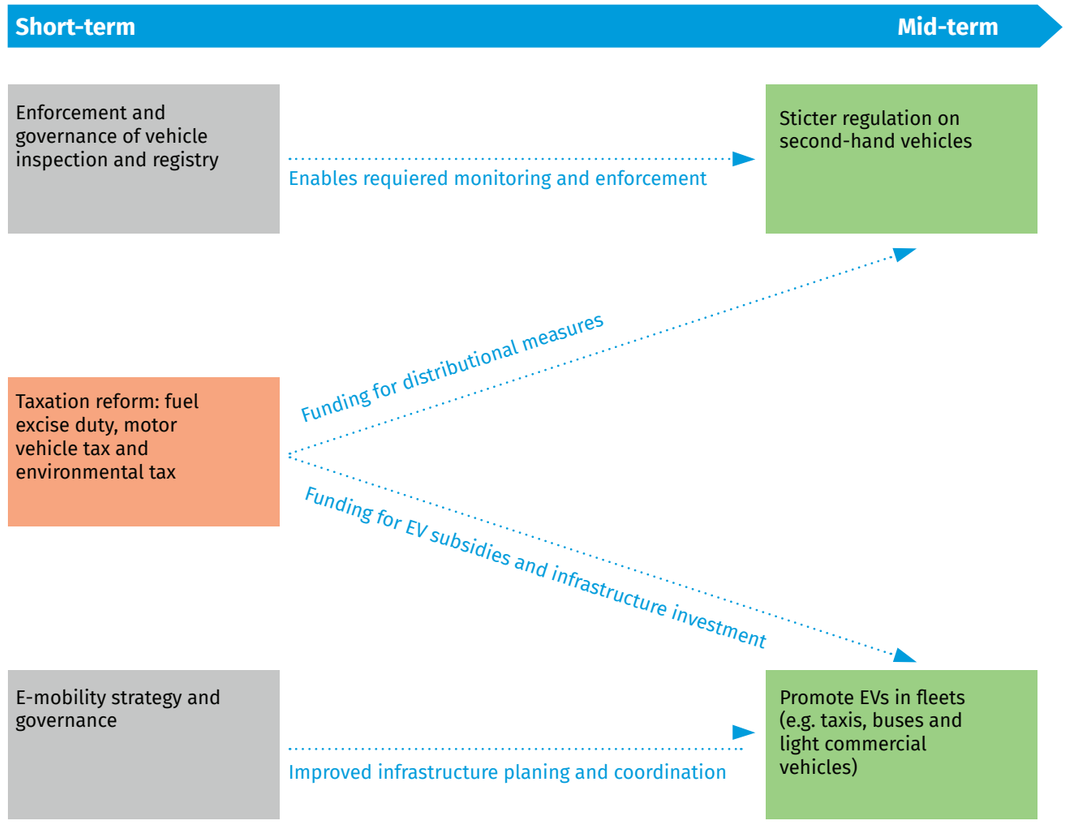


Source: IEA (2019a; 201%)

Figure 15 — Comparison of CO_2 emissions for newly-registered cars

It has proved possible to identify the strategic actions required, some of which can be summarised in Figure 16, from the study on the Western Balkans:

Figure 16 — Some policy recommendations for Ukrainian transportation



This figure does not consider the rebuilding of transport infrastructure, the upgrade of existing public transport infrastructure and equipment or "congestion payments" as discussed above. These, however, are all areas which will need to be considered.

Expanding each of the proposals of Figure 16, this report suggests the following:

Enforcement of vehicle inspections:

- A clear governance framework on vehicle technical inspections and better access and exchange of vehicle data should be adopted, both to facilitate the adoption of stricter regulations on second-hand vehicles for emissions related with air quality and to better control vehicles already in use in Ukraine. This reform would involve some investment, particularly to develop IT tools for the vehicle registry and staff training.
- Investment in additional testing stations would also be required, to rectify the lack of such stations which led to the suspension of private vehicle inspections.
- Enforced inspections would improve efficiency and create employment.

Taxation reform:

- A reform on road transport fuel excises may well be beneficial in the short term to align with the EU Energy Taxation Directive, generate additional fiscal revenue and incentivise lower consumption of fossil fuels in road transport.
- fuel tax reform would lead to a higher benefit in GHG and air pollution emissions, attributed to fuel savings from a reduction in activity, as well as a shift towards more fuel-efficient vehicles (although the current level of fuel tax is unknown);
- fuel tax reform would be expected to lead to substantial fiscal revenue, which could be used for further transport sustainability reforms;
- an increased fuel tax burden would be expected to have a more significant cost impact on heavy goods vehicles, rather than on passenger cars;
- fuel excise rates could be gradually increased in line with EU accession timescales.
- A motor vehicle tax reform involving an increase in the contribution of CO_2 emissions to tax rate would be expected to bring additional emission reductions and fiscal revenues in the short term, although much more limited than those of the fuel tax. Taxation linked to vehicle mass (if not already imposed) might also lead to efficiency improvements.
- Taxation reform, not only on fuel and motor vehicle tax but also schemes such as low emission zones, might be controversial and unpopular in a country struggling after a war. Nonetheless, if the objective really is to enhance the environmental performance of transport, all those involved with using it are likely to have to contribute to the cost.

