# Application of PETRA Methodology in Kiev

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## Zusammenfassung Résumé Abstract

The present project has supported Ukrainian stakeholders, interested in adopting a strategy to assess energy efficiency (EE) of housing stock, to use a contextual version of PETRA (Platform for Energy and Technical Retrofit in Architecture - former EPIQR+). This methodology, currently in use in Switzerland and other European countries, evaluates EE and the energy potential of building upgrades, including the energy performance certificate (EPD) that will become mandatory in Ukraine once the final adoption of the law on 'Energy Efficiency in Buildings' passes.

# 1. Ausgangslage – Contexte – Scope

Under former socialist regimes most of the residential housing stock in Eastern Europe was built, owned, and managed by the government. Its quality varies across countries, but has in common that many of its multi-apartment building were built in the 1970 when technologies and awareness about energy saving insulations were still rather underdeveloped.
As a consequence of urbanization in the 19th and early 20st century in Europe, high density or urbanizing areas became a determining factor of construction policies as land became scarce and expensive. The typical building type in a city was the multi-floor tenement house with rental apartments, owned by the developers or investors. Owner-occupied multi-unit buildings gained importance after World War I. The existing urban housing stock was nationalized and transferred into state or municipal ownership in most socialist countries after World War II (Turner et al. 1992). While inner city tenement buildings, now converted into some form of public or shared ownership, remained an important form of multi-apartment housing, new urban housing investments were dominated by multiunit high-rise buildings in housing estates, typically located in the outer ring of cities. From the late 1960s to the end of 1980s, prefabricated construction technologies became the most widespread form of urban housing development. This phase coincided with a period of forced industrialization, accompanied by robust urban construction, which took place in many of the socialist countries. Therefore, 60% of the housing stock in a typical socialist city consisted of prefabricated multiunit blocks, managed by state-owned companies, condominiums and housing cooperatives, which in all cases functioned very similarly to state-owned companies. Tenants and owners had little influence on decision making related to the management of the housing stock, but housing costs were kept very low (Turner at al. 1992).

The quality of the prefabricated high-rise housing estates built between 1960 and 1980 varies greatly between different post-socialist countries. In former Yugoslavia, Hungary and Czechoslovakia the quality was comparatively higher, while Moldova, Russia, and Bulgaria constitute the other end of the spectrum. One extreme case is represented by the five-floor apartment buildings in Russia and Ukraine known as “khrushchevki”. Urban housing estates occupied a special status in socialist housing policies. They were well located, typically had good infrastructure (roads, schools, health institutions, etc.), and were well connected to public transportation. However, the management companies have long neglected their maintenance. This applies in particular to the relatively new housing estates, where in some cases no maintenance has taken place since the beginning of their existence. While this situation could have led to a fast physical as well as social degradation of related neighborhoods this has fortunately not been the case yet because they have generally maintained a relatively good image and social mix even after two decades of transition. (Hegedüs 2012).

After the collapse of the socialist regimes in 1989-1990, a mass privatization and restitution program took place in most transition countries leading to a steep rise in home-ownership (Clapham et al. 1996; Struyk 1996; Lux 2003; Mandic 2010, Hegedüs, 2013b). In the past twenty years, almost every transition country has introduced important changes for the regulation of condominiums. However, the regulatory framework pertaining to the management of multi-unit buildings often remained undeveloped for years into the transition. The poorly regulated privatization was also responsible for disputes concerning land ownership and the property rights of the various facilities attached to condominiums. Tenants without previous experience in managing common properties suddenly found themselves as collective responsible over the maintenance of their condominiums. The adequacy of the institutional frameworks that were created to this aim varies across countries but in most cases the currently prevailing poor condition of multi-apartment buildings reflect a combination of problems, such as shortcomings in the quality of construction and lack of maintenance due to poor governance, financial constraints and the lack of social capital.

After the privatization and the transformation of property management for multi-unit buildings after the transition, apartment’s owners with different financial and cultural backgrounds and aspirations faced new challenges in how to manage the buildings. This led to a number of studies focusing on how to enhance cooperation and community-based decision making among owners with regard to maintenance, renovation, and the use of common spaces (Bank et al. 1996; Rabenhorst and

Ignatova 2009, Rabenhorst 2012, Hegedüs-Teller 2013). These tasks were unknown during the socialist period and the new owners had to develop the capacity to manage these issues within emerging legal and institutional frameworks. In a few transitional countries some new owners were able to operate home owners' associations efficiently, but the overall improvement remains rather slow due to ineffective regulations, lack of support or incentives and, in some cases, due to the voluntary nature of such associations (Hegedüs 2012).

