SELECTED HIGH-IMPACT MEASURES

Energy efficiency in public buildings – 50% retrofitting target until 2030

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Low Carbon Ukraine

Implemented by
Berlin Economics

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based on a decision of the German Bundestag

Motivation and project background

This policy proposal is part of a series which was elaborated in the framework of the project Low Carbon Ukraine (LCU) supporting more ambitious paths for selected energy and climate policy areas.

The idea to develop the present ten "Policy Proposals" arose in the course of LCU's support for the Ministry of Energy of Ukraine in setting up a National Energy and Climate Plan for Ukraine. While Ukraine's climate targets are partially very ambitious, we often observed a lack of underlying analysis and concrete policy measures to achieve those targets. For the most crucial topics, we provide a comprehensive analysis and propose concrete policy measures based on international experience.

Each Policy Proposal was written in a multi-stage process: a first draft of LCU experts or invited professionals was discussed over summer and early autumn 2020 with Ukrainian experts and stakeholders. Results of those discussions were taken into account when updating the Policy Proposals. It is important to note, that the presented results reflect the view of the authors and not necessarily the position of the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety).

We hope that the present analysis and proposals will contribute to a fruitful and constructive discussion and help Ukraine to develop ambitious, yet realistic energy and climate policies.

Dr. Georg Zachmann, project leader
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Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy. It is part of the International Climate Initiative (IKI) and is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on the basis of a decision adopted by the German Bundestag. The project is implemented by BE Berlin Economics GmbH.

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Executive summary

Deferred maintenance and repair investments reduce the value of the Ukrainian building stock and annihilate private and public property. Moreover, the poor condition of the Ukrainian building stock accounts for high energy consumption and is a large contributor to GHG emissions. Both is economic inefficient in short and long-term and directly impact living conditions of the population negatively. A long-term retrofitting strategy in line with the Energy Efficiency Directive (2012/27/EU) is required for residential as well as public buildings.

We evaluate an ambitious annual retrofitting of approx. 5,500 public buildings representing approx. 16 m m². This will require energy saving related investments of EUR 1 bn annually until 2030. The primary energy savings sum up to 700 TWh until 2059 and save 140 Mt CO_2. We propose to finance the energy retrofitting through emitting green bonds worth EUR 8 bn. Assuming a constant bond issue in EUR in the period 2021-2030 with an interest rate of 7% and a run time of 15 years – trough reinvestment of bonds with a maturity of approx. 5 years – the CAPEX sums up to approx. EUR -19.6 bn, including a budget funded own contribution of building owners of approx. EUR 1.6 bn (see Table 1). Energy savings reduce payoffs amounting to approx. EUR 24 bn until 2059 while the resulting CO_2 abatement costs are approx. -5 EUR/t CO_2 discounted which indicates a gain. We expect additional non-energy related investment needs of about EUR 640 m that are required for an overall modernisation of these public buildings. A funding has to be provided by the state and/or municipal budgets for securing long-term usability of the building stock. This funding is not considered in the following analysis.

We are aware of the administrative difficulties resulting from the implementation of green bonds at state level to finance investments at local and/or municipal levels. We recommend that this issue be addressed in a newly established working group for exchange between the Ministry of Finance and the Ministry of Regional Development of Ukraine.

Table 1: Results of retrofitting public buildings 2020-2059

	m UAH	m EUR
Bond issue	260,000	8,000
Governmental extra payment	53,000	1,600
Total investment	313,000	9,600
Interest payments	-330,000	-10,000
Bond payback	-333,000	-8,000
Governmental extra payment	-53,000	-1,600
CAPEX	-716,000	-19,600
Monetary energy Savings	980,000	24,000
Total 2021- 2059	264,000	4,400

Required policy measures, more precise regulatory economic planning as well as information instruments need to be anchored in national legislation and provide framework enforcing and supporting retrofitting activities. Therefore, we recommend the following measures:

i. Define quantitative retrofitting targets following a long-term retrofitting plan.

ii. Define what type of construction activity to what extent in or at a public building counts as an energy efficiency retrofitting measure in the sense of this proposal.

iii. Define energy efficiency levels that must be achieved by a retrofitting measure.

iv. Define funding instruments that consist of national and regional contributions and include national and international financial intermediaries.

Apart from primary energy savings of up to 2,300 ktoe annually and related emission reductions of up to 5 Mt CO_2 annually from 2030 onwards, further socio-economic co-benefits arise. Investing in public buildings represents an economic governmental demand-side stimulus that increases aggregated demand and, therewith, GDP. Such investments will create about 50,000 jobs. In the course of job creation, new business models arise and employees' skills increase. The latter will lead to improvements in economic efficiency in case large-scale retrofitting measures are taken on the residential building stock. The retrofitting of schools, hospitals and offices further improve basic building services, which has positive effects for the users of these buildings.

Ukrainian public building stock

The share of public buildings in the total building stock accounts to max. 15%.[1] In total, the building sector consumed 42% of total final energy in 2017 with commercial and public services consuming 9% (IEA, 2019).

Ukraine suffers from an outdated building stock that often does not comply with modern EE requirements.

In Ukraine, like in other former communist countries, outdated Soviet style buildings are a common problem. Most public buildings were built before 1990. Their architectural and building systems include mostly large-panel, large-block and frame made systems with precast concrete and do not comply with modern energy efficiency requirements. 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 outdated codes regulating the construction of buildings do not allow for exploiting economic and environmental benefits of district heating, which is quite inefficient in Ukraine. The lack of consumption-based billing has meant that there are often no incentives to implement energy-efficiency measures.

[1] Up to our knowledge, official statistics only provide limited statistical information on the structural breakdown by types of public buildings. Thus, we cannot accurately determine the generalized value of estimated energy consumption of the entire stock of public buildings, since it is impossible to precisely determine (as %) the number of typical objects relative to the total number of buildings. According to the Energy Community (2019), 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 still ongoing.