E-mobility

- The deployment of EV charging infrastructure requires a clear governance framework and coordination among relevant public and private stakeholders, although the Law of Ukraine "On Certain Issues of the Use of Vehicles Driven by Electric Engines ..." and/or the transposed Energy Performance of Buildings Directive appear to provide the regulatory stimulus for this.
- These coordination efforts should lead to a clear framework for installing EV charging points and a prioritisation and planning of publicly accessible charging infrastructure, with minimum requirements gradually converging to those of the EU Alternative Fuels Infrastructure Directive.
- There is a need to identify potential early adopters of EVs in the country (i.e. vehicles that could benefit the most from a transition to EVs in the short term) to facilitate the business case around the deployment of charging infrastructure, particularly in urban nodes, and increase the availability of EVs in the second-hand market. Early adopters of EVs are likely to be highly utilised vehicles, such as buses, taxis and light commercial vehicles used for urban deliveries. The cost-effectiveness EVs in cold climates is a factor to account for.
- Alternative electric mobility devices, such as E-scooters and E-bicycles, may prove effective and more energy-efficient than heavier EVs. Private and public hire schemes of these have proved popular and effective throughout many EU cities.
- Credits targeted to the import of vehicles with zero tailpipe emissions (or simply to EVs, or differentiated credits to plug-in hybrid vehicles and battery electric vehicles), in regulatory frameworks regarding the CO_2 emissions of used vehicle imports, may help to encourage such imports (although the second-hand market for EVs in the EU, which have low performance compared to new EVs, is still not well-established in the EU and it remains to be seen whether it will develop).

Regulations on second-hand vehicles:

- A stricter Euro standard for second-hand import vehicles (e.g. to Euro 6/VI) would effectively improve the environmental performance of the fleet with respect to local pollution. Any affordability or equity concerns (anyway expected to be small, as most of the vehicle depreciation occurs in early years of ownership) should be addressed with suitable mitigation measures.
- Setting (stricter) Euro standards for second-hand import vehicles needs to go hand in hand with an improvement of the monitoring of vehicle emissions performance for second-hand vehicle imports and the enforcement of applicable regulations (see above for emission testing inspections) and a structured data exchange between different organisations into a centralised vehicle registry.
- Additional regulatory requirements can address the energy efficiency and CO_2 emissions of imported vehicles, complementing the fiscal measures mentioned above to exclude imports of highly energy intensive vehicles. Regulatory requirements could take the form of upper energy use or CO_2 emission thresholds per km, differentiated based on weight, or as standards applied to importers to encourage a greater supply of low (and zero) emission vehicle imports.

Among the priority areas for Ukraine in the framework of the Ukraine Energy Strategy (UES) is the greening of transport. These include reducing greenhouse gas emissions in the sector by 90% (although it is unclear whether this is relative to 1990 emissions or not), increasing the share of sustainable modes of transport such as rail and inland waterway, tightening pollutant emission standards for vehicles with internal combustion engines, and developing infrastructure for electric vehicles. The UES envisages a 90% reduction in transport emissions by 2050, which should be facilitated by all modes of transport (road, rail, water and air)[154].

Ukraine has published two policy documents aimed at guiding the transport sector towards a low-carbon future: the Low Emissions Strategy for Ukraine 2050 and the Transport Strategy 2030. While the Low Emission Strategy sets broad goals, the Transport Strategy lists specific measures. However, it remains unclear how these measures fit into the broader cross-sectoral strategy. It does not make sense to solve problems separately, as different measures are interdependent. That is why Ukraine should consider integrating certain transport policy measures into a comprehensive strategic structure that covers all sectors of the economy.

One final policy option, well worth considering, is the following. Instead of a car-centred mobility model followed by many European countries, Ukraine should aim to progress to a sustainable transport sector in which cars are only one means of transportation besides many others. The still low level of motorisation offers Ukraine the opportunity to directly move to a sustainable mobility model. Public transport has to play a strong role, which is complimented by an efficient fleet of passenger cars. An overreliance on a fleet of electric cars only would go hand in hand with problems such as high energy usage, loss of public space, and ultimately congestion[155].

The quantification of the suggestions made above, by way of cost-benefit-analysis and/or RIA, on the other hand, has proved effectively impossible with the limited resources available to this project, as has any attempt to validate the 90% reduction in CO_2 emissions. By way of comparison, the study in the Western Balkans, which did produce tangible results in terms of cost implications and savings in greenhouse gas emissions (but not energy saving), which has been cited in this report and from which several of the policy suggestions have been drawn, required 9 months to complete, relied on the collection of far more data (such as vehicle excise information and fuel taxation regimes) than could have been collected by this project. Moreover, that report relied in simulations using a proprietary program, SULTAN, which is not publicly available.

In terms of RIA, the lowest-level conclusion is that EU legislation in the sustainable transport area cannot be wholly cost-inefficient, because prior to its implementation, the European Commission must have carried out RIA. Similarly, the roll-out of congestion charging schemes throughout the EU demonstrates that these, too, must have merit (and evidence from London does show a reduction in overall pollution levels), although they are paid for primarily by vehicle drivers.

In its updated climate change commitment (2021), Ukraine committed to cut its GHG emissions by 65% by 2030 compared to 1990 levels. With emissions of 112 Mt CO_2-eq in 1990 and 35 Mt CO_2-eq in 2017, this target has already been reached so can no longer be considered as a 'driver'. If the 90% reduction in CO_2 emissions set out in Ukrainian strategy was achieved by 2050, and assuming that this is 90% of 1990 levels, emissions in 2050 should be 11 Mt CO_2-eq. This would represent a saving of 24 Mt CO_2-eq compared with today. Because emissions in 1990 were rather high, a 90% cut does not represent a very ambitious target, however, and saving would be about 50% greater if the 90% cut were changed to recent emission levels.

Cumulative savings cannot easily be evaluated, however, because these will depend on progress towards the 90% target. One report[156] suggests that most CO_2 reductions will be achieved by 2035 so, if a linear improvement is assumed between now and 2035, and no substantial fall after that, however, emissions fall from 26 to 11 Mt CO_2-eq over the next 10 years, giving cumulative savings of 135 Mt CO_2-eq over the same period.

Overall, however, this report concludes that more, and more detailed, research, with access to much better data, is required before any real quantification of the costs and benefits of changes in transport policy can be achieved. It is worth mentioning, in addition that, while it might be assumed that the State and funding agencies will contribute to some initiatives, states do not have their 'own money'. Leaving donor funding aside, states only have either money raised through taxation or borrowing, the latter which, if it becomes excessive, causes difficulties. Greening initiatives (not only for transport but for all other measures suggested by this report) should, therefore, aim to ensure that State-funded initiatives are covered by taxation revenue, and this means that there are likely to be cost burdens on Ukrainian citizens.

