Ph.D. Thesis Booklet

UNIVERSITY OF PÉCS

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POTENTIALS FOR ENERGY SAVINGS BY APPLYING STANDARD AND ADVANCED REFURBISHMENT MEASURES ON THERMAL ENVELOPE OF THE RESIDENTIAL BUILDING STOCK IN PRISHTINA

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1.1 Statement of the problem and research questions

Investments towards existing buildings renovations in Republic of Kosovo in general and city of Prishtina i particular is an unenviable need to increase the living and working commodity and decrease the current high energy consumption as a result of heat loss and non-efficient way of energy use.

Currently there are deficiencies of fundamental data and studies to identify the current state of the RBS and also intervention plans towards improvements. This leads to some fundamental questions which derived to the main research questions of this study:

1. What is the current state of physical components of the residential building stock in city of Prishtina?
2. How could all technical data of the current state of RSB stock based on the building typology and construction period be structured in a unified database?

3. How could the identification of the current general state help on a proposition of a large scale building renovations on achieving the decrement of heat energy loss by the residential buildings?

4. Which are the potential improvement intervention possibilities to achieve optimal and advanced solutions towards heating energy savings?

1.2 The Aim and Objectives of the Study

The main aim of this study is to conduct an evaluation of the current state of the residential building stock in city of Prishtina, create a matrix based database of building stock and offer practical solutions for each and specific type of building towards energy efficiency which would meet the current and future energy efficiency standards in Kosovo.

The general objective of this study is the improvement of the current state of the residential building stock in city of Prishtina, in terms of energy efficiency on one hand and the living commodity on the other hand. This will be conducted and elaborated based on findings which will be provided by the statistical data from official sources and finding from field data gathered.

1. Structuring of the residential building typology and designing of the matrix based database using official statistical data.
2. Analysis of current state of the residential building stock based on building typology referent building.
3. Designing of two scenarios for building renovation and refurbishment, which would meet optimal and advanced energy efficiency standards in Kosovo, based on current state of the residential building stock findings
4. Conclude and propose recommendations based on results and findings.

2. New Scientific Results

2.1 1st Thesis

Creation and utilization of the matrix based database for Residential Building Stock and Typology for city of Prishtina is a key instrument for any future developments and interventions toward building stock, towards energy savings and living commodity, in local level and level of the country.

I have created and developed a matrix based database of statistical and technical data of Residential Building Stock referent buildings which contains all relevant and necessary technical data, material descriptions and U values for each referent buildings of four building types and five construction periods. The database matrix confirms that for any conduction of investigation towards residential building stock related to building renovation, energy efficiency and living commodity the need of structured and descriptive technical database is a key instrument by offering sufficient relevant technical data.

Renovation of Residential Building Stock i city of Prishtina of any investigation towards decrement of energy loss through building envelope is considered crucial and urgent. Development of a structured statistical and technical database matrix establishes a platform upon which it is than possible to conduct necessary investigations, designs of any measure regarding the existing residential buildings sustainability, energy efficiency and living commodity within dwellings.

		Period of construction 1	*Period of construction 2*	*Period of construction 3*	*Period of construction 4*	*Period of construction 5*
1	*Building type 1*	**ReEx 1.1**	**ReEx 1.2**	**ReEx 1.3**	**ReEx 1.4**	**ReEx 1.5**
2	*Building type 2*	**ReEx 2.1**	**ReEx 2.2**	**ReEx 2.3**	**ReEx 2.4**	**ReEx 2.5**
3	*Building type 3*	**ReEx 3.1**	**ReEx 3.2**	**ReEx 3.3**	**ReEx 3.4**	**ReEx 3.5**
4	*Building type 4*	**ReEx 4.1**	**ReEx 4.2**	**ReEx 4.3**	**ReEx 4.4**	**ReEx 4.5**

Table 1. The Residential Building Stock sample based on TABULA building typology structuring

Building type/year of construction	*Build. Elem 1*	*Build. Elem 2*	*Build. Elem 3*	*Build. Elem 4*	*Build. Elem 5*
ReEx 1.1. photo	Graphic. & descripton of the element	Graphic. & descripton of the element	Graphic. & descripton of the element	Graphic. & descripton of the element	Graphic. & descripton of the element
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Table 2. The Residential Building Stock sample based on TABULA building typology structuring

2.2 2nd Thesis

Findings of the research show that the majority of Residential Building Stock in the city of Pristina does not meet the minimum requirements of energy conservation through building envelope envisaged by Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo.