In recent years, individual heating units have been massively installed at multi-apartment and public buildings in Ukraine to regulate heat demand and perform localised hot water preparation for the clients (KeepWarm, 2019). Projects supported by the EU, GIZ, UN, NEFCO and EBRD triggered improvement of energy efficiency in Ukrainian public buildings[2]. Nevertheless, while these projects are implemented on a small scale, annual energy saving potential of public buildings still amounts to 800 million m^3 in gas equivalent (SAEE, 2018). Therefore, we propose broad-based energy efficiency retrofitting for Ukrainian public buildings.

On a small scale, projects supported by International organisations triggered EE improvements.

Currently, significant bottlenecks hinder broad-based energy efficiency retrofitting activities:

- limited capacities and know-how in the building sector to set up complex and nationwide retrofitting programs; most contractors are located in Kyiv, meaning huge deficits in other regions,
- limited ability on the municipal level to plan, procure and control implementation of the projects,
- high risk of poor-quality implementation on regional level,

current decentralization reforms (transfer of ownership of many public buildings from the central to the local level).

There are still crucial obstacles to EE retrofitting In Ukraine: limited capacities, limited ability and Institutional barriers.

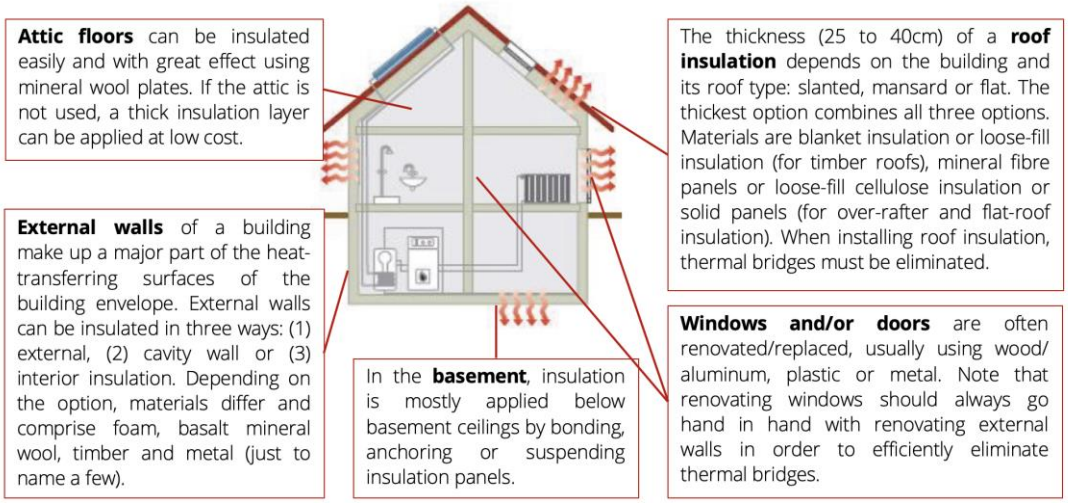
Proposed measures

I. Technical measures

For any thermal insulation, the physics of the building needs to be considered. Figure 1 presents building components which can be renovated.

Retrofitting measures can be aimed at the building components and the engineering systems.

Figure 1: Retrofitting measures for different parts of a building



Source: SAEE (2019b) and Schulze Darup *et al.* (2015) (adapted)

[2] Covenant of Mayors (funded by EU), Removing Barriers to Increase Investment in Energy Efficiency in Public Buildings in Ukraine through the ESCO Modality in Small and Medium Sized Cities (funded by UNDP), Public Sector Energy Efficiency Financing Framework (PSEEF) (funded by EBRD), Energy Efficiency financing program for public buildings (funded by NEFCO) and Implementation of the Municipal Energy Management System in 20 Small Cities (funded by GIZ)

Retrofitting measures are also applied to the building engineering systems. Table 2 presents its different components and typical retrofitting measures. Note that in most public buildings, the heating systems consume the bulk of energy while the ventilation, hot water, and lightning system only account for minor parts of total energy consumption of the building.

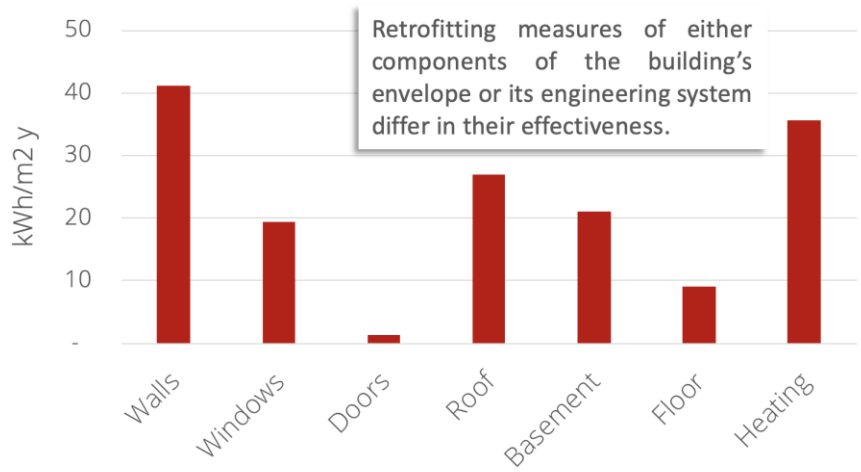
Table 2: Building engineering systems

	Heating system	Cooling system	Hot water system	Lighting system
Retrofitting measure	• Regulators to automatically adjust amount of heat consumed • Insulation of main pipelines • Installation of balancing valves	• Modernization of ventilation system	• Installation of electrical storage boiler	• Replacement of old lamps with LED lamps

Source: SAEE (2019b)

Figure 2 shows the average energy saving potential per retrofitting measure based on our sample. According to this, thermal renovation of walls has a big effect on energy saving while renovating doors only has a minor contribution.