### 1.1 Housing stock in Ukraine:

The Ukrainian housing stock has a total of 19.3 million units of buildings, of which 9.3 million flats divided into 82,000 multi-family buildings. 70% of them are in the city and host over 80% of the Ukrainian population (Derzhkomstat 2012). The average age of buildings in Ukraine is relatively old, and many of these, characterized by the use of cheap materials, poor quality and unproven industrial materials and lack of maintenance, are now in poor general conditions. Life in these buildings is very unhealthy due to the low thermal comfort and exposure to inexpensive and environmentally hazardous building materials (GOU 2011, Zapatrina 2010).
In conditions when Ukraine can count only on using the gas of domestic extraction for heating, the priority for the country has become implementation of energy saving projects and, in the first place, decreasing of heat consumption in buildings. Taking into account the limited possibilities of budget support for such projects, a rigorous sustainability assessment with tools such as PETRA with EPC is urgently needed along with an overall assessment of the socio-economic and institutional opportunities and challenges.

In Ukraine, the need to improve energy efficiency in buildings is one of the priority tasks faced in several ongoing research projects. Although they share the same goal of reducing energy consumption, there are currently no plans to develop a methodology that evaluates buildings EE, investment calculations and the EPC at the same time. At present, there are no officially recognized labels for energy efficiency in Ukraine.
The timing of this project is particularly appropriate as the Ukrainian Parliament acknowledged the urgency of these instruments by introducing adaptations to energy-saving legislation.

The legal basis for the implementation of modernization projects for multi-family residential buildings in Ukraine is still inadequate, and at present, only a small part of the owners would be able to attract financial resources for this. The same phenomenology appears in the public buildings sector: administrations, schools, hospitals. In this last category, financing for modernization is easier. For this reason, the EE evaluation has been conducted on ten public buildings (schools) and on two multi-family buildings (private condominiums).

## 2. Vorgehen – Méthode – Methods

The project has introduced in Ukraine the Swiss experience in increasing energy efficiency of public and residential buildings. The timing of this project is particularly appropriate because of necessity to assist the cities to determine the buildings that first require thermo-modernization, and to optimize the use of budget funds for this purpose. It is also important that presently the Government of Ukraine is in the process of drafting policies to increase energy efficiency of buildings and is looking for relevant methodologies and the preparation of EPC. In the Memorandum between Ukraine and IMF (implementation of which is supported by USAID Municipal Energy Reform), the following tasks were recognized as important: stimulation of population and multi-apartment buildings co-owners unions to buildings energy efficiency and introduction of ESCO contracts. The Ukrainian Parliament recognized those tasks as the first priorities in the Coalition Agreement, adopted on November 21, 2015.
At the same time, the issues to develop a methodology to evaluate buildings energy performance characteristics and cost of their thermos-modernization are not covered by the current projects of international assistance. A dissemination of the Swiss experience among Ukrainian stakeholders is extremely important with the aim to introduce rigorous approaches in this area, in particular, opportunities of practical implementation of the set tasks. Pechersk и Shevchenkovskyi District state administrations in Kiev expressed the interest to use of PETRA methodology, by proposing pilot

buildings to prepare EPC using this methodology, and to conduct wide public discussion of the audit results.

The purpose of the project is the transfer of methodology in the field of building renovation, thanks to the Swiss instrument PETRA, which contains the following stages:

- the diagnosis of existing real estate assets, including the collection of relevant data;
- actual heat balance and forecast;
- analysis and forecasting of operational energy;
- economic analysis and forecasting;
- definition and comparison of refurbishment scenarios.

It will allow local governments, the "Energy efficient cities of Ukraine" and the "Union of homeowners in Ukraine" to conduct assessments on energy efficiency. These entities will therefore spread the PETRA methodology to other stakeholders.
The most relevant results were the following:

- Adaptation of the Swiss instrument to Ukrainian conditions (PETRA-Ukraine);
- Training of Ukrainian energy experts (total 19 people) with formal examination and issuance of certificates;
- Application of PETRA-Ukraine in the evaluation of twelve representative buildings in Kiev;
- Widespread dissemination of results.

**Implementation of the project:**
**WP0**: The activities started with literature review, state of the art of research and secondary data collection, an extensive contextual and policy analysis, with legal framework, and socio-technical challenges.
This has provided a better understanding of Ukrainian reality and conditions, giving useful information that determined the direction to be taken.

**WP1**: many meetings with relevant stakeholder took place in this phase, for example the Kick-off meeting with all institutional interested parties and a Round Table Discussion with a selection of Organisation. Objective of the round table was the exchange of experiences, to show how this project fits in the existing other projects and researches. In addition the round table provided the opportunity to meet many stakeholders and to establish new contacts and connections. For example, through the meetings with Union of Housing Owners of Ukraine, Communal Enterprise “Kiev ESCO”, Kiev Energy Agency and Ukraine Association of Energy Auditors, the selection criteria have been established, both for the workshop participants and for the sample of buildings to conduce the energy efficiency assessment.
Furthermore, EBRD and GIZ showed us interest to invite more energy auditor from other cities to the PETRA teaching workshop. Effectively a group of 7/8 external energy Auditor participated to the learning.