I have proven by applying specific calculations based on EN ISO 15316 for finding the heat loss through transmission of building envelope and windows based on all gathered technical data that the majority of the Residential Building Stock does not fulfill the minimum requirements of the Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo.

The buildings built after year 2000 Buildings constructed after the year 2000 have a tendency to fulfill the minimum requirements according to the Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo and in some components outreach the current regulations by achieving higher standards.

This has been proved by generating concrete results of heating energy loss through transmission and the final energy need for space heating.

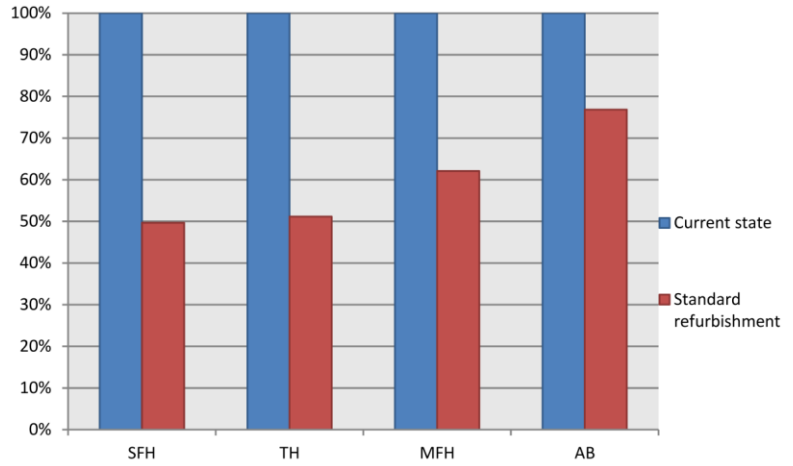
Concrete renovation propositions for Residential Building Stock towards decrement of energy loss through building envelope require precise calculated technical results of the current state of buildings. By identifying the currents state of the buildings by this research, complete renovation measures of the building envelope components have to be conducted. In case of buildings built after year 2000, renovation measures should be applied partially in specific components depending on specific cases included in this research.

2.3 3rd Thesis

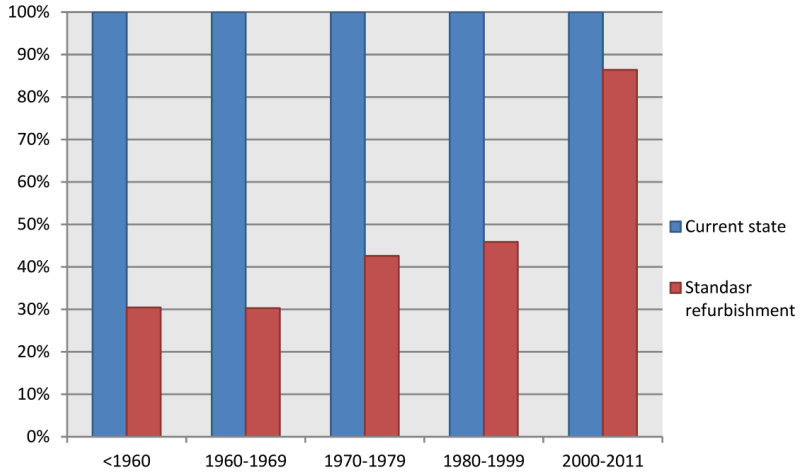
The current overall energy demand for heating by the Residential Building Stock can be decreased with 26.74% only by applying the minimum requirements of the Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo.

I have proven by applying specific calculations based on EN ISO 15316 and by applying technical measures of additional thermal insulation, window replacements and specific calculation for generating measurable results of energy savings and energy need for heating that the realistic potential of energy saving in Residential Building Stock only by applying the minimum requirements for heat transmission of the building envelope components envisaged by the Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo is 26.74%.

Application of renovation measures of the building envelope components such as walls, roofs and floors and replacement of the existing windows according to the minimum requirements of the Technical Regulation on Thermal Saving and Thermal Protection in Buildings of Kosovo can decrease the heat loss through transmission of the building by 26.74%. Application of all recommended renovation measures and generated results within this study research will assure the decrement of energy loss to 26.74% and increment of living commodity within Residential Building Stock in city of Prishtina.