Figure 2: Average energy saving potential per retrofitting measure



The range of investments, energy savings and profitability of the measures differ due to the type of building, size and the initial energy efficiency class.

Our analysis of SAEE data indicates that for the technical measures the range of investments, energy savings and, thus, profitability of retrofitting measures in public buildings is large. We identified three main reasons for that:

1. The **type of public building** (schools, universities, hospitals, offices etc.) determine the usage patterns of the building, such as
    a. required room temperature
    b. ventilation needs
    c. illumination needs

d. daily use time

2. The **building size** – co-determined by the type of building – defines the relation of building envelope to basement and roof.
3. The initial energy efficiency class and to some extent the age of the building obviously define **energy consumption per square meter**.

SAEE data further indicates that some measures are much more cost-effective (e.g. replacement of heating equipment) than others (e.g. roof insulation). Hence, we will assume that all proposed measures are conducted by a retrofitting activity because of two reasons:

The analysis focuses on educational buildings, healthcare facilities and administrative buildings based on 64 buildings of the SAEE database.

1. It remains unclear whether only single measures enable an efficient energy consumption reduction as they could, e.g., leave thermal bridges behind.
2. Furthermore, some measures discussed in the SAEE database are necessary to ensure the continuity of the building. Even if the energy retrofitting share in such measures (e.g. wall insulation or roof replacement) remains limited, it increases the lifetime of the building and is therefore considered in our analysis.

Our assessment is based on three types of public buildings: Educational buildings, healthcare facilities and administrative buildings, such as offices. We use a sample of 64 buildings in energy efficiency classes D, E, F and G. For the further analysis of aggregated effects, we only use the average investment and energy saving deducted from this sample.

We evaluate an ambitious scenario assuming that 16 million square meters can be retrofitted annually, which leads to an aggregated energy retrofitting of 160 million square meters of public buildings until 2030 – about 50% of the total stock, respectively.

II. Policy measures

Planning instruments

We recommend defining an ambitious quantitative retrofitting target of around 50% of the public building stock by 2030 following a long-term retrofitting plan for public buildings, whereby annual retrofitting should not undershoot 10 million square meters.

A long-term plan needs to be developed.

Regulatory instruments

A retrofitting measure should result in an energy efficiency level of at least class C. To guarantee the energy efficiency outcome, we propose defining required skills for executing energy audits and energy retrofitting in various types of public buildings to support specialisation of energy auditors on particular types of buildings. Therefore, training programs to qualify the workforce on all levels to conduct efficient and high-quality retrofitting measures are needed. Regions beyond Kyiv should be in the focus of such qualification programs.

The regulatory instruments include a minimum target for retrofitting (EE class C), the qualification of auditors and a transparent procedure for retrofitting measures.

The issuer of green bonds must establish a transparent procedure for project evaluation and selection of eligible retrofitting projects, taking into account the environmental objectives of the projects, as well as a system for managing the proceeds of the bonds issued in order to comply with international green bond principles.

Financing instruments

The financing structure foresees a financial contribution by the owner of the building and up to 80% financing through green bonds.

We recommend a funding structure consisting of a 15-20% contribution by the owner of the buildings at lowest administrational – e.g. within regions – level and up to 80% financing through green bonds issued by the state. The issuance of green bonds by the state needs to be coordinated with the overall borrowing policy of the Ministry of Finance taking into account any restrictions/limits on the size of the external debt of Ukraine (see section "Financing via green bonds").

Information instruments

Database on retrofitting options by 2025

A comprehensive database on energy consumption and retrofitting options for at least 80% of the public building stock in Ukraine should be established until 2025. In parallel, a reporting system to report the allocation of proceeds from issued bonds must be established.

Reporting system on proceeds from issued bonds

The issuer of green bonds must establish a reporting system to report on the allocation of proceeds from issued bonds to eligible retrofitting projects in order to comply with the international principles for green bonds.

Background info

Public Buildings in EU Member States

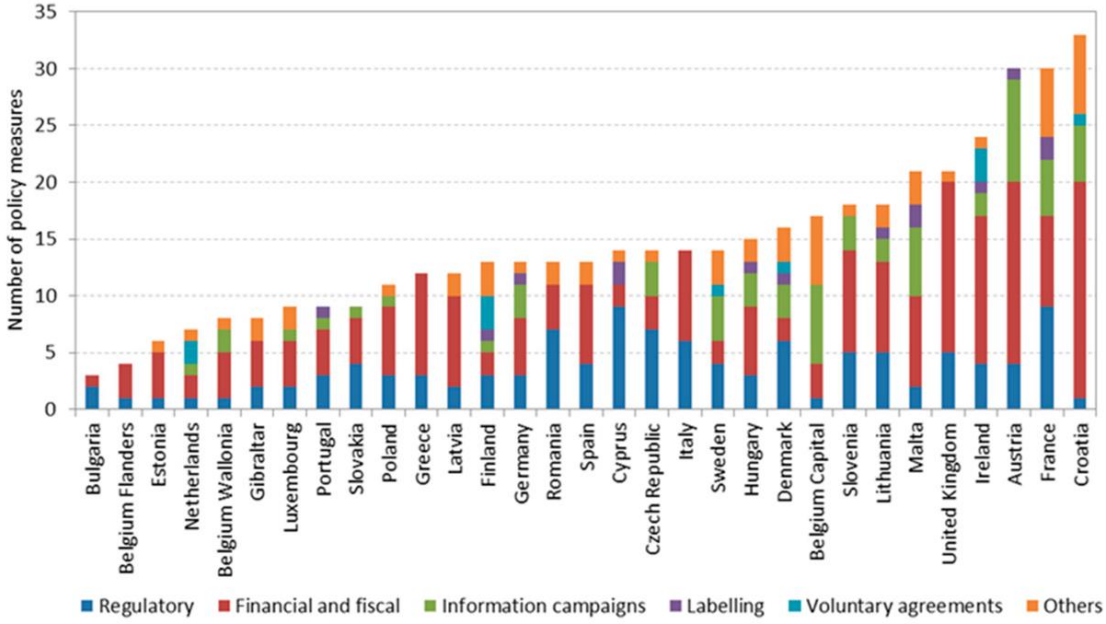
Approx. 12% of the total building stock in the EU is either owned or occupied by public authorities (EUROSAI 2018). The average energy consumption in the non-residential sector is 280 kWh/m2 (D'Agostino *et al.* 2017). Between 2000 and 2008, energy consumption in the non-residential sector increased by 2.5% per year and since then by 1.1%. Member states are required to establish a long-term building renovation strategy (Buildings Directive, EPBD, Directive 2002/91/EC & Directive 2010/31/EC). The Energy Efficiency Directive requires that EU countries conduct energy efficient renovations of at least 3% per year of buildings owned and occupied by central governments. The renovation rates for non-residential buildings, including public buildings in the EU between 2012 and 2016, amounted to approx. 10% (EUC 2019, pg. 18) whereby only 2% followed a at least 'medium' retrofitting below 1% a 'deep'. (see Figure 4). Deep renovation allows for energy savings of up to 66%.