**Comparative analysis of PETRA with other existing methodologies, with a comprehensible demonstration of efficiency and applicability of Petra methodology.**

The deliverable of this phase is condensed in a diagram (Figure 1) which contains a visual comparison that shows the field of application of six different Tools (Petra, the Swiss official EPC-GEAK, and 4 tools used in Ukraine).
This graphic confrontation clearly shows the additional value of the PETRA Tool as resumed here:

- Web-based instrument
- Adapted to Ukraine condition
- Contains analysis of actual situation
- Contains energy balance of buildings
- Contains actual EPC
- Contains more than three renovation scenarios (with or without thermo-modernisation), each with EPC forecast
- Contains Data Bank of buildings including Safety and Heritage.

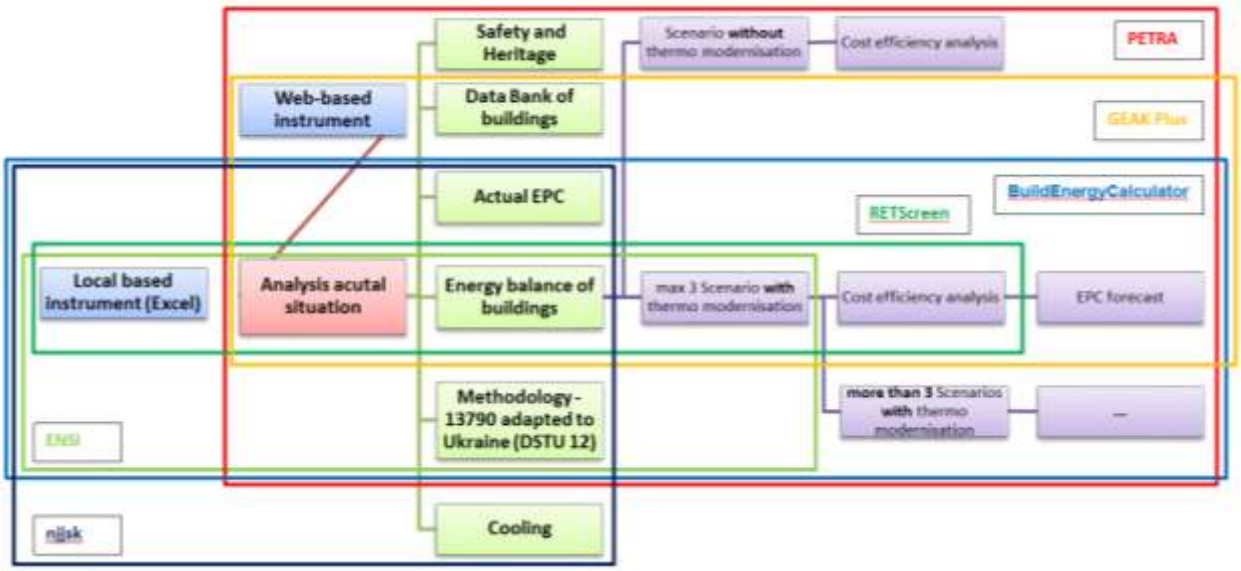



*Figure 1* *Visual restitution of the comparison*

**Integration of data related to Ukrainian standards: PETRA-Ukraine.**

The creation of the PETRA-Ukraine website has been done with a DUMP, that integrates the result of the comparison between Swiss and Ukrainian standards; the Algorithm for EPC; the climatic data of Kiev, the different coefficients and the Ukrainian costs. After analysis of the data collection and the implementation of the PETRA-Ukraine, the assessment of a multifamily house has been conducted. The results of this first attempt have been encouraging because the difference between PETRA and the Ukrainian draft law on energy efficiency was only 8%.

**WP2**: **Training Workshop to enable 12 Ukrainian instructors to use the methodology.**

This phase includes the theoretical presentation to inform on Swiss regulations, which are the basis of the calculation tool, compared with the European regulations in part into force in Ukraine, to introduce the PETRA tool, containing a small and simple exercise in order to familiarize with the methodology.

Then started the inspection of four buildings that is an essential part of the methodology. The purpose of the visit was to examine the buildings following a default checklist, performing an analysis of the degradation of the construction and plant elements.

The last part of the teaching was dedicated to work with the on-line tool, following the checklist of the previous day. Data entry begins with the modeling of the building, by calculating all dimensional coefficients, by entering the degradation codes (Figure 2) and energy data of each of them. Subsequently each trainee had to define different refurbishment scenarios. In each of those scenarios, the tool calculates the payback time and the forecast of the EPC.