Graph 1. Potential savings after implementation of "Standard refurbishment" measures based on building typology



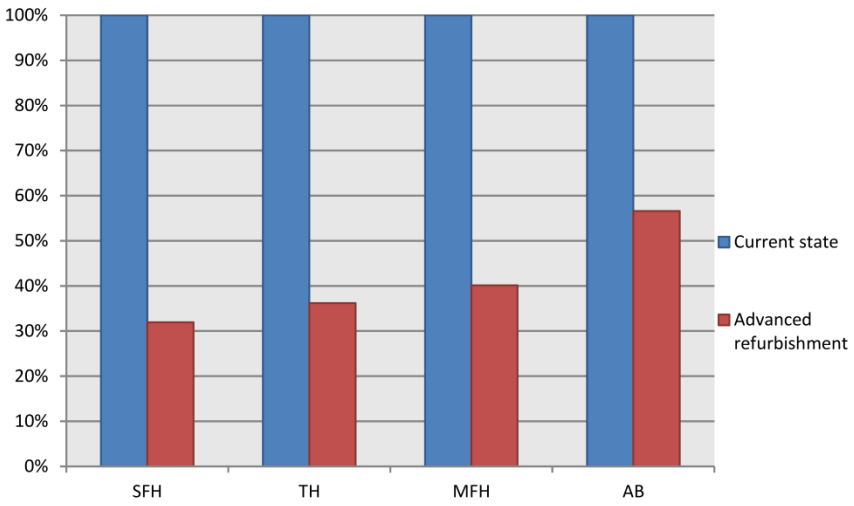
Graph 1. Potential savings after implementation of "Standard refurbishment" measures based construction period

2.4 4th Thesis

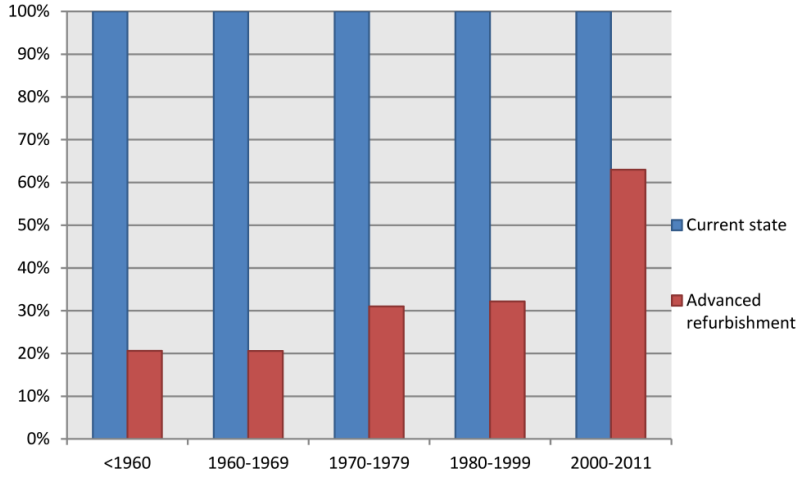
The current overall energy demand for heating by the Residential Building Stock can be decreased with 46.85% only by applying high standard of building quality equal to Nearly Zero Energy Buildings.

I have proven that the Residential Building Stock has a higher potential of savings if the higher standards of renovation measures are applied. By applying technical measures of additional thermal insulation, window replacements that comply with Nearly Zero Energy Buildings the potential of energy saving in Residential Building Stock will is 46.85%.

Developments for perspective of energy savings in Kosovo should focus in higher energy efficiency standard and living commodity. Recommended renovation measures by this research study and calculations in compliance with Nearly Zero Energy Buildings standards will assure the potential energy savings by 46.85% and increment of living commodity within Residential Building Stock by lowering the heat loss through transmission to 0.18 W/m^{2}K for envelope components and 1.0 W/m^{2}K for windows.



Graph. 3. Potential savings after implementation of "Advanced refurbishment" measures based on building typology



Graph. 4. Potential savings after implementation of "Advanced refurbishment" measures based construction period

2.5 5th Thesis

Application of standard refurbishment measures make a significant increment of internal surface of building shell elements temperature by increasing the weighted average temperature by 11% for walls, 18% for roofs and 10% for floor, when the external air temperature is -10°C.