154 https://brdo.com.ua/en/news/vidnovlennya-transportnogo-sektoru-ukrayiny-yak-zrobyty-jogo-zelenym/.
155 https://www.lowcarbonukraine.com/wp-content/uploads/Low-Carbon-Transport-Policies-for-Ukraine.pdf.
156 https://unfccc.int/sites/default/files/resource/Ukraine_LEDS_en.pdf.

4 Roadmap for the greening of Ukrainian built infrastructure

4.2 Introduction

This section proposes the timing, considered as short (considered as Years 1 to 2), medium (Years 3 to 8) and long (beyond Year 8) term, for the various proposals made in this report, together with some short considerations of key points, with regard in particular to NQI and other resources, required. This should not, however, be considered as more than preliminary proposals; each activity depends to a certain extent on the situation in Ukraine, depends a great deal on the availability of funding and resources, and each activity should be subject to more detailed analysis prior to the implementation of specific proposals.

The roadmap should be a living document that should be updated every year. Any feedback and comments will make it better. The proposals overall are presented in Table 19 overleaf, and each is discussed briefly below.

4.3 Roadmap management

There are many State organisations (ministries, agencies and others), private sector organisations, and development and funding agencies currently involved in the reconstruction of Ukraine, and many development and funding agencies have broadly the same objectives. Consequently, there is a risk of duplication of effort and/or conflicting advise and activities, with resulting loss of efficiency. The creation of one single organisation with overall responsibility for the implementation of Roadmap activities is proposed, with its membership made up of representatives of all actors involved in implementation. A Roadmap website is also proposed, serving as the single point of contact for Roadmap activities, and which could include presentation of Roadmap activities and projects, calls for tender, examples of best practice, etc.

Finally, the organisation charged with overall responsibility would be responsible for drawing up annual Roadmap programmes and reporting on the implementation of these programmes. This organisation would not take the place or responsibilities of State organisations or individual development/funding agencies but would, instead, have a broader coordination role.

Table 19 — Outline Roadmap for the Green Reconstruction of Ukraine

Short term	Medium term			Long term
Years 1-2	Years 3-4	Years 5-6	Years 7-8	Year 9 onward
Roadmap management				
Identify organisation responsible for implementing Roadmap				
Establish Roadmap website				
Manage Roadmap implementation, website and annual reporting by this organisation				
Energy Performance of Buildings legislation, energy efficiency and voluntary measures				
Properly implement energy certification and EPC issue in new and existing buildings undergoing major renovation.				
Identify organisation responsible for implementing Roadmap	Enhance the independent control system of EPCs and quality assurance mechanism.			
Enhance the mechanism for qualification of auditors and the number of qualified specialists operating in the market.				
Law amendment to include the obligation of issuing EPC for building units, in major renovations and real estate transactions.				

Table 19 (continued)

Energy Performance of Buildings funding

Short term	Medium term			Long term
Years 1-2	Years 3-4	Years 5-6	Years 7-8	Year 9 onward
Understand conditions for the ESFD+ instrument and related implementing IFIs (EIB & EBRD) to operate in Ukraine.				
Consultation with potential "intermediary banks".				
Investigation of private sector availability to participate in clean energy projects supported by IFIs.				
Baseline assessment, identification of measures, life-cycle cost analysis, energy performance calculation, cost-optimal calculation.				
Evaluation of impact assessment: 1) total reduction of CO_2 emissions, 2) reduction of consumption, 3) economic and financial impact.				
Selection of priority measures, definition of criteria for government contribution, elaboration of project pipeline.				
Establish agreements with materials producers, define construction company requirements, create monitoring system, elaborate law for energy requalification of buildings.				
	Conclude agreements with IFIs, banks and private investors.			
	Launch first energy rehabilitation campaign.	Launch second building energy rehabilitation campaign.		
	Elaborate implementing decrees for second launch of energy requalification of buildings campaign.	Elaborate first quality control report	Revise agreements with construction material producers/ traders.	
		Follow up of the campaign of energy rehabilitation of buildings		
		Quality control report and revision of eligibility criteria		

Table 19 (continued)

Construction products — regulation and environmental product declarations

Short term	Medium term			Long term
Years 1-2	Years 3-4	Years 5-6	Years 7-8	Year 9 onward
Ensure that all standards required for EPDs are in place.				
Develop awareness-raising of and technical assistance for the development of EPDs				
Promote and/or create EPD certification capacity.				
Ensure that Ukraine is represented in CEN TC 350/WG1 for EPDs.				
	Consider adopting World Green Building Council carbon targets.			
	Progressively promote the use of EPDs in public and private purchasing. Develop incentives for the wider use of green construction products.			

Circular economy

Introduce circular economy principles into university courses.				
Ensure that Ukraine is involved in CEN TC 350 SC1.				
Ukraine to participate in key international for a for circular economy and adhere to the European Green Deal.				
	Educate decision-makers and specifiers/purchasers to be able to adhere to circular economy principles more widely.			
	Develop and implement a consistent set of metrics, benchmarks and indicators to evaluate circular economy projects and initiatives.			
	Develop initiatives to favour circular economy principles and projects.			
				Ensure that all construction projects follow circular principles.

Table 19 (continued)

Construction products — manufacturing

Short term	Medium term			Long term
Years 1-2	Years 3-4	Years 5-6	Years 7-8	Year 9 onward
Establish and maintain efficiency targets for industry.				
Identify a priority list of Ukrainian manufacturers by energy/CO_2 emission saving potential.				
Perform energy audits of production facilities.				
	Progressively seeks funding to upgrade production processes and install latest production methods.			
	Progressively include green procurement rules into public purchasing.			
	Develop incentives for green private procurement.			
	Consider the introduction of environmental taxes on less-green products. timal calculation.			
Establish planning procedures for reconstruction and refurbishment, to ensure that demand for resources does not pass available supplies.				

