ELBASAN REGIONAL ENERGY EFFICIENCY ACTION PLAN

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

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1. Executive Summary

Albania is a country of approximately three million people that has set relatively ambitious energy savings targets both nationally and for its capital, Tirana. Albania is pursuing a ground-up approach to developing effective energy efficiency policies at the local level, and this Regional Energy Efficiency Action Plan focuses on the Regional Council of Elbasan, due to the fact that insufficient data existed in other region to form the basis for an energy efficiency action plan. In order to develop an indicative data baseline, it was agreed to re-focus on Elbasan, which has an economy that reflects the energy intensity profile of the whole capital region.

The region of Elbasan is the third largest in the country after the Capital Tirana, and Fier. It has an area of 3,292 km², and a population of 283,822 inhabitants, which is approx. 10 % of the total population of Albania. The total number of energy subscribers for the Elbasan region is 101,475, 88% of which are households.

As implementation and data collection progressed, it became clear that data were not available for many of the sectors initially intended to enable modelling originally envisaged to be undertaken. The plan therefore focuses more detail on the sectors for which data were available, specifically public buildings and to a lesser extent public lighting.

Detailed modelling work on public buildings shows that substantial cost-effective energy savings opportunities exist in the sector, notably for hospitals, dormitories, kindergartens and schools. Size of the opportunity and net present values vary with each sector. However, the modelling allows consideration of a range of different options for a program of thermal retrofit for public buildings. Similarly, strong opportunities exist for efficiency in street-lighting, especially given current poor performance of the lighting infrastructure in Elbasan.

A number of recommendations and suggested policy options have been provided across the two sectors for which data was available, and also based on more general policy recommendations across transport, residential buildings and industry. Should there be interest from the Elbasan Municipality to take these recommendations further, a process of consultation is needed to decide the length and breadth of the resultant energy efficiency implementation program that Elbasan will undertake. Similarly, the Municipality must also decide the extent to which this consultation must be conducted. A clear additional recommendation is for a plan to be made to source additional data on the key parameters of energy use, so that modelling can be undertaken on the potential savings and cost effectiveness to be derived from particular measures.

The report authors are aware of and able to deliver substantial assistance in terms of policy input, information and connection to service and technology providers that can help deliver on the decided scope of the Elbasan energy efficiency implementation plan. Depending on the initiatives and technology deployments outlined, there is also connection to the possibility of discussions regarding financing models such that the work can be funded and successfully executed.

2. Context

2.1. The Albanian Energy Sector

The energy sector is a priority for the Government of Albania for both its contribution to environmental impacts and for the nation's economic development. Albania has adopted an Integrated Planning System (IPS) to provide a set of operating principles for facilitating coordinated, coherent and integrated government policy planning. Part of the IPS is the second National Strategy for Development and Integration (NSDI-II) which describes the national social, democratic and economic development objectives for the period 2015-2020. The NSDI-II identifies secure and cost-effective energy supply as a key policy objective for Albania. This is set within broader economic goals that include a provisional targeted real Gross Domestic Product (GDP) growth rate of 4.9% by 2020.

Final energy consumption in Albania grew gradually between 2007 and 2011 before seeing a contraction in 2012, coinciding with a slowdown in the Albanian economy, as shown in Figure 1. This decline in consumption in 2012 was particularly noticeable in the construction sub-sector and transport sector which are sensitive to economic output. However, despite GDP growth remaining subdued, energy consumption nevertheless rebounded sharply in 2013, mainly due to increased residential demand. It then saw a further large increase in 2014 driven primarily by the iron and steel sector. In summary, over the period 2009-2014, final energy consumption expanded from 1,871 ktoe to 2,070 ktoe. This represents an increase of approximately 11%, though the growth rate was not consistent over the period.[1]