By applying specific calculations I have proven that current differences of the temperatures between internal surfaces of the building shell elements and internal air when the external temperature is -10°C, can be significantly decrease. The weighted differences of temperatures between internal designed air of 21°C and current surface of wall of 3.37°C can be decreased to 1.23°C, for roof from 4.47°C to 0.88°C and floors from 3.09°Cto 1.06°C.

The temperature difference between air temperature and internal surface of the building envelope is an important component of the living commodity. This component has been positively altered after standard renovation recommended measures by increasing the potential living commodity during the heating season.

2.6 6th Thesis

Application of advanced refurbishment measures achieve increment of internal surface of building envelope temperature and decrease the temperature difference between surrounding internal surfaces and internal air to less than 1°C.

By applying specific calculations I have proven that by applying advanced refurbishment measures it is possible to achieve a difference of temperatures between internal air temperature 21°C and internal surfaces of the building envelope elements to less than 1°C, when the external air temperature is -10°C.

The difference between the internal air temperature and internal surfaces of the building envelope under 1°C insures the elimination of the temperature difference sensing by the building users which contributes directly in the living commodity within dwellings. Achievement of such low temperature differences between internal surfaces and internal air temperature when the outside temperature is -10°C not only creates a higher living commodity but also eliminates the possibility of appearance of condensation in building components. The results of the calculations resulted that such a difference can be achieved by applying advanced measures in compliance with Nearly Zero energy Buildings standard.

2.7 7th Thesis

Resizing of the windows oriented in East South and West, showed that the solar heat gains can be increased by average weighted of 13.7% and as a result impact in reduction of the energy needs for space heating by average weighted of 6.1%.

I have proven, based on calculations that enlargement of specific openings oriented on the East, South and West, respectively can increase the passive solar heat gains for each referent building by increasing the passive heat gains in a range of lowest of 7.0% to highest of 46.4% for respective referent buildings, by increasing the share of transparent surface in relation with opaque surfaces. As a result the energy needs for space heating decreased in a range of lowest of 3.3% to highest of 11.7% for respective referent buildings.

The energy efficiency of the building is not achieved only by energy conservation but also by passive energy gaining. Resizing of building openings is the potential of increasing the weighted average solar energy gaining by 13.7% which directly decreases the weighted average energy need for heating by 6.07% of the Residential Building Stock. Changing of the wall to window by leaving the construction system intact, is a practical measure that will contribute in achievement of energy efficiency in Residential Sector in city of Prishtina

	Solar gains			Energy need for heating		
Build. Type	Current kWh/a	Increased kWh/a	Increment %	Current kWh/a	Increased kWh/a	Decrement %
SFH 01	1951.9	2287.5	17.2%	4270.7	3974.4	6.9%
SFH 02	2105.5	2430.7	15.4%	4478.9	4188.6	6.5%
SFH 03	5153.8	5545.2	7.6%	8813.5	8497.3	3.6%
SFH 04	3900.2	4231.4	8.5%	6741.0	6419.5	4.8%
SFH 05	9192.0	10137.2	10.3%	14943.6	14118.1	5.5%
TH 01	3184.6	3544.7	11.3%	4744.0	4441.2	6.4%
TH 02	1490.8	1815.2	21.8%	3411.5	3156.3	7.5%
TH03	7737.1	8658.1	11.9%	15345.9	14438.6	5.9%
TH 04	7010.7	7502.9	7.0%	15654.2	15136.1	3.3%
TH 05	2999.7	3376.5	12.6%	5835.1	5499.7	5.7%
MFH 01	11467.2	12784.0	11.5%	29693.5	28352.3	4.5%
MFH 02	8325.4	9404.6	13.0%	15775.8	14785.6	6.3%
MFH 03	35663.4	38824.4	8.9%	83072.2	79769.5	4.0%
MFH 04	13573.3	14909.2	9.8%	26472.5	25211.6	4.8%
MFH 05	32207.1	34473.5	7.0%	55008.4	52860.4	3.9%
AB 02	20880.6	30572.6	46.4%	30510.4	27769.4	9.0%
AB 03	55950.3	65105.7	16.4%	67872.2	59962.4	11.7%
AB 04	36061.3	39566.9	9.7%	62286.4	58924.6	5.4%
AB 05	145229.8	165729.1	14.1%	175702.6	158428.7	9.8%

Table 3. Potentials of solar gains by resizing the building openings

3. Results

By gathering and structuring the statistical and technical data of the Residential Building Stock, now it is possible to conduct any investigation regarding residential sector in terms of renovations, energy efficiency and living commodity.