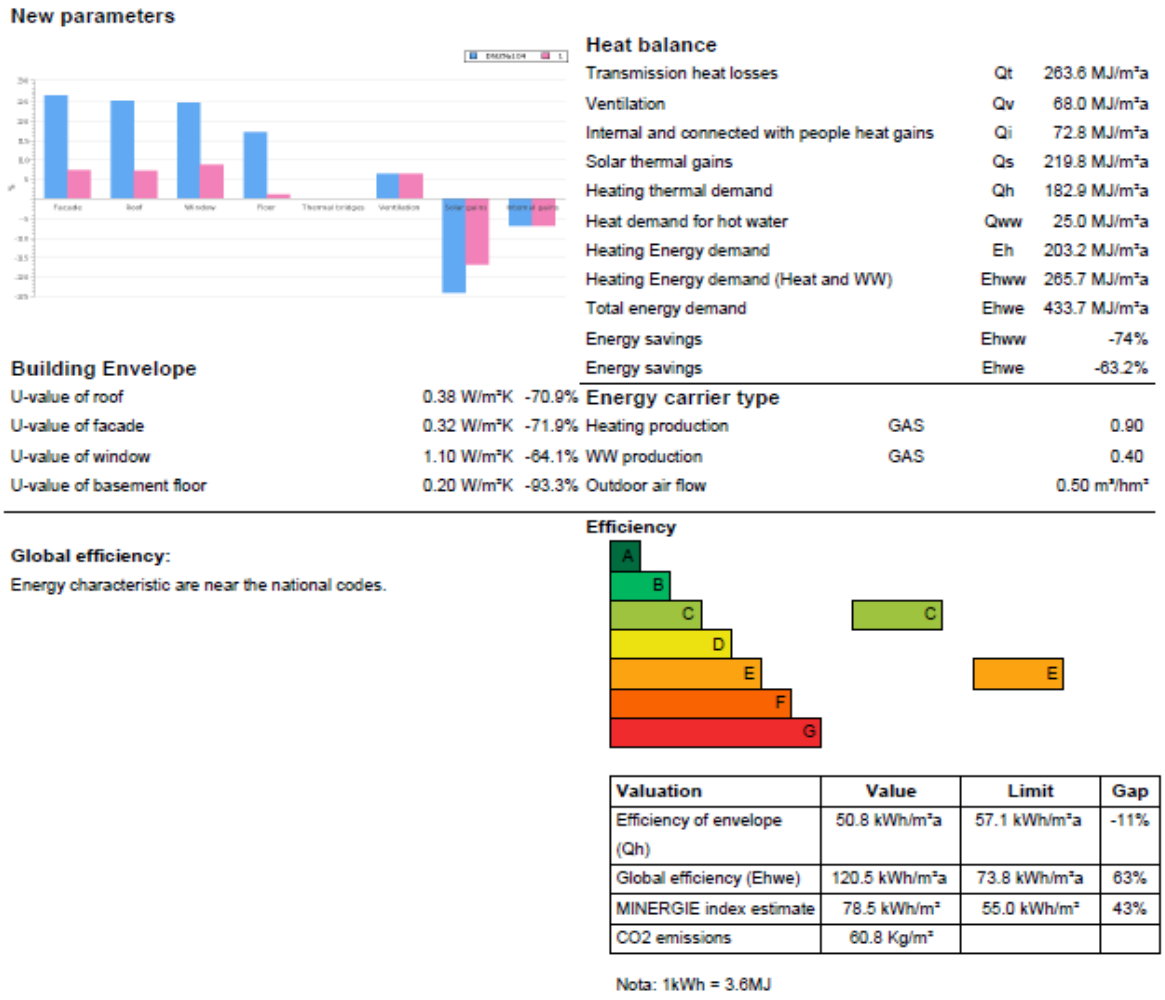
**Windows**

| | a | b | c | d |
|---|---|---|---|---|
| C01-01-31 \|\| Wood-metal windows \|\| w-e | | | | |
| C01-01-31 \|\| Wood-metal windows \|\| w-w | | | | |
| C01-01-31 \|\| Wood-metal windows \|\| w-n | | | | |
| C01-01-31 \|\| Wood-metal windows \|\| w-s | | | | |
| C01-01-32 \|\| Plastic or aluminium windows \|\| al-n | | | | |
| C01-01-32 \|\| Plastic or aluminium windows \|\| al-s | | | | |
| C01-01-41 \|\| Glass facade \|\| f-e | | | | |
| C01-01-41 \|\| Glass facade \|\| f-s | | | | |
| C01-05-22 \|\| Internal sun protection | | | | |

*Figure 2* *Resume of the diagnosis with degradation codes concerning Roofs, Façades and Windows of the Kindergarten #104, 58 Polkova str.*

**Case studies of residential or public buildings.**

In accordance to the Ukrainian stakeholder, at the end of the training workshop, twelve buildings have been selected (2 residential buildings and 10 School / Kindergarten) and assigned to each of the twelve participants.