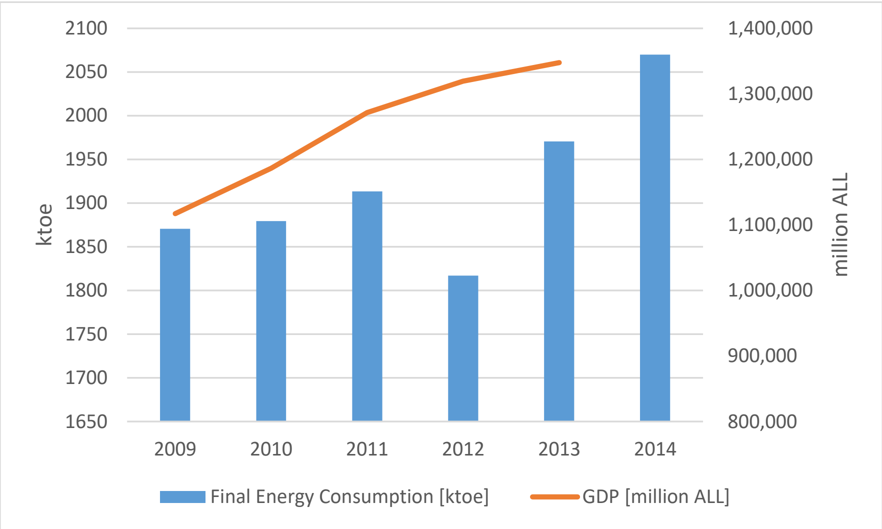


Figure 1: Final energy consumption over review period

[1] Second and Third National Energy Efficiency Action Plan 2016- 2020, Government of Albania

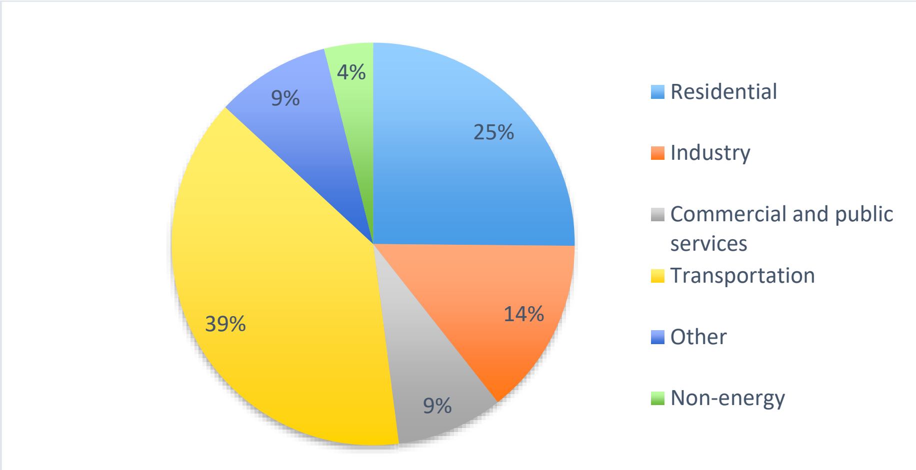


Figure 2: Final energy consumption by sector, 2014

Source: Albania energy consumption overview, *Albanian Energy efficiency guide, by Meister consultants groups, May 2014*

With respect to climate change, Albania has submitted its intended nationally determined contribution (INDC) which forms part of the United Nations Framework Convention on Climate Change (UNFCCC) process for setting and meeting emissions reduction targets at the international level. In compliance with COP21 of the UNFCCC, Albania's NDC set a baseline scenario target which targets a level of savings (11.5% reduction in CO_2 emissions by 2030) below a forecasted baseline trajectory.

Significant developments are ongoing in order to advance Albania's energy sector governance and meet the above targets. To this end, the National Renewable Energy Action Plan (NREAP) for the years 2015-2020 was approved by the Council of Ministers on 20th January 2016 which outlines a plan to reach the 2020 target of 38% of final energy consumption to come from renewable energy sources.

With respect to energy efficiency, the landmark Law on Energy Efficiency (Law 124/2015) was adopted in November 2015 which transposes many of the requirements of Directive 2012/27/EU (the "Energy Efficiency Directive"). Similarly, the adoption of the Law on the Energy Performance of Buildings (EPB) transposes Directive 2010/31/EU (the "Energy Performance of Buildings Directive") – an area with great potential in Albania and its major population regions. Together these primary laws provide the foundation upon which a more complete regulatory framework can be built, the institutional structure and financing support can be established, and the foreseen measures within this REEAP successfully implemented.

2.2. Climate data

Albania is divided into three climate zones: zone A is the mildest along the coastline, zone B is the medium zone, and zone C is the coldest in the mountainous region.