Appliances used in buildings

Identify appliances manufactured/ assembled in Ukraine.				
Identify testing capacity in the country.				
Verify appropriateness of transposed eco-design legislation and adjust as needed.				
	Provide technical assistance to manufacturers on eco-design compliance.			
	Train market surveillance officers.			
	Awareness raising of better-performing appliances; development of incentive schemes for the supply or purchase of these.			
		Monitor eco-design compliance levels; continually align national legislation with EU legislation.		

Table 19 (continued)

Renewable energy

Short term	Medium term			Long term
Years 1-2	Years 3-4	Years 5-6	Years 7-8	Year 9 onward
Align the legislative and institutional framework of Ukraine.	Develop programmes, investment plans and regulations for district heating and programmes to support home owners to install RES.			
Assess the potential to switch to individual heating where economically feasible.	Attract investment for energy source replacement. Withdraw subsidies for fossil fuels.			
Develop guidelines for the integration of low-temperature renewables in district energy systems and case studies.	Develop financing models and subsidies for the heat transition of residential buildings. Support schemes for feasibility studies.	Develop financing models and subsidies for the heat transition of residential buildings. Support schemes for feasibility studies.		
	Update greenhouse gas taxation system and monitoring system.			
				Continue investment in RES technologies of the housing sector.

Urban transport

Update CO_2 emissions targets for transport.				
Align fuel excise duty with EU Energy Taxation Directive.				
Establish legislation for vehicle inspections; invest in testing stations.				
Link motor vehicle tax to CO_2 emissions.				
Progressively consider policy options to move away from a car-centred economy.				
Seek full membership of the (EU) Transport Community.				
	Tighten emission standards on second hand vehicles to Euro 6.			
		Consider the introduction of low emission zones.		
	Progressively invest in EV charging infrastructure.			

4.3 Energy Efficiency of Buildings Directive, energy efficiency and voluntary measures

4.3.1 Regulatory provisions

Based on the outcomes of the impact assessment performed, priority actions to be taken by the organisations responsible together with the resources required are proposed.v

A. To properly implement energy certification and EPC issue in new and existing buildings undergoing major renovation:

- **Action:** increase the number of energy audits, which in turn means increasing also the number of qualified experts operating in the market. Human and financial resources need to be provided and the mechanism for qualification of auditors/inspectors strengthened.
- **Organisations responsible:** Certification commissions established by higher education institutions or by self-regulatory organisations in the field of energy efficiency.
- **Human resources:** 5-7 000 specialists.
- **Financial resources:** total cost for the additional professionals needed (of 4 500 further to 1 542 already qualified) is €2 250 000.

If no action is undertaken and resources not provided:

- in new constructions or major renovations the building energy profile (consumption) will not be recorded and known either to owners/tenants or to the State authorities;
- awareness level on energy efficiency materials/measures will remain low and conventional building practices will continue;
- mapping and analysis of the energy performance of the building stock will not be feasible, so assessment of the impact of national policies and measures for the improvement of energy efficiency of the building sector for improvement of energy efficiency will not be feasible.

B. To extend the obligation of energy certification to building units/apartments:

- **Action:** an amendment of the law in force is needed.
- **Organisations responsible:** the central executive authority in charge of shaping the State policy in the field of construction, housing policy and policy in the field of housing and utility services (MinRegion).
- **Financial resources:** internal administrative costs, so financial impact is minimized. The cost of issuing EPCs, to be borne by apartment owners, it is estimated at €120-150/apartment.

If no action is undertaken:

- the impact of energy refurbishment of existing building units/apartments realized under current financing mechanisms or private initiatives will not be recorded and no information will be available on the national database of EPCs. This will not allow for either corrective actions or new targeted policy/funding initiatives for further mechanisms promoting building energy refurbishment.

C. To enhance the independent control system of EPCs and quality assurance mechanism:

- **Action:** increase the number of checks and improve the control procedure, (in line with Annex II of the EPBD), undertaken by the organisations responsible for control.
- **Organisations responsible:** SAEE and MinRegion.
- **Financial resources:** assuming an increase of 2% of the rate of checks and a critical mass of 150 000 residential buildings damaged to be refurbished and an EPC issued, the additional administrative cost is estimated at €405 000.

If no action is undertaken:

- the quality of EPCs will not improve, this resulting in potential failures in implementation of adequate energy efficiency measures;
- the value of the EPC as a tool for data collection and analysis of the building stock energy profile will be limited;
- questioning of EPC quality would result in non-acceptance of the document as a useful tool for energy renovation, this in turn leading to failure of the certification system established.

D. To set out the obligation for installing building automation systems and self-regulating temperature controls:

- **Action:** an amendment of the law in force is needed.
- **Organisations responsible:** MinRegion.
- **Financial resources:** part of internal administrative costs, so the financial impact is minimised. For purchase/installation of automation, borne by building owners, indicative cost in the EU market is €20 000 for a medium size hotel or office building.

If no action is undertaken:

- building-level heat metering and consumption-based billing will not be feasible,
- improvement and affordability of district heating services cannot be ensured,
- lowering household costs cannot be achieved.

E. To set out the obligation for installing Electromobility infrastructures in buildings:

- **Action:** an amendment of the law in force is needed.
- **Organizations responsible:** MinRegion.
- **Financial resources:** part of internal administrative costs, so the financial impact is minimized. For installation of recharging points or ducting infrastructure, indicative cost in the EU market in non-residential buildings is at the level of €10 000 for 100 parking spaces.

If no action is undertaken:

- the lack of charging infrastructure will discourage the use of electric vehicles, leading to the continuation of conventional fossil fuel vehicles, thus failing to reduce emissions, meet the CO_2 reduction national targets or reduce dependence on the imports of fossil fuels.