Table 3 lists the different types of measures and indicates which EU member states have implemented supporting energy retrofitting in public buildings. D'Agostino *et al.* (2016) indicate a heterogeneity of national policy packages in the EU member states in terms of the number of measures and policies. Regulatory, financial & fiscal policies represent the most extensive types of interventions in all member states, while labelling is underrepresented.

Table 3: Examples of measures targeting central government buildings

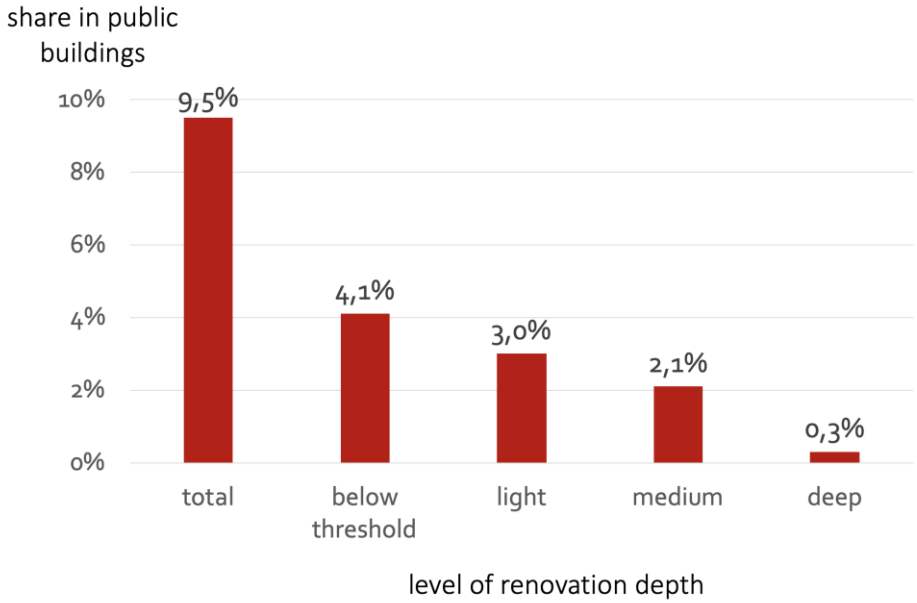
Type of measures	Examples from EU Countries
Financing	• Energy performance contracting and ESCOs (Austria, Portugal, Croatia)
Renewable energy	• PV installations for own consumption (Malta, Poland)
Energy management	• Appointing energy officers in each building (Ireland, Portugal) • Operations optimisation (Denmark, Austria) • Metering for energy and water (Croatia) • Smart meter installation (Malta) • Control of air conditioning (Malta)
Inspections	• Inspections of down-time electricity use (Finland) • Analysis of energy consumption during off-times (nights, weekends etc.)
Property management	• Penalties and bonuses for energy efficiency in contracts with property management companies (Finland)
Public procurement/ sustainable procurement	• Switching to energy-saving devices (Denmark) • Rental contracts being renewed become green lease contracts (Finland)
Behavioural change	• Raising awareness among building users (France, Denmark) • Large-scale behavioural change campaign (Ireland) • Behaviour change programme for employees (Netherlands)

Figure 3: Number of measures in the building sector (implemented and planned) in the EU by country and type



Source: D'Agostino *et al.* (2016)

Figure 4: Share of non-residential buildings that underwent energy-related renovation per level of renovation depth in EU28 countries (average 2012 – 2016)



Source: EUC (2019, pg 18)

Assessment of effects through energy retrofitting of public buildings

At this stage, we discuss the overall effects induced by successfully implemented retrofitting measures in public buildings taking into account the five dimensions: energy security, internal energy market, energy efficiency, decarbonisation of the economy and research, innovation and competitiveness. In addition, we will present a quantitative assessment of additional socio-economic co-benefits.

Energy security

A reduction of energy consumption in the public building stock of Ukraine reduces the need for energy imports as well as for domestic extraction of natural gas and coal. The implementation leads to savings of up to 500 TWh of final energy and up to 700 TWh of primary energy until 2059. By avoiding imports of up to 70 bcm this reduces dependency on international energy markets and secures for negative macroeconomic effects due to price fluctuations and/or supply shortages.

The implementation of retrofitting leads to a reduction of energy consumption and, thus, reduces the need for energy imports.

The aggregated direct effect remains limited due to the relatively low share of public buildings in the cumulated energy consumption. However, spill over into other retrofitting activities leads to indirect effects and supports the long-term reduction of energy imports.