**New parameters**

**Heat balance**

| | | |
|---|---|---|
| Transmission heat losses | Qt | 263.6 MJ/m²a |
| Ventilation | Qv | 68.0 MJ/m²a |
| Internal and connected with people heat gains | Qi | 72.8 MJ/m²a |
| Solar thermal gains | Qs | 219.8 MJ/m²a |
| Heating thermal demand | Qh | 182.9 MJ/m²a |
| Heat demand for hot water | Qww | 25.0 MJ/m²a |
| Heating Energy demand | Eh | 203.2 MJ/m²a |
| Heating Energy demand (Heat and WW) | Ehww | 265.7 MJ/m²a |
| Total energy demand | Ehwe | 433.7 MJ/m²a |
| Energy savings | Ehww | -74% |
| Energy savings | Ehwe | -63.2% |

**Building Envelope**

| | | |
|---|---|---|
| U-value of roof | 0.38 W/m²K | -70.9% |
| U-value of facade | 0.32 W/m²K | -71.9% |
| U-value of window | 1.10 W/m²K | -64.1% |
| U-value of basement floor | 0.20 W/m²K | -93.3% |

**Energy carrier type**

| | | |
|---|---|---|
| Heating production | GAS | 0.90 |
| WW production | GAS | 0.40 |
| Outdoor air flow | | 0.50 m³/hm² |

**Global efficiency:**

Energy characteristic are near the national codes.

**Efficiency**



| Valuation | Value | Limit | Gap |
|---|---|---|---|
| Efficiency of envelope (Qh) | 50.8 kWh/m²a | 57.1 kWh/m²a | -11% |
| Global efficiency (Ehwe) | 120.5 kWh/m²a | 73.8 kWh/m²a | 63% |
| MINERGIE index estimate | 78.5 kWh/m² | 55.0 kWh/m² | 43% |
| CO2 emissions | 60.8 Kg/m² | | |

Nota: 1kWh = 3.6MJ

*Figure 3 Description of scenario 1 in the Kindergarten #104, 58 Polkova str.*

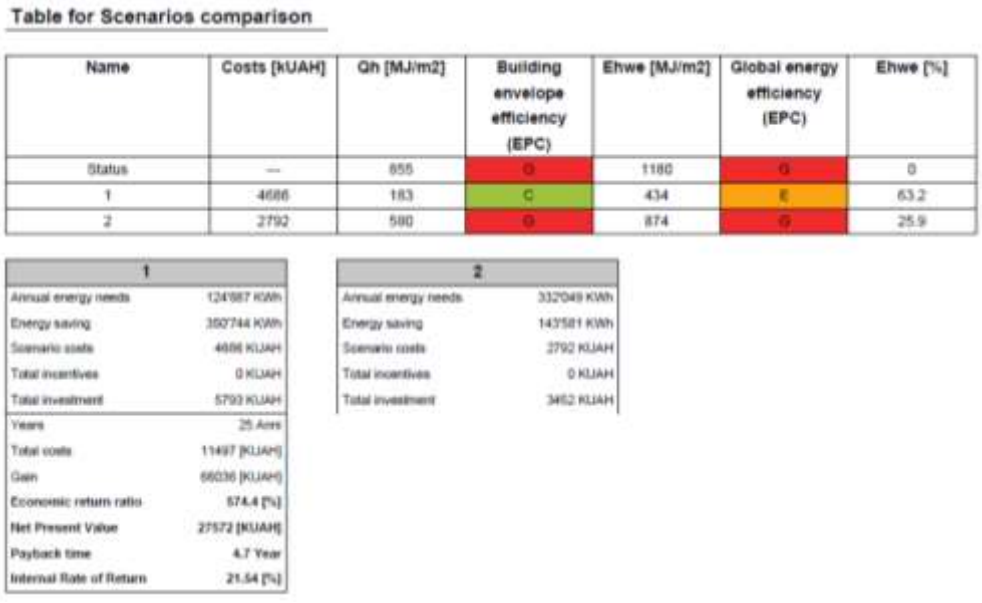


**Table for Scenarios comparison**

| Name | Costs [kUAH] | Qh [MJ/m2] | Building envelope efficiency (EPC) | Ehwe [MJ/m2] | Global energy efficiency (EPC) | Ehwe [%] |
|---|---|---|---|---|---|---|
| Status | — | 855 | G | 1180 | G | 0 |
| 1 | 4686 | 183 | C | 434 | E | 63.2 |
| 2 | 2792 | 580 | G | 874 | G | 25.9 |

| 1 | |
|---|---|
| Annual energy needs | 124'687 KWh |
| Energy saving | 350'744 KWh |
| Scenario costs | 4686 KUAH |
| Total incentives | 0 KUAH |
| Total investment | 5793 KUAH |
| Years | 25 Anni |
| Total costs | 11497 [KUAH] |
| Gain | 66036 [KUAH] |
| Economic return ratio | 574.4 [%] |
| Net Present Value | 27572 [KUAH] |
| Payback time | 4.7 Year |
| Internal Rate of Return | 21.54 [%] |

| 2 | |
|---|---|
| Annual energy needs | 332'049 KWh |
| Energy saving | 143'581 KWh |
| Scenario costs | 2792 KUAH |
| Total incentives | 0 KUAH |
| Total investment | 3462 KUAH |

*Figure 4: Scenario comparison with Payback time for the Kindergarten #104, 58 Polkova str.*

## 3. Resultate – Résultats – Results

The results reached at the moment, are listed here:

- Adaptation of Swiss PETRA methodology to Ukrainian conditions;
- Training of Ukrainian instructors on the use of the PETRA methodology in Ukraine with a formal examination at the end of the course and the issuance of certificates;
- Application of the adapted PETRA tool in assessing a representative sample of buildings in Kiev.