4.3.2 Funding of energy efficiency of buildings

For this topic, a lot of preparatory activities have to be developed in the first two years. The implementation can start only after a thorough preparation and agreements with international financial institutions (IFIs), to guarantee the financial and technical sustainability. Moreover, concerning the preparatory phase to support the financial impact of the initiative, a specific investigation must be made of the opportunities for input from the European Fund for Sustainable Development Plus (EFSD+) for Neighbourhood Countries, for Ukraine. The main steps in the first years of the Roadmap are shown in a European Commission document[157], but their implementation should be the topic of another specific project.

The main steps in this topic are the following:

Short term (1-2 years)

The conditions for the ESFD+ instrument and related implementing IFIs (EIB and EBRD) to operate in Ukraine to support the issuance of new debt guarantees in favour of clean energy projects and reconstruction/energy rehabilitation of buildings need to be studied and understand. This can then be followed by consultation with potential "intermediary banks" and investigation of private sector availability to participate in clean energy projects, supported by IFIs.

The next steps involve establishing a baseline scenario to represent the current state of the building stock in terms of energy performance, identifying a range of possible energy performance measures that could be applied to buildings (insulation, heating, cooling, lighting, etc.) and performing a life-cycle cost analysis for each identified measure (including operational and maintenance costs over the lifetime of the measures). This is followed by estimating the energy savings associated with each measure and translating them into monetary terms using appropriate energy prices, then comparing the total costs (investment, operation and maintenance) with the energy savings and other benefits achieved by each measure (definition of the most cost-effective solutions).

An **evaluation of impact assessment of the measures** will be required, comprising:

- total reduction of CO_2 emissions into the atmosphere,
- reduction of consumption and bill expenses,
- occupational aspects (direct and indirect),
- economic and financial impact (gross-cost for the State and induced effects that create income to the State).

Selection of priority measures for the energy rehabilitation of the Ukrainian apartment-building stock is a further important element, made up of:

- definition of criteria for establishing the percentage of government contribution to energy rehabilitation interventions (buildings/families eligibility criteria leading to a priority list)
- elaboration of a project pipeline.

The final short term action is establishing of agreements with building materials producers and traders to fix materials prices (control of the raw materials market), definition of construction company requirements to participate in national tenders for energy rehabilitation of buildings, creating a monitoring system for quality control and elaborating and issuing a law for the energy requalification of buildings and related implementing decrees.

Medium term (3-4 years)

Action early in the medium term involve:

- conclusion of agreements with IFIs, intermediary banks and private investors,
- launch of the first energy rehabilitation campaign,
- elaboration of implementing decrees for the second launch of the energy requalification of buildings campaign.

Medium term (5-6 years and 7-8 years)

A second building energy rehabilitation campaign will be launched, to follow up and build upon the first, and a quality control report of the first campaign will be elaborated. Lessons can be learned from the first campaign, and care should be taken not to repeat the experience from Italy, whereby Superbonus 110% led to substantial price increases of construction products. Consequently, the results of both campaigns will be assessed and follow-up, and the agreements with construction product manufacturers and traders, and the eligibility criteria for buildings, will be revised as necessary.

157 https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/european-neighbourhood-and-enlargement-negotiations_en.

4.4 Construction products — regulation and EPDs

EPDs could be promoted either as a part of the new EU's Construction Products Regulation (CPR), likely to make them compulsory, or as a voluntary initiative in their own right. The former does not exclude the latter, and is recommended as a short-term option, and awareness-raising and development of, e.g. public purchasing policies to consider the environmental performance of products are the route to increasing the wider use of EPDs. Whether voluntary or regulatory, certification bodies sufficient to meet the demand for EPDs will need to be established although, strictly speaking, Ukraine could use certification capacity from other countries.

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In many cases, the required thermal performance data needed for insulation projects do not require full transposition of the CPR; to an acceptable level of accuracy reference data can be taken from tables and used in calculations. The same is not true of dangerous substances content, however. It is well beyond the scope of this report to provide advice on the possible approximation/transposition of the CPR in Ukraine, but experience from many other countries is that attempting to bring the regulation into force for all construction products, without first ensuring that the NQI resources exist, especially in terms of testing, inspection and certification capacity, will lead to very low levels of compliance.

It is difficult to estimate the potential consequences on CO_2 emissions and energy savings of insufficient investment of resources into transposition and enforcement of the CPR and/or to the promotion of EPDs. There is no direct correlation between EPDs and savings because they mainly address indirect effects such as embodied carbon on the possibilities for recycling, reuse or repurposing of products, and because currently there is no lower limit on environmental performance. That said, EPDs are an important 'tool' within the wider sphere of greening and, without some investment to promote them and create a market for them, it seems unlikely that they will gain much usage in Ukraine.

Ukraine should, however, consider adopting the carbon reduction targets of the World Green Building Council, if it has not already done so. In addition, the creation of incentives to promote the greater use of green construction products, both in the public and private sectors, should be considered as a medium-term objective.

If it is not already a member, Ukraine should ensure that it is represented on CEN TC 350/WG1, the Working Group specifically charged with developing and maintaining standards for EPDs.

4.5 Circular economy

The development of a circular economy is perhaps the most challenging topic for which to propose specific Roadmap actions. This is in part because the whole subject area is relatively news, in part because there is no agreement on exactly which instruments to use to promote it, and in part because of the many options and measures possible to help create it.

At its most basic, a circular economy involves the following activities:

Maximise reuse (including refurbishment and repurposing) by: 1) reusing the existing asset (building), 2) recover materials and products on site or from another site at end-of-life, and c) share materials or products for onward reuse or repurposing.

Design buildings for optimisation by: 1) designing for longevity, 2) designing for flexibility and/or adaptability and c) design for assembly, disassembly and recoverability.

Modular systems: using standardised, modular and possibly constructed off-site, building elements with less waste and easier to reuse.

Products as a service: creating payment systems whereby materials are treated as a 'service' and payment is for the service of using materials instead of for the materials themselves.