Internal energy markets

The modernization of buildings, such as the improvement of metering systems, increases price sensitivities. Consumption-based billing affects purchasing behaviours and, thus, leads to more economical behaviour of consumers. We, therefore, expect a better functioning internal energy market.

Metering systems for the buildings increases price sensitivities.

Energy efficiency

Improving energy efficiency is a key target of energy retrofitting of public buildings. The building specific efficiency improvements range – depending on type of building, initial energy consumption and size – between 20% and 70%. Average improvements of approx. 40% for all types of buildings with an initial energy efficiency class of D-G becomes possible. Energy consumption per square meter can be reduced to 100 – 200 kWh/m^2 with an average of 120 kWh/m^2. Annual final energy savings – following an annual retrofitting trajectory of 16 million m^2 – amount to 19,000 GWh in 2030 (approx. 1,600 ktoe).

Energy efficiency improvements range between 20% to 70%. The annual primary energy savings of 300 ktoe lead an emission reduction of 0.6 mton per year.

Decarbonisation of the economy

Assuming a reduction in natural gas consumption through the energy retrofitting – either for decentralised heat generation within the buildings or for heat generation in district heating facilities – the annual primary energy savings of up to 300 ktoe (of mainly natural gas) per retrofitted 16 million m^2 lead to an emission reduction of 0.6 Mt per year. CO_2 savings increase to approx. 5 Mt CO_2 in 2030 or 2% of current national emission, respectively.

Research, innovation and competitiveness

The Ukrainian building stock requires deep energy and comfort related retrofitting measures. Given approx. 14.9 million households, nearly 10 million apartments and single-family houses need to be retrofitted within the next 20 years. With increasing incomes, the demand for such retrofitting will increase. For this process and for meeting the increasing demand, the construction sector requires the acquisition of new skills. Typically, this acquisition is time- and cost-consuming and follows long-term learning curves. Especially at the beginning of such a process, learning rates are very high and marginal learning costs are low.

Retrofitting of public buildings can be seen as a training ground for energy efficiency improvements of residential buildings.

Furthermore, with increasing skills and increasing experiences in retrofitting, aggregated retrofitting costs will decrease.

Investments allow for developing new green business models alongside the entire value chain.

Green-business models are business models that generate – in addition to the underlying profit related reasoning – an environmental related co-benefit. In general, investments allow for developing such new business models alongside the entire value chain (respectively within value networks). New business models lead to the development of new interactions within value networks, increase competition and induce therewith innovation processes. Ideally, such effects spill over onto other sectors.

Public buildings provide an appropriate training ground for these learning and cost reduction processes. The following points support this assessment:

- Public buildings are typically more complex than residential buildings, which increases the learning effect (broader learning due to more types of craft work in action)
- In contrast to residential buildings, only one owner is responsible for the commissioning which reduces coordination
- Learning includes the learning about the final costs of a retrofitting measure. Handling an overshoot of costs is less complicated in public buildings than it would be within homeowner associations.

Socio-economic co-benefits

Even if the present analysis focuses mainly on the effects that energy retrofitting measures have on energy consumption and GHG-emissions, we want to present a rationale for focussing on public buildings that finds its reasoning in additional co-benefits.

a. Governmental demand-side economic stimulus

A governmental demand-side stimulus is expected to incur increasing GDP and employment directly and indirectly.

Investments in energy retrofitting of public buildings – EUR 10 bn are connected to state expenditures and increase aggregate demand. Therewith, such expenditures have a positive economic stimulus which increases the GDP as well as employment directly and indirectly. Even if the limited number of public buildings restricts the overall economic effects, they might stabilise the expectations within the construction sector. Positive expectations on the other hand lead to new market entries, an increase in competition and investments in the sector alongside the value chain.

b. Employment effects

Employment effects from energy retrofitting sums up to approx. 50,000 new jobs generated in the construction sector and alongside the value chain.

Following international experiences, the direct and indirect employment effects from energy retrofitting activities account for 30 – 60 working years per invested EUR 1 m.

Given this figure and following an assumed constant investment flow of approx. EUR 1 bn until 2030, the employment effect from energy retrofitting sums up to approx. 50,000 new jobs generated in the construction sector and alongside the value chain. Additional effects of about 20,000 new jobs can be expected if non-energy related modernisation is also taken under consideration.

c. Improvement of basic building specific services

Non-energy related measures that accompany energy efficiency retrofitting will increase the quality of the building's specific service.

While technological measures of energy retrofitting only focus on reducing energy consumption, comfort related measures increase the conditions of the specific type of building. Like each type of building, public buildings provide a specific service to their specific users. Retrofitting measures that exceed pure energy retrofitting will increase the quality of the building's specific service:

- Hospitals with higher comfort increase the well-being of patients and therewith the recovery,

- Retrofitted schools and universities have a positive influence on the teaching and learning atmosphere and
- Retrofitted offices increase the well-being of employees which typically increases productivity.