The technical analysis, generation of the specific results and recommendations for concrete renovation measures provided by the by the research, now it is possible to conduct renovation measures on building stock and orient the investments in specific building type and/or building age in which the most potential impact can be achieved. Providence of all specific technical solutions and specification recommendations of renovation measures for each specific building and building envelope component subserves any renovation investments by dismissing any need for technical calculations.

4. Further research

Considering the fact that this study had the main focus of physical properties of the building envelope as one of the components with a significant influence in energy demand of a building, it is obvious that additional complementary studies should be conducted to enclose the overall study by including other disciplines. Recommendations for further research should be focused on deficiencies of this research:

- Financial impact of proposed measures should be an imperative research study which should offer the most optimal and economical solutions.

- Study with a focus on the potential of energy savings by implementing replacement measures for heating carriers and systems in residential sector.

- A further analysis towards minimization of architectural impact of the refurbishment measures onto specific building styles by considering the use of specific materials which would imitate the elements and constructive details which represent a respective architectural period or style.

Presentation in a foreign language appearing in the publication of conference

- Second Kosovo Green Festival “The BUSINESS of Energy - Promote energy efficiency in buildings Energy efficiency in buildings, Sustainable investments, Kosovo Energy Efficiency Action Plan and Law. Presentation title “Survey approach towards identification of the currents state of space heating of the residential sector” Petrit Ahmeti, Researcher, Ahmeti P., September 19-21, 2017.
- Lisbon AESOP Annual Congress 2017. Title “The impact of internationally urban culture in redesigning and reclaiming local public spaces”, [1]Dalipi I., [2]Ahmeti P. 17, July 2017.
- 12th Miklós Iványi International PhD & DLA Symposium Pécs, Hungary, Title “Assessment of the heating performance and inhabitants satisfaction of the residential sector in city of Prishtina”, Ahmeti P., 2016.
- 5th International Conference on Business, Technology and Innovation, “Living and thermal commodity in residential buildings in city of Prishtina”, Ahmeti P., October 2016.
- ECOWEEK Prishtina 2016 “Heating energy resources and consumption by the residential sector in city of Prishtina”, Ahmeti P., 11 September 2016.
- International Summer Academy 2016”, Title “Smart Grid, Smart houses and sustainable buildings”, Ahmeti P., June 2016.
- 11th Miklós Iványi International PhD & DLA Symposium Pécs Title “Assessment of the living commodity, heating energy consumption and resources by the residential sector in city of Prishtina”, Ahmeti P., 2015.

Publishing

- Published on POLLACK PERIODICA An International Journal for Engineering and Information Sciences DOI: 10.1556/606.2017.12.1.12 Vol. 12, No. 1, pp. 147–158 (2017), Title “Current heating energy demand by the residential sector in city Prishtina based on the main resources” [1]AHMETI P., [2]DALIPI I., [3]BASHA ., [4]KISTELEGDI I.
- Accepted on 10th of October 2018 (to be published on Vol.14, 2019) POLLACK PERIODICA An International Journal for Engineering and Information Sciences 2019 Vol. 12, Title “Energy consumption by the type of energy carrier used in residential sector in city of Pristina”, [1]AHMETI P., [2]KISTELEGDI I.
- Published on Book of Abstracts 30th annual AESOP 2017 Congress Lisbon, Title “The impact of internationally urban culture in redesigning and reclaiming local public spaces”, [1]Dalipi I., [2]Ahmeti P., p. 253-254.
- Published on Book of Proceedings 30th annual AESOP 2017 Congress Lisbon, Title ““The impact of internationally urban culture in redesigning and reclaiming local public spaces”, [1]Dalipi I., [2]Ahmeti P., p. 1040-1048.

Other

- External expert/co-author for development Developing building typology for residential Sector in Kosovo, GIZ KEEP Kosovo, 2018.
- Translation and adoption of the Simplified Building Energy Model (iSBEM) software and user manual in Albanian language for use of Ministry of Environment and Spatial Planning in Kosovo, 2018.

- Translation and adoption of the Passive House Planing Package (PHPP) software and user manual in Albanian language for use in Kosovo, 2009.