Minimise impact and waste by: 1) using lower impact (lower embodied carbon) new materials, 2) using recycled content or secondary materials and 3) designing-out waste.

Some of the options contributing to a circular economy are presented elsewhere (e.g. promoting EPDs, improving production technologies and green purchasing) and these are not repeated. Instead, the following additional activities are suggested:

Short term (1-2 years)

1) Introduce the teaching of circular practices to architects, structural engineers and others on university courses.
2) If not already involved, ensure that Ukraine is represented on CEN TC 350/SC1, the Sub-Committee responsible for the circular economy in the construction sector.
3) Ensure that Ukraine participates in appropriate international fora in which circular principles are being established, such as the World Economic Forum, OECD and the EU, and ensure that Ukraine is aware of and associated with the European Green Deal (once the three actions in the short term are established, they continue).

Medium term

1) Educate decision-makers and specifiers/purchasers to be able to adhere to circular economy principles more widely.
2) Through international collaboration, contribute to the development of, and then implement, a consistent set of metrics, benchmarks and indicators to evaluate circular economy projects and initiatives.
3) Develop initiatives to favour circular economy principles and projects.

Long term

1) Ensure that all construction projects follow circular principles.

4.6 Construction products — manufacturing

There is a serious risk that the demand for refurbishment and reconstruction exceed the feasible total production capacity of Ukrainian construction products manufacturers. This is likely is certain key products such as cement, concrete and reinforcing steel, thermal insulation and doors and windows. Some, but not all, of this shortfall can be made up by imports, but there is a risk that this will negatively effect Ukraine's balance of trade. Consequently, there is a likelihood that pressure will be placed on existing manufacturers to provide products as quickly and cheaply as possible, using existing, inefficient, methods, rather than ensure a transition to more environmentally-sustainable production methods.

Reconstruction requires central planning over time to ensure that immediate demand does no exceed supply capacity. Products need to be reused or recycled to the greatest extent possible, to reduce the demand for virgin materials.

The actions and timescales proposed for this topic are the following, although some activities may need adjusting depending upon the current state of manufacturing in Ukraine:

Whole reconstruction period

1) A country-wide reconstruction/refurbishment plan needs to be developed, to ensure that there are sufficient construction products to satisfy the demand without, either, leading to high price inflation, negative consequences on Ukraine's balance of trade or the promotion of rapid production but using old, inefficient, production methods.

Short term, 1-2 years

1) If not already in place, ambitious targets for energy efficiency and CO_2 emissions should be set, monitored and updated as necessary, either for construction products specifically, for all industry sectors together or a combination of whole industry and specific sectors. Care needs to be taken that the baseline for these targets is realistic.
2) An inventory of all national construction product manufacturers needs to be established and ranked in terms of energy saving /CO_2 reduction potential.
3) Energy audits of manufacturers will be required to identify the state of development and savings potentials.

Long term

1) Having identified priority construction products, funding will need to be sought to bring production processes fully up-to-date. In some cases the investment might come from manufacturers themselves, especially where a demand for greener products has been created; in other cases it might come through donor grants or loans; or it might require State funding where, for whatever reason, the two previous options are no feasible.
2) Green procurement rules will need to be progressively built into public procurement, so as to create a demand for products having the best environmental credentials (this lies in with EPDs and the Circular Economy). As explained throughout this report, neither conventional cost-benefit-analysis nor least price are suitable tools for assessing bids, unless a 'threshold' of green performance is first established, to exclude 'conventional' design and build solutions. These rules should apply both to nationally-produced and imported products.
3) Incentives and targets for the specification of green products should also be considered. These could take the form of simple targets (but this would need monitoring and would most likely lead to higher prices passed on to purchasers), direct subsidies (which would affect public budgets) or indirect subsidies (such as a reduction in local taxes (rates) paid on buildings constructed with more efficiently-produced products).
4) A progressive tax on products with the highest embodied carbon could also be considered but, for this not simply to result in higher prices, must be combined with sufficient availability of lower embodied carbon products.

Consequences of under-investment

Production technology is not an area conventionally subject to direction regulatory provisions. Where it is regulated, this is usually indirectly, through for example CO_2 permits; in other cases, production improvements are made because there are cost and/or efficiency benefits for the manufacturer, or because a 'market' has been created for more efficiently-produced products.

It is possible to identify and quantify energy savings and CO_2 emission reductions for individual production plants (although to do so for Ukraine would require additional studies of current manufacturers to identify savings potential). To assess the benefits across the whole construction products sector, though, would require a great deal more data, some of it difficult to quantify, such as the total demand over time. It seems fairly clear that the greater the investment, the greater the energy savings will be (CO_2 emissions can also be reduced by changing the renewable energy sources). But until tools are fully developed to quantify and possibly monetise CO_2 reductions, it may need to be accepted that some investments are made because they are "the right thing to do", rather than that they are demonstrably cost-effective.

4.7 Appliances used in buildings

This is a largely stand-alone topic, but one with potentially important energy, CO_2 emissions and cost savings, provided that the underlying legislation is properly enforced. Although Ukraine has already transposed EU legislation and therefore it might be reasonably assumed that some sort of RIA has already taken place, it has not proved possible to verify this.

The conventional stages for improved appliance eco-design performance are the following:

Short term, 1-2 years

1) Identify appliances manufactured/assembled in Ukraine. If a particular type appliance type is totally imported, the enforcement of legislation is relatively easy, but importers need to be made aware of the need to supply only compliant products.

2) For both market surveillance purposes and for conformity testing, Ukraine will need testing capability for eco-design, and gaps identified.

3) Ukrainian legislation needs to be appropriate for the technology of appliances manufactured or assembled in Ukraine. If it is not (i.e. if Ukrainian producers are not able to comply, either the legislation should be adjusted accordingly and/or investment and technical assistance needs to be offered to producers to upgrade their appliances to the most recent technology.

Medium term, 3-8 years

1) Early in the medium term (Years 3-5), technical assistance needs to be offered to Ukrainian producers to ensure that they understand how to draw up EPDs.