The Albanian regulations provide the heating degree days for the largest cities of Albania, but other climatic data are missing. The free version of the Meteonorm database contains information on the climate of Tirana (global, diffuse and direct horizontal radiation, air and dew point temperature, and wind speed). Radiation on vertical surfaces for each orientation was approximated based on the climate dataset of the PHPP software (Passive House Planning Package) for the Italian city of Bari, which has a very similar climate to Tirana (difference in air temperature of 2 percent, and difference in radiation of 5 percent).

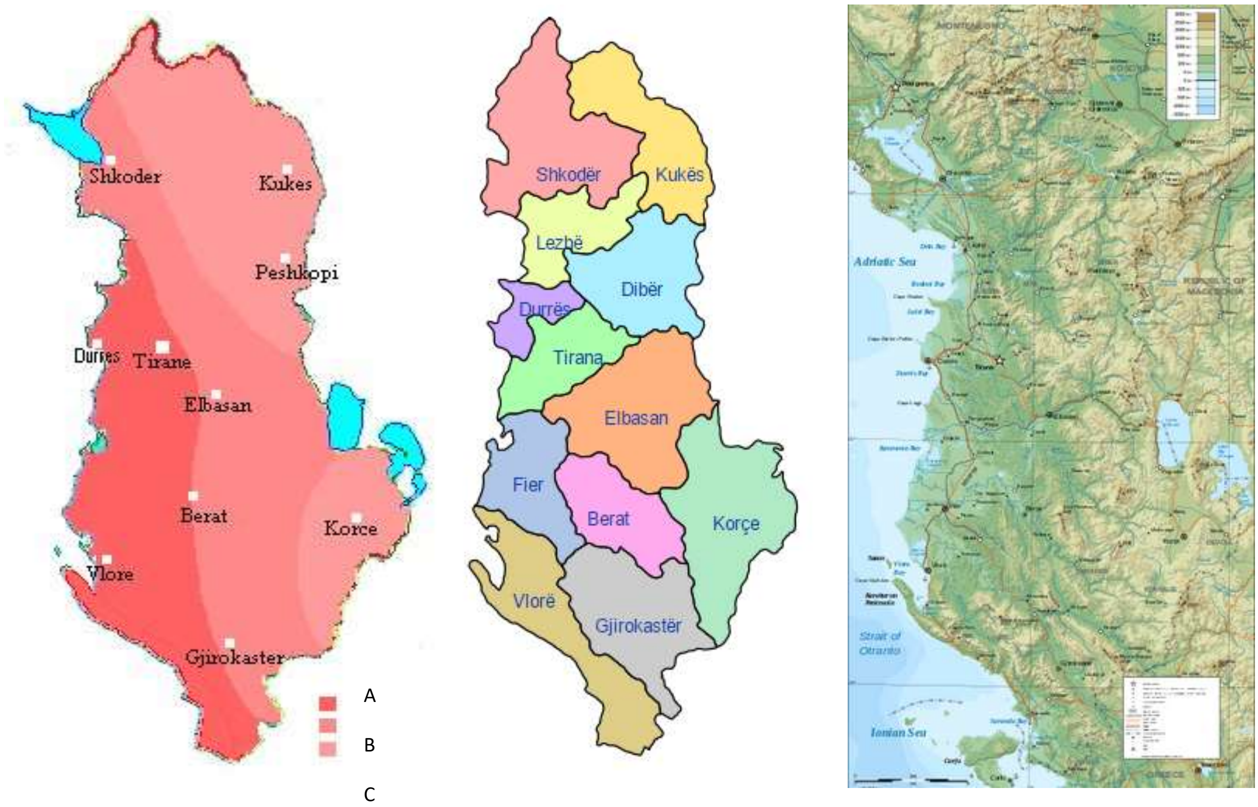


Figure 3: Climate zones and prefectures in Albania (Simaku, Thimjo, and Plaku 2014; "Wikipedia" 2015; "Wikimedia" 2015)

The length of the heating season was fixed to six months from October to March, and the cooling season also to six months from April to September. According to the calculation method of the EN ISO 13790, the fixed length should be long enough to include the months with heating/cooling demand, but its value is not critical, as the actual length of the season is determined by the gain (loss) utilization factor. Global radiation and degree days were also calculated for this fixed season length (**Error! Reference source not found.**). The climate data for Albania are estimations, which could be corrected in the future once more accurate data becomes available.