Financing via green bonds

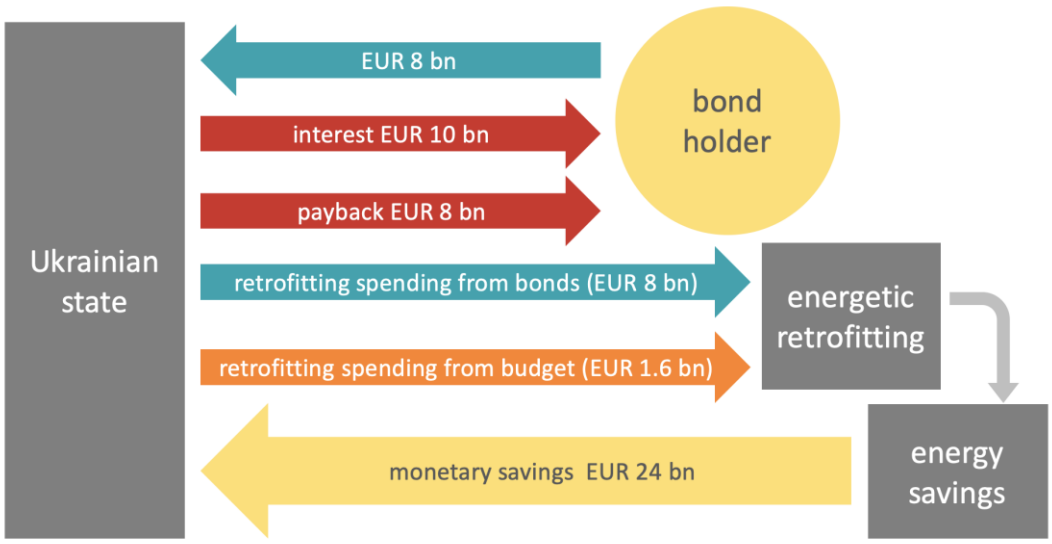
Green bonds can raise high volumes of funding and should be used for financing the retrofitting measures.

We propose the use of green bonds for covering the retrofitting activities in the sector of public buildings. Due to increasing demand for this type of investment, green bonds provide the ability to raise high volumes of funding for specific investment targets. They address investors focussing on environmentally friendly projects and can provide relatively cheap capital (compared to loans) if well-structured. Institutional as well as private investors are searching for new types of investment options to diversify their portfolios. They are increasingly focusing on integrating environmental, social and governance factors which led to a significant increase in green bond issuance worldwide from USD 41.8 bn in 2015 to USD 257.7 bn in 2019. For such investors, green bonds offer relatively secure options in large-scaled projects. Climate Bond Initiative (2020) assesses that in the long-term 40% of the green bond market will relate to energy efficiency retrofitting and zero emission building constructions. Note that in 2019 the share of the buildings sector already accounted for around 30% of all green proceeds allocation.

Required funding sums up to around EUR 8 bn within 10 years.

Required funding for the proposed retrofitting sums up to approx. EUR 8 bn within 10 years. Assuming a lending period of 15 years, an automatic reinvestment of bonds with lower maturities up to 15 years respectively, the bond holders receive total interest payments of approx. EUR 10 bn and at the end of the lending period the provided funding. The bonds issuer – the Ukrainian state – receives approx. EUR 24 bn energy savings until 2059, if bonds' term to maturity ends.

Figure 5: Structure of green bond funded retrofitting



Source: own depiction

The Ukrainian Budget Code needs to be changed so that loans can be extended from the State budget to local budgets.

Issuance of green bonds by the Government of Ukraine for the purpose of retrofitting public buildings which belong to local governments (municipalities, consolidated territorial communities) will require changes in the budgetary legislation (the Budget Code, in particular). Current interbudgetary relations do not provide for loans to be extended from the State budget to the local budgets for the purpose of retrofitting of buildings. Such financing can only be done in a form of the non-refundable subventions. At the same time, the administrators of the public buildings (so called "managers of budget funds") are to be financed on non-

refundable basis from the local budgets and are not allowed to borrow. In addition, the current mechanism of defining the basis for calculation of expenses to support a public building from public funds does not provide for accumulation of monetary savings (as compared to the baseline spending level prior to a retrofitting project) to be channelled to repay investment into such building – as soon as a lower level of expenses for energy is reached for a particular building, this level should be used as the basis to calculate the local budget expenses for this building for the next budget year. In order to implement the proposed green bond issuance program, it will be required to make changes in the budgetary legislation – e.g. allowing loans from the State budget to the local budgets and/or to administrators of public buildings by the means of establishing a communal enterprise that is allowed to borrow.

Coordination with decentralisation reform requried that envisages a transfer of the ownership of many buildings from the central to the local level.

Notably, the logic of the current decentralization reform envisages transfer of the ownership of many public buildings from the central to the local level with the expectation that the decisions will be made by the local governments which buildings to maintain and which to dispose of. The proposed green bond issuance program will require coordination with the directions of the decentralization reform in order not to discourage the local governments in fully assuming the responsibility for maintenance and renovation of the public buildings in the most effective way. Such coordination may include clear definition of the scope of the program in the long-term.

References

Bean F., C. Rata, S. Steuwer and D. Tzanev (2019). 'EU Energy Performance program of buildings – Guidance for pubic officers'. Available at: http://bpie.eu/wp-content/uploads/2019/03/our-buildings_-euki_epbd-guidance_final.pdf

Bund Technischer Experten e.V. (Association of Technical Experts) (2008). 'Lebensdauer von Bauteilen, Zeitwerte‘

Climate Bond Initiative (2020). 'Low carbon buildings'. Available at: https://www.climatebonds.net/standard/buildings

D’Agostino D., P. Zangheri and L. Castellazzi (2016). 'Towards Nearly Zero Energy Buildings in Europe: A Focus on Retrofit in Non-Residential Buildings', Energy, Transport and Climate Institute, Joint Research Centre (JRC)—European Commission. Available at: https://www.mdpi.com/1996-1073/10/1/117

D'Agostino D., Cunibert, B. and, Bertoldi, P. (2017). 'Energy consumption and efficiency technology measures in European non-residential buildings', Energy and Buildings, Volume 153, Pages 72-86. Available at: https://www.sciencedirect.com/science/article/abs/pii/s037877881730676x

EBRD (2020). ‘Supporting the Government of Ukraine on updating National Determined Contributions (NDC)’. DRAFT.