2) Customs officers also require training, and possibly additional resources, to ensure that eco-design and energy labelling legislation is properly imposed. The challenge, usually at the start of enforcement action, is to change the mindset of appliance suppliers, such that they understand that they can no longer supply non-compliant products; once this has been achieved, control levels can be reduced.

3) There is a need to raise awareness of eco-design provisions amongst consumers and public purchasers, to ensure that they switch from least-cost appliances towards most-efficient ones. In addition, schemes can be devised to provide incentives, either directly to consumers or to electricity generators, to purchase and/or supply low-energy appliances. If this does not have the desired effect, Ukraine could consider introducing threshold energy consumption levels higher than those in the EU.

2) Finally, compliance levels should be monitored on an on-going basis, and actions taken if these levels are not sufficiently high. Because of likely changes in eco-design provisions in the EU, Ukraine needs to be constantly monitoring developments in EU legislation and updating its own legislation where this is necessary/appropriate.

Consequences of a lack of investment

The need for investment is greatest in market surveillance (public sector), and testing equipment (public and/or private sector). Although much market surveillance can be done by documentary verification rather than testing, a common mistake is for countries to devote insufficient resources to market surveillance (and customs) and, consequently, suppliers have little obligation to shift to providing more energy-efficient appliances. Test equipment is, however, needed for manufacturers to assess their products. Investment can be economic for the private sector where the equipment is used both for initial type testing and routine quality testing (and private sector equipment can, under carefully-controlled conditions, also be used for market surveillance). Where private sector is not economic, the need for public sector investment arises.

4.8 Renewable energy

In accordance with Decision of the Ministerial Council of the Energy Community D/2021/14/MC-EnC of 30th November 2021, Ukraine undertook to implement the EU fourth Clean Energy for all Europeans package, to harmonise the national legislation with Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II) by the end of 2022.

Seven main national-level institutions have energy policy responsibilities:

- **Ministry of Energy and Environmental Protection (MEEP)** is responsible for most energy supply policies, sustainable energy policy and climate change policy, and for co-ordinating energy policies across the government and advising the parliament,
- **State Agency on Energy Efficiency and Energy Saving (SAEE), under MEEP**, is the central government body responsible for advancing and promoting energy efficiency and renewable energy developments and technologies,
- **Ministry of Finance** is responsible for taxation relevant to the energy sector,
- **Ministry of Regional Development, Construction and Housing (MinRegion)** develops local-level policies and programmes,
- **National Commission for State Regulation of Energy and Public Utilities (NKREKP)**, established by Presidential Decree No. 715/2014 in September 2014, supervises the natural gas and electricity markets as well as the heat sector,
- **Anti-Monopoly Committee** is responsible for preventing excessive concentration of market power,
- **State Nuclear Regulatory Inspectorate** has regulatory responsibility for the operation of nuclear facilities, including uranium mining, radioactive waste storage and decommissioning at Chernobyl.

Stakeholders in the field of RES energy:

- Ukrainian Wind Energy Association (UWEA),
- Ukrainian Renewable Energy Association (UAWE),
- CSIS Ukraine Economic Reconstruction Commission,
- National Commission for State Regulation of Energy and Public Utilities (NKREKP),
- National Energy and Utilities Regulatory Commission of Ukraine (NEURC),
- Association “Energy Efficient Cities of Ukraine” (EECU),
- Energy Efficiency Fund of Ukraine,
- Renewable Energy Agency (REA).

Suggestions for actions to uptake in short, medium and long-terms:

Short term, 1-2 years

1) Alignment of the legislative and institutional framework of Ukraine relating to renewable energy sources (RES) with the EU acquis in the field:

1.1) Development/amendment of RES energy related laws, bylaws, resolutions, procedures, implementing acts, others in Ukraine for ensuring compliance with the relevant EU acquis;

1.1.1) involving all competent bodies, relevant stakeholders and public in the coordination of RES-related legislative acts to adopt and transpose relevant EU acquis,

1.1.2) conducting campaigns throughout the RES legislative development process to raise citizens’ awareness of State policy, legislative framework and available supporting measures regarding the RES integration in the housing sector,

1.1.3) increasing visibility and awareness among municipalities, and support/capacity building for all relevant stakeholders.

1.2) Development and strengthening of enforcement capacity of competent bodies to ensure the proper implementation of the RES energy national legislation aligned with the EU acquis:

1.2.1) developing certification schemes, qualification requirements and training programmes for installers and designers of all forms of RES systems in buildings and industry (e.g. for individuals, small-scale renewable energy installers/companies, others),

1.2.2) establishing certification bodies and certification and training providers for RES installers and designers, and designation of a competent body,

1.2.3) developing the national legislation associated with the certification schemes.

2) Assessment of the potential for optimisation of central heating systems by switching to individual heating in the regions and at sites where it is economically feasible.

3) Development of guidelines for policy makers to facilitate the integration of low-temperature renewables in district energy systems (available tools and solutions for strategic heating and cooling plans, mapping demands and resources, stakeholder involvement, and technical challenges, case studies).

Medium term, 3-4 years

1) Development of residential buildings modernization/retrofitting programmes (at state, regional and local level) and related investment plans to ensure the transition from fossil fuels-based energy to RES; Development of regulatory framework for district heating, including pricing regulations and non-profit requirements; Development of programmes for a continuous support of households and condominiums to install RES.

2) Introduction of mechanisms for attracting investments for the implementation of the energy generation sources replacement programmes in residential buildings; development of policies for ultimate withdrawal of subsidies for fossil fuel-based production and consumption, which distort markets and impede their development.

3) Development of suitable financing models and subsidies to bring about the heat transition of residential buildings; support schemes for feasibility studies as an important element of the financial support framework.

4) Updating the greenhouse gas taxation system and monitoring system.

Medium term, 5-8 years

Construction of local production capacities for solar PV and heat pumps systems, storage devices and related auxiliary equipment to accelerate the energy transition in the residential sector.