In this paper, have been displayed few extracts from a report carried out at a Kindergarten, as an example of all the work done so far to the end of WP2, while the WP3 should be initiated soon. Figure 3, 4 and 5 have been extracted from a reports, to show the degradation codes fixed during the inspection, the parameters that describes one refurbishment scenario and a table with the comparison of the different scenario with the actual situation.
The results are in the moment only partial and to start the comparative analysis between the twelve reports, each Trainee has now to improve his own work.

After this step, those other results can be assured in the next future:

- To enable Ukrainian instructors to train energy efficiency specialists and maintain and/or adapt the tool to the changing framework conditions;
- To enable Ukrainian specialists to maintain and/or adapt the tool to the changing framework conditions;
- Wide dissemination of the results to the local governments and public through publications, seminars, workshops and a conference;
- To raise awareness among key stakeholders including the private sector about the potential and benefits of energy saving.

Consequently, State and local decision-makers will understand what amount is needed to substantially reduce energy consumption in buildings.
On the one hand, this could stimulate and motivate the population that has the potential to invest in increasing the energy performance of their buildings to initiate the implementation of similar projects. On the other hand, the State will be able to assess the amount of funds in the state budget intended to finance some of these measures in favor of the less well-off population.

The quantification of the foreseeable short-term impact of the energy conservation of the ten school buildings analyzed in this project is as follows:

- Reduction of the annual energy consumption by 5.6 GWh (average improvement of 67%);
- Decrease of annual carbon emissions by 1’125 tons.

At the same time, at the qualitative level, comfort conditions of these buildings will obviously be better, reducing illness rates of pupils, improving learning conditions and increasing the desire to go to school. The positive experience of scholars may also convince many parents to take up energy-saving measures in their own home.
In a longer-term perspective, the energy refurbishment of all the schools in Kiev would lead to the following quantitative impact:

- Reduction of the annual energy consumption by 5’600 GWh;
- Decrease of annual carbon emissions by 1’125’000 tons $CO_2$.

The pay-back of energy-saving interventions is on average 4 years (see graph), a particularly short period compared to Swiss standards. This is due in particular to the lower costs of construction in the light of energy supply prices that are similar to Switzerland. With targeted funds research, some of the 10 school buildings analyzed could be possibly be refurbished.