Energy Community (2019). 'Ukraine: The 2nd National Energy Efficiency Action Plan for the 2019-2030 Period'

EUC (2019). 'Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU'. Available at: https://op.europa.eu/en/publication-detail/-/publication/97d6a4ca-5847-11ea-8b81-01aa75ed71a1/language-en/format-PDF

EUROSAI (2018). 'Energy efficiency of Public Sector Buildings'. Available at: http://www.eurosaiop.org/docs/upload/documents/riigikontroll_aruanne_veeb_1548765711.pdf

International Energy Agency (IEA) (2017). 'World Energy Balances 2019'. Available at: https://www.iea.org/data-and-statistics

KeepWarm (2019). 'Improving the performance of District Heating Systems in Central and Eastern Europe. District Heating in Ukraine'. Available at: https://keepwarmeurope.eu/fileadmin/user_upload/country-pages/ukraine/keepwarm_dh_in_ukraine.pdf

SAEE (2018). 'Ukraine: Energy efficiency and renewable energy', presentation. Available at: http://saee.gov.ua/sites/default/files/documents/saee_invest_potential_ee_re_29_05_2018.pdf

SAEE (2019a). 'Third Annual Report under the Energy Efficiency Directive'. Ukraine. Available at: https://www.euneighbours.eu/sites/default/files/publications/2020-02/UE_3EED_AR_112019.pdf

SAEE (2019b) 'База даних енергетичних сертифікатів’ (Database of energy certificates). Available at: https://saee.gov.ua/uk/content/energy-certificate

Schulze-Darup, B., Zwiauer, K., Burghardt, M. (2015). 'Thermal Building Renovation – Thermal Renovation of Building Components'. e-genius – Verein zur Förderung und Entwicklung offener Bildungsmaterialien im technisch-naturwissenschaftlichen Bereich. Available at: https://www.e-genius.at/fileadmin/user_upload/bauteilsanierung/en/Thermal%20Renovation%20of%20Building%20Parts.pdf

Annex: Methodology

The calculation is based on a three-step approach:

1. Determination of energy retrofitting costs and energy saving potentials for respective building types
2. Determination of retrofitting costs and energy savings for an average generic public building, based on an aggregation of three building types – educational buildings, hospitals and administrative buildings including offices
3. Determination of a cash flow trajectory, based on annual pay-outs and monetary energy savings

The methodology follows the assumption that funding will be based on issuance of bonds, emitted in Euro. We consider an exchange rate increase from 30 UAH/EUR to 41 UAH/EUR until 2032.

Retrofitting costs and energy savings

The calculation is based on energy efficiency analyses of a sample of 64 public buildings, provided and collected by SAEE. All buildings are in energy efficiency classes D-G. Based on that sample, retrofitting costs and energy savings per square meter are determined.

Average retrofitting costs and energy savings

We follow EU4Energy *et al.* (2020) that indicates the shares of building types in the public building stock of Ukraine and defines average energy consumption, savings and costs:

Table 4: Weighted averages for calculations

parameter	weighted average
energy consumption, kWh/m^2 y	260
energy savings, kWh/m^2 y	120
energy saving related investment, EUR/m^2	60

Source: Own calculation based on SAEE

We assume constant energy retrofitting costs in Euro of 60 EUR/m^2. Given the assumed depreciation of the Hryvnia, retrofitting costs in UAH will increase from 1,600 to 2,300 UAH/m^2 in 2030.

Determination of cash flow trajectory

The determination of a cash flow trajectory, including all pay offs and monetary energy savings, takes place in the following steps:

a. Energy saving trajectory

We assume that the retrofitting activities will take place between 2020 and 2030. The energy savings for each building will be achieved within a time span that depends on the typical lifetime of the various building components, such as walls, heating equipment, windows, etc. The lifetime of these components varies and so do future energy savings.

Table 5: Average lifetime of building components

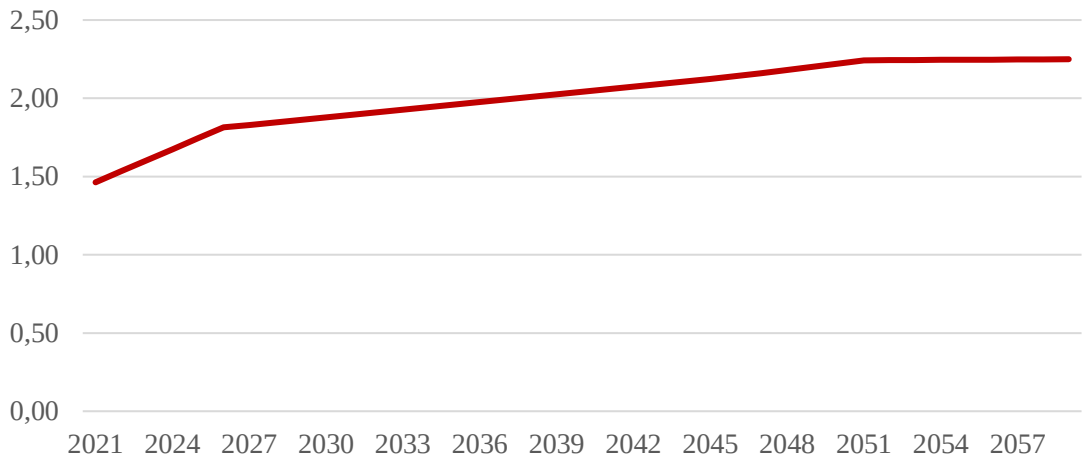
Building component	Energy consumption kWh/m2 y
Walls	44
Window, balcony	41
Doors	41
Roof + attic floor	40
Basement	50
Floor	50
Heating system	18
Cooling system	18
Hot water system	16
Lighting system	10

Source: Bund Technischer Experten e.V. (Association of Technical Experts) (2008)

b. Assumed price development

Monetary energy savings depend on the assumptions of price changes. Due to the long perspective of the effects of retrofitting, all assumptions are quite uncertain. We assume that **all buildings consume heat from district heating companies**. Further, the district heating price is linked to the natural gas price projections, depicted in the National Determined Contribution (NDC) report of Ukraine (EBRD, 2020, draft).