Table 1: Estimated climate data

	Heating		**Cooling**		**Yearly global radiation**				
	HDD	Length	CDD	Length	North	East	South	West	Global
	hK/a	h/a	hK/a	h/a	kWh/(m²a)				
Zone B	1674	4368	756,8	4392	372	951	1234	924	1552

2.3. Albania National Energy Efficiency Action Plan (NEEAP)

i. Key features

According to Albania's NEEAP, first published in 2010, the overarching aim is to reduce energy consumption by 3% by 2012, and by 9% by 2018. The absolute savings are divided by sector as follows:

Table 2: Absolute savings per sector

Sector	Absolute Savings
Residential	22%
Services	19%
Industry	25%
Transport	31%
Agriculture	3%
Total Saving Potential	**100%**

This is based on higher potential, least-cost, current level of energy consumption and existing interventions.

It is planned to implement legislation which makes energy audits and EE measures compulsory for public institutions. Sector-specific info and proposed measures include:

Residential - thermal insulation, central and district heating, solar heater systems, appliance labelling, efficient lightbulbs

Services - heating oil, thermal insulation, solar heating, small-scale CHP & central heating, energy audits

Industry - main energy consuming industries are food & beverage, construction materials, chemicals, ore extraction. Proposed measures include an auditing scheme, minimum energy efficiency standards, small-scale CHP, voluntary agreements, inclusion of EE into environmental permit, management improvement, maintenance & modernisation of technologies, technological improvements, EE stand-by modes.

Transport - road transport consumes most of the energy in the sector (86%), hence measures focus on this sub-sector. energy labelling of new cars, levy on CO_2, information campaign on energy efficient driving, modal share measures (improving public transport in municipalities, improving railway services, promotion of walking & biking), freight transport specific measures (eco-driving courses for professional lorry drivers, improving railway freight services).

Agriculture - biomass schemes/biogas from animal waste, solar energy for drying, efficient irrigation schemes

ii. Updated NEEAP

The Government of Albania is in the process of finalising its National Energy Efficiency Action Plan, which builds on the previous 2010-2018 version. The new Action Plan provides a contextual framework for proposed work in Elbasan, with regional targets to be developed in alignment with overall contributions to national plans.

2.4. Sustainable Energy Action Plan (SEAP): Tirana

Tirana is important overall to energy efficiency policy deployment in Albania and Elbasan because a) it is home to almost 30% of Albania’s population; and 2) as the capital city with strong trade connections to Elbasan, policies and trends emerging in the city will be influential on regional trends.

Tirana’s Sustainable Energy Action Plan (SEAP) identifies and provides precise and clear guidelines for the implementation of projects and measures of energy efficiency and use of renewable sources of energy at the city level, which result in the reduction of CO2 emissions by more than 20% by the year 2020[2]. The key goals of the development and implementation of the Action Plan are:

- Reduction of the CO_2 emissions in the sectors of building, transport and public lighting through the implementation of energy efficiency measures, through the use of renewable sources of energy, management of consumption, education, etc;
- Maximal contribution to the security and diversity of city's power supply;
- Reduction of consumption of energy in the building, transport and public lighting sectors;
- Increase of the share of power obtained from renewable sources;
- Enabling the transformation of urban areas into ecologically sustainable areas.

2.5. Rationale for the focus on the Elbasan Region and its applicability to other regions/cities

Albania is in the process of developing key tools for its regional capacity in low-emissions development. By focusing on the local level, Albania is pursuing a ground-up approach to developing effective energy efficiency policies at the local level. This Regional Energy Efficiency Action Plan focuses on the Regional Council of Elbasan and through government institutions working in sustainable development such as the Regional Centre of Expertise (RCE) on Education for Sustainable Development Middle Albania.

Initially intended to cover Albania's capital region of Tirana, Durres and Elbasan, the Regional Energy Efficiency Action Plan narrowed its focus to Elbasan. The rationale for this reset was due to the fact that insufficient data existed in the capital region to form the basis for an energy efficiency action plan. Therefore, in order to develop an indicative data baseline, it was agreed to re-focus on Elbasan, which has an economy that reflects the energy intensity profile of the whole capital region.