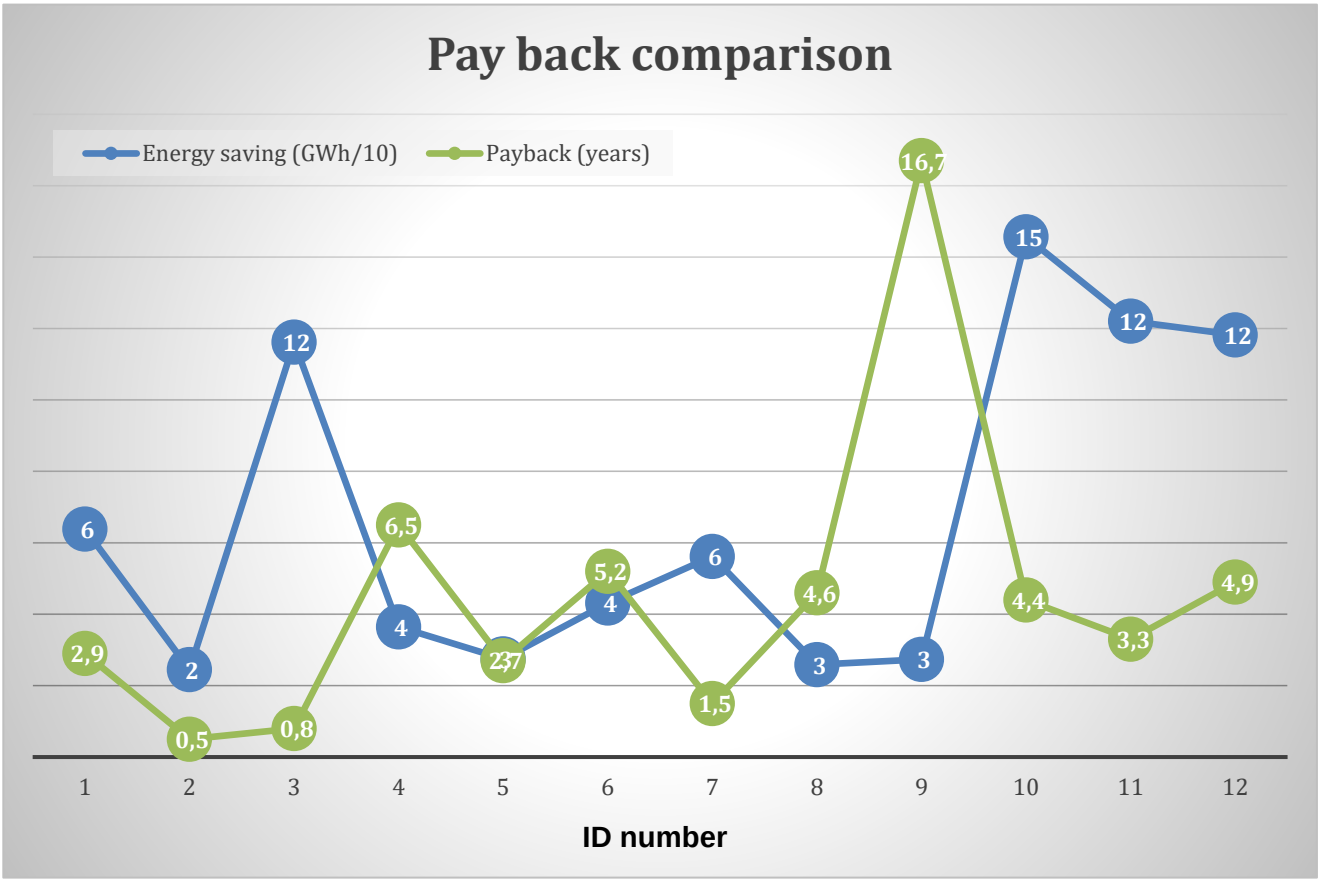



*Figure 5: Relationship between pay-back and energy savings of the 12 stables analyzed*

## 4. Diskussion – Discussion – Discussion

The project enables Ukraine stakeholders to conduct rigorous assessments of energy efficiency characteristics of buildings, and overall refurbishment requirements, and the development of related renovation strategies through training and through the dissemination of a contextually adapted version of a methodology and software developed and currently used in Switzerland. The expected result is a higher comfort of life of the Ukrainian citizens, in particular, low-income families, by decreasing their expenditures for heating's energy resources in conditions of considerable increasing of tariffs for communal services, by improving the environment and by decreasing negative influence of old construction materials on people. The Government and the citizens of Ukraine will be able to meet their global commitment to reduce $CO_2$ emissions' and to re-direct budget funds that are now used to cover energy consumption, to other potentially important tasks. It will further decrease the energy dependence of Ukraine from importation, thus contribute to its sustainable economic development.

The project provides a cost-effective strategy to support the implementation of Ukraine's new law on energy efficiency in public and residential building. As soon as the law will be adopted, public authorities will start preparing energy performance certificates for buildings and calculate the necessary funds to increase their energy efficiency. Results after application of the methodology, inclusive refurbishment, will be implemented in sample buildings in Kiev within a year after the adaptation of the PETRA tool.

The tariffs for communal services has grown in the last two years and the planned further increasing in the nearest future in accordance with Ukraine's obligations to IMF. In this way, the consumption reduction is becoming economically efficient for homeowners and they are ready even now to invest in the EE. In such conditions, population and market subjects will extremely demand EPC and the related investments calculation will permit them an easier access to financing. The Ukrainian Union of Housing Owners is ready to promote the use of the tool in the whole country.

According to the official policy, the homeowners and a part from the state funds will cover a part of the refurbishment investments required to enhance the energy efficiency of residential buildings. The return of the investment has been determined in WP1, and was expected to be quick due to the poor conditions of the constructions. This was actually confirmed, for example by mentioning the payback time of the scenario 1 for the Kindergarten #104 (picture 5), which is 4.7 years.

The project results will enable local governments, the Association “Energy Efficient Cities of Ukraine” and the Union of Housing Owners of Ukraine to conduct energy efficiency assessments. These entities will thus disseminate the PETRA tool and related knowledge to other relevant stakeholders, including the private sector. The Ukrainian Association of Energy Auditors in the Housing and Communal Sector and the Institute for Environment and Energy Conservation will apply this methodology and develop it further by taking into account the specific conditions of Ukraine. It needs to be underlined that the private sector in Ukraine has a particularly important role in the implementation of projects aiming at enhancing energy efficiency and in the development of related methodologies. This is because the state can create the framework conditions and some specific incentives, but most of the effective work and the investments are to be searched in the private sector. Information exchange with private sector representatives will also be possible within the framework of the UNECE Housing Forum, which counts on the participation of a tangible number of stakeholders working in the domain of energy efficient housing and refurbishments.

## 5. Ausblick – Perspectives – Perspectives

The project implementation will allow the population of Ukraine and the decision makers at the state and local level to understand which amount of funds is required to reduce essentially energy consumption of buildings and when the projects on EPC increasing could be recouped. Firstly, this will stimulate and motivate the population that has opportunities to invest in increasing of energy performance of their buildings to start implementation of similar projects. Secondly, the state will be able to evaluate the amount of funds in the state budget that shall be allocated for partial financing of these measures by poor population. Thanks to the assessment of the energy efficiency indicators of those buildings analyzed with PETRA, it was possible to estimate the level of energy savings that could be achieved in Ukraine in the case of a generalized energy refurbishment. This also enables the State to plan the co-financing of these projects that is needed to meet Ukraine's obligations under the Energy Union Accession Agreement, the EU Association Agreement and the Memorandum with the IMF.