Building a system for monitoring the implementation of sectoral legislation and the transition from fossil fuels-based energy sources to RES in residential buildings.

Long term, Year 9 onwards

Continuous investments in the sustainable development of the energy independence of the housing sector through the use of RES technologies.

Consequences of under-investment

Under-investment could result either at State/large donor funding level, company level (RES developers) or private level (building owners); there will be an almost direct correlation between the level of investment and the resulting installed capacity of renewable energy systems.

4.9 Urban transport

Although it is possible to make Roadmap proposals for the transport sector, it has not been possible to verify that these are considered beneficial overall. Raising fuel and road tax rates, and introducing low-emission zones, could be contentious and impose cost burdens on citizens who do not have easy means to reduce or avoid them. Consequently, more research and assessment should be carried out before the actions proposed below are implemented.

Medium term, 3-4 years

1) Update CO_2 emissions reduction targets for transportation, especially because existing targets have already been achieved.
2) Align fuel excise duty with the EU's Energy Taxation Directive.
3) Seek full membership of the (EU) Transport Community.

Medium term

1) Tighten emission standards on second hand vehicles to Euro 6.
2) Consider the introduction of low emission zones.

Short and medium term (1-8 years)

1) Establish legislation for vehicle inspections; invest in testing stations and train inspection staff.
2) Link motor vehicle tax rates to CO_2 emissions.
3) Progressively consider policy options to move away from a car-centred economy.

Medium and long term

1) Progressively invest in EV charging infrastructure.

5 Conclusions

That Ukraine needs rebuilding and reconstruction is not in any question. The war zone will most certainly need reconstruction, but the infrastructure throughout the country is in relatively poor condition, from an energy usage and environmental point of view, and consequently in need of refurbishment. Leaving agriculture aside, the three biggest energy users, and consequently the three largest producers of carbon dioxide in most countries, are transport, buildings and industry.

This report has considered all three sectors in detail, as well as looking at the potential for renewable energy generation in Ukraine, and greater implementation of the circular economy within the construction sector. Where it has been possible to estimate figures, the report shows the following:

- residential buildings sector: potential energy saving ≈ 180 TWh/y, CO_2 emissions reduction ≈ 55 Mtoe, total investment cost ≈ €67 billion;
- construction products manufacturing sector (cement and concrete): potential energy saving ≈ 5 GWh/y, CO_2 emissions reduction ≈ 2 Mtoe, total investment cost ≈ €0.02 billion;
- renewable energy: current capacity = 9.6 GW, potential capacity ≈ 875 GW, total investment cost ≈ €1 trillion.

In general, these figures have to be considered as conservative for the country as a whole. There are greater savings to be made by considering all buildings and there are savings in other construction products manufacturing areas, but it has not proved possible to quantify these. In addition, it has not proved possible to estimate savings from more efficient appliances, the transport sector or the circular economy.

These savings will not, however, occur without a great deal of political and financial will. The challenge is not particularly a technical one; there is a great deal of experience available covering what needs to be done. The greatest challenges are, firstly, to develop the political will to commit fully to a green reconstruction and, secondly, to obtain the necessary financing to cover the required investment. By way of very rough comparison, the GDP of Ukraine in 2021 (possibly the last normal year) was €200 billion; the investment in more energy-efficient buildings is, therefore, 30% of annual GDP, while the investment required for renewable energy is five times the annual GDP. The required investments will not, of course, all take place in one single year but, despite this, the sums required are extremely large.

A regulatory basis, derived in part from EU provisions, exists and is in part implemented or being implemented in Ukraine, covering all sectors considered by this report (with the possible exception of the Circular Economy, which is still developing). Regulations alone, though, will not bring about the identified investments; without proper awareness-raising and enforcement, experience proves that regulations do not achieve anywhere near their desired effects. The costs of implementation and enforcement, in comparison with the total investments proposed above, are very small, but should by no means be underestimated.

Accepting that the full benefits will not be achieved without the full investment (over a period of time, although partial benefits would be achieved with partial investment), the key question is how to fund these investments. With the exception of the reconstruction/refurbishment of the residential sector, where a possible funding model is presented and discussed in this report, specific financing proposals have not been considered, although these merit as great attention as the technical details of what needs to be done.

It is, in principle, legitimate for Ukraine to borrow money to fund a green reconstruction. However, the Ukrainian national debt stood at 50% of GDP in 2021, rose to 63% in 2022 and seems likely to continue to rise while the war continues and general economic activity is suppressed. Consequently, it is impractical and unrealistic to assume that Ukraine should put itself into an unsustainable debt situation, leading to the classic conundrum of how to finance a green recovery while economic realities suggest that this is unfeasible.

Donor and development funding, in the form of grants rather than loans, are one potential income source but cannot realistically be expected to cover the full cost. This leaves, therefore, only one remaining option; the Ukrainian population is going to need to contribute to its own green recovery, by one means or another. Ukrainians might benefit substantially (by around €1 000 a year) on fuel bill reductions as a result of better thermal insulation of their residences, for example, but innovative ways of using these savings need to be found so that citizens feel able and willing to contribute to greening. Equally, though, they may find that they are having to pay more for transport than previously, if the transport sector is also to be greened.

As discussed in this report, a paradigm shift will be required so that not only can the green reconstruction of Ukraine be funded without leaving the State in an impossible economic position, but also that greening initiatives can be evaluated and chosen by means other than conventional 'least cost' or 'most profitable' metrics. The research indicates that much more work is needed to develop these new financial tools, especially when it is currently challenging to 'monetise' the true economic consequences of global climate change.

Many countries have fine greening and development intentions and, as a general rule, all stakeholders know what needs to be done. But for various, sometimes complex but often linked to finance and resource reasons, these intentions remain unachieved. It appears that a great deal more research, thought and innovative ideas are needed to ensure that the highly commendable intention of a green reconstruction of Ukrainian built infrastructure does not fall prey to political and financial expediency.

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