Figure 6: Heat price assumptions (UAH/kWh)



Source: Own assumptions based on EBRD (2020)

c. Definition of a retrofitting target

We assume a retrofitting target of 50% until 2030. According to EU4 Energy (2020), the total stock of public buildings in Ukraine sums up to approx. 322 million m² from which approx. 160 million m² would be retrofitted within 10 years. We split these on a constant annual target of approx. 16 million m² and further assume that the structure of annually retrofitted buildings represents the respective shares in the total stock. We also assume that buildings of energy classes E-G will be retrofitted according to the respective shares of each class in the total stock. The reasoning is that it is not obvious to start retrofitting with so called "low hanging fruits", meaning buildings that have very high energy consumptions. Learning effects and the resulting reduction in retrofitting costs could cancel out any higher monetary savings that might have been achieved earlier.

d. Structuring project funding

We propose funding energy retrofitting of the public building stock through the issuance of (green) bonds. We assume that required bonds are Euro denominated from external markets.

We assume a bond interest of 7%, based on current 10y governmental bonds in Ukraine.

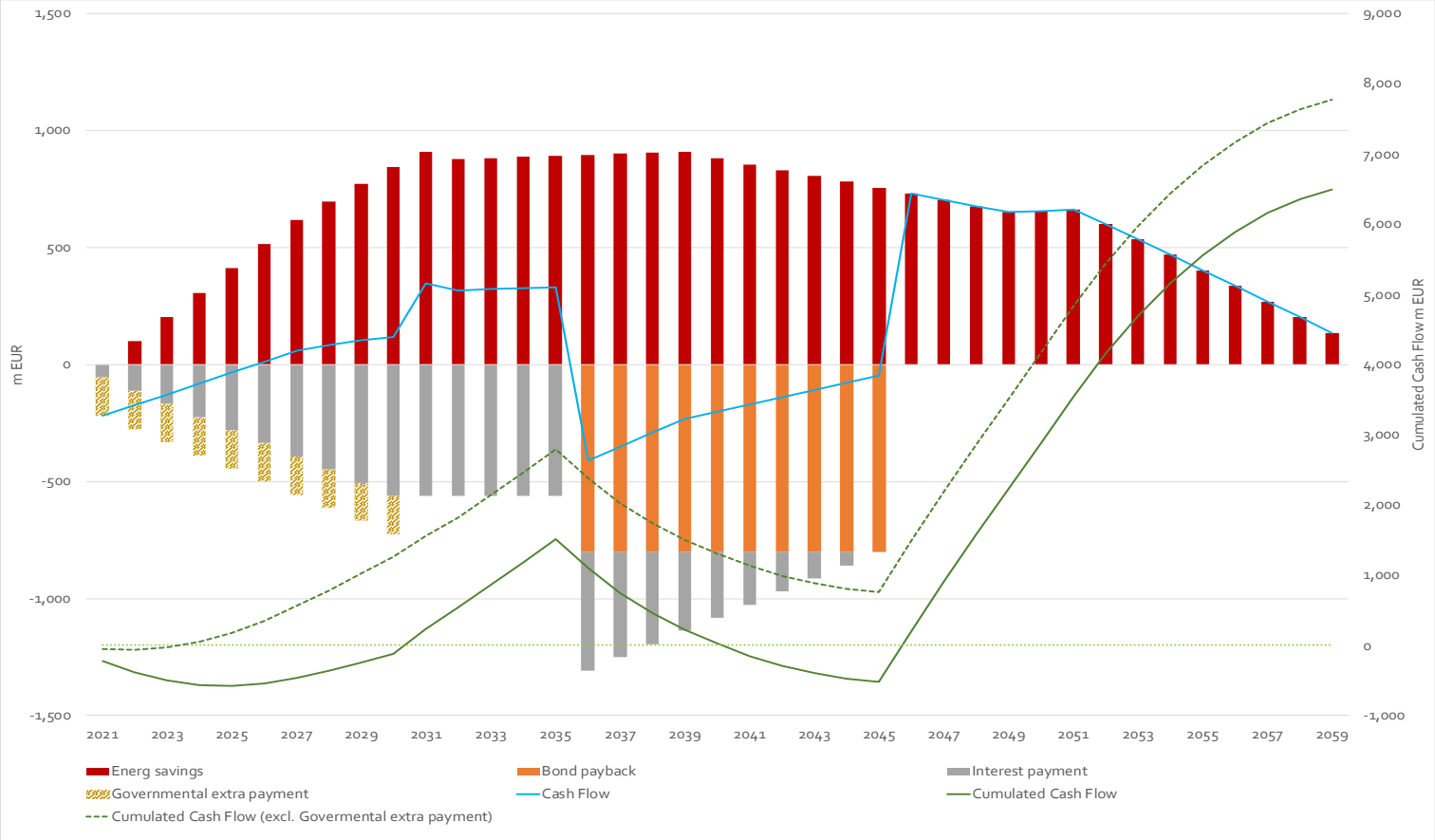
We do not consider changes of the interest rates over the funding period.

Bond payback takes place in Euro. Due to the depreciation of Hryvnia, bond payback is 28% higher than the issued volume in Hryvnia.

We further assume a duration of 15 years for the bonds (total run-time through reinvestment of bonds with maturity of ca. 5 years).

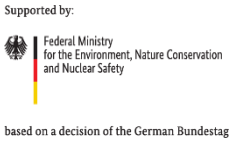
We assume a 17% governmental spending as the share of the total investment value each year until 2030. We do not consider any additional costs (interest payments) from the budget spending.

Figure 7: Energy-retrofitting results, trajectory 2021-2059



Source: Own calculation

Implemented by



Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy.

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We are grateful for your feedback on this Policy Proposal. Please get in touch via info@LowCarbonUkraine.com.

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