Possible added values and commodities of the project are:

- increasing of employment of the population through development of small business in field of energy efficiency;
- decreasing of fee for the consumed communal services and possibility to use saved money for social initiatives;
- decreasing of level of illness among children and poor population;
- decreasing of quantity of accidents because of using electric and gas ovens for heating.

The training component of the project will raise professional energy auditors’ and academics’ (faculty and graduate students) competence in conducting refurbishment assessments with special reference to energy efficiency. This will be of pivotal importance to the implementation of Ukraine’s energy efficient policy. The relevance and replication of the project is ensured by the fact that the request for this projects comes from key stakeholders working in close cooperation with the Government of Ukraine and local authorities.

The project will further:

- Enable a large number of Ukrainian Energy Auditors to carry out PETRA assessment/EPC and to determine institution that will prepare corresponding specialists at the permanent basis (start with 15, every year 25 new auditors);

- Make recommendations to the Government of Ukraine with regard to the introduction of a new methodology for assessing the energy efficiency characteristics of buildings; to prove their recommendations by concrete figures received as a result of inspection of buildings;
- Enable the refurbishment of representative sample of buildings in Kiev based on the results of the PETRA analysis (1-2 buildings carried out from the initial selection – results of this refurbishment will be published form the Ukrainian partners, not in this project);
- Allow to monitor the achieved energy efficiency results for research and policy advocacy purposes in leading scientific institutions of Ukraine;
- Raise awareness among institutes and actors involved in the development and implementation of energy efficiency policies in Ukraine on sustainable energy management strategies in all regions of Ukraine;
- Create the framework conditions for a critical reflection on the relevance, effectiveness, and replicability of PETRA and EPC in the Eastern European context.

## Anhang/annexe
## Literatur/Referenzen – Littérature/références – Literature/references


[1] Bank C. O'Leary S. and Rabenhorst C. 1996. *Privatized housing and the development of condominiums in Central and Eastern Europe: the cases of Poland*, Hungary, Slovakia, and Romania. Blackwell Publishing Ltd. Association of Regional Science Conference.

[2] Clapham D. and Kintera, K. 1996. *The patterns of Housing Privatization in Eastern Europe*. In: Clapham D., Hegedüs J., Kintrea K. and Tosics I. (eds.) 1996. Housing Privatization in Eastern Europe. 169-190. Greenwood.

[3] DSTU.2014. “Manual on conduction of thermo-modernization of residential buildings” (“ДСТУ-Н Б В.3.2-3: 2014”)

[4] Derzhkomstat. 2012. *Social and demographical features of Ukrainian households in 2011* (based on Research on living conditions of households). Kiev: Derzhkomstat.

[5] GOU. 2011. *Report on technical and economic state of construction sector*. Kiev: Ministry of regional development, construction and housing and communal services of Ukraine.

[6] Hegedüs J. 2012. *Homeowner's associations in post-socialist countries*. In: Susan J. Smith (ed), International Encyclopedia of Housing and Home. Amsterdam: Elsevier.

[7] Hegedüs J. 2013b. *Housing privatization and restitution in post-socialist countries* in Hegedüs-Lux-Teller (eds.): Social Housing in Transition Countries. pp. 33-49 Routledge.

[8] Hegedüs J. - Teller, N. 2013. *Social Landlords and Social Housing Management Introduction: Trends in Social Housing Management*. In Hegedüs-Lux-Teller (eds.): Social Housing in Transition Countries. pp. 81-97 Routledge.

[9] Mandic S. 2010. *The changing role of housing assets in post-socialist countries*. Journal of Housing and the Built Environment. 25. pp. 213-226.

[10] Rabenhorst C. and Ignatova S. I. 2009. Condominium Housing and Mortgage Lending in Emerging Markets - Constraints and Opportunities. IDG Working Paper No. 2009-04 June.

[11] Rabenhorst Carol S. 2012. Homeowners Association in Central and Eastern Europe: Opportunities and Challenges for the Real Estate Market Two Decades after Housing Privatization. Washington DC: International Housing Coalition December 2012.

[12] SIA 380/1:2009. “*Thermische Energie im Hochbau*” (Swiss Norm 520 380/1)

[13] Struyk R. 1996. The Long Road to the Market. Economic Restructuring of the Former Soviet Bloc. The Case of Housing. Washington: The Urban Institute Press.

[14] Turner B., Hegedüs J. Tosics I. (eds.) 1992. The Reform of Housing in Eastern Europe and the Soviet Union. Routledge.

[15] Zapatrina I. 2010. Housing and communal infrastructure: reforms and system of their financial support [Жилищно-коммунальная инфраструктура: реформы и система их финансового обеспечения]. Kiev: Institute of economics and forecasting of National Academy of Science.