2.6. Overview of the Elbasan region and its energy sector

The region of Elbasan is the third largest in the country after the Capital Tirana, and Fier. It has an area of 3,292 km², and a population of 283,822 inhabitants, which is approx. 10 % of the total population of Albania, 2,876,591 inhabitants (INSTAT 2017). 60% of the region´s population lives in rural areas and the other 40% in urban ones. The most important economic sectors in terms of GVA are: commerce, hotels and restaurants, transport and communication (27% of GVA); agriculture, hunting and forestry, fishing (24%) and industry (18%). SMEs are dominant with 93% of micro size (they have from 1-4 employees).

Table 3 Population of Elbasan Region, divided according to urban and rural zones

Municipalities	Total population	Urban population	Rural population
Elbasan	125,173	125,173	0
Cerrik	14,872	14,872	0
Belesh	10,000	3,528	6,472
Peqin	8,950	8,950	0
Gramsh	13,870	13,870	0
Librazhd	10,500	10,500	0
Prrenjas	8,723	6,553	2,170
Total communes	91,734		91,734
Total	**283,822**	**183,446**	**100,376**

[2] Sustainable Energy Action Plan of the City of Tirana (2014)

The total number of energy subscribers for the Elbasan region is 101,475 (88% households, 10% private businesses, 2% others).

Table 3: Electricity expenditure for Elbasan Municipality for 2016

	Albanian Leks (ALL)	EUR
Urban	35,693,505	267,515
Rural	3,752,394	28,123
Total	**39,445,899**	**295,638**

The region has high current and potential use of hydro-electric power. There are four hydro-electric stations established alongside the branches of rivers Shkumbin and Devoll (installed power is 25.85 MW). A new hydropower station (Devolli Hydropower Plant) is under construction in the area of Gramsh. Moreover 6 other smaller new stations are planned in Librazhd (3), in Gramsh (1), and in Elbasan (1). For now, there are no major initiatives to explore opportunities of using renewable energy sources other than rivers in the Elbasan region.

The region is connected to the national and international road, rail, sea and air network. Elbasan city is 75 km from Qafe Thana (border with Former Yugoslav Republic of Macedonia (FYROM)), 135 km from Kapshtica (border with Greece), 80 km from the Port of Durres, 125 km from the port of Vlora and 80 km from the Rinas Airport.

The Albanian railway system is in poor condition. There is one line connecting the region of Elbasan (from Rrogozhina to Pogradec near FYROM (Gurkuq), 117km). Two carriages and one locomotive are functional, transporting passengers rather than goods. The infrastructure is in extremely poor condition and there are no investments planned.

National and international routes; The highway Peqin-Elbasan-Librazhd, part of 'EU Corridor 8', National axis is the 'Eastern Ring' from the northernmost point of Albania (Vermosh) through Kukes-Peshkopi-Librazhd-Prrenjas-Korçe-Erseke to Permet. The other is the 'South Axis' which will connect Paper (Elbasan) -Cerrik (Elbasan) - Dragot (Elbasan) - Kuçove - Berat and cross over with the Tepelenë - Gjirokastër road. National roads in Elbasan constitute 12% of the total road length, the regional roads 18% and the communal ones 70%. The national road network in Elbasan region has the length of 405 km of which 85% is in good conditions; the regional network of 535 km is in mixed condition the communal roads of 2,094 km are mainly unpaved.

3. Data availability, capture and analysis – target sectors and methodology

At inception, this report targeted the collection of data, subsequent analysis on energy use and savings potentials, and economic analysis for the key energy using sectors in Elbasan, namely the public lighting transport, buildings, and industrial sectors. Most of the data were expected to be indicative and proxy, retrieved mainly from different Departments in the Municipality of Elbasan (e.g. Urban planning department, Statistics department, Transport department) and various Ministries (e.g. Ministry of Transport, Ministry of Urban Planning, Institute of Statistics, energy distribution operators etc. Planned methods for data collection were through interviews, government and municipal data, reports and national and local strategies.

Subsequent missions to Albania, discussions with officials and data collection efforts were unable to uncover detailed data for the Elbasan region to enable modelling originally envisaged to be undertaken. This is especially true of the transport and industry sectors, where no specifically stratified data has been identified to enable detailed quantitative analysis. Further resources and time would need to be allocated to measurement and data generation by local authorities if such analysis were to be performed, and could be the subject of specific further studies if there was interest in modelling energy savings for these sectors. For these sectors, the report therefore provides comments on the existing data and indicative recommendations only, based on successful policy implementation from other similar cities in the region, and also on connections with other city and national energy efficiency priorities in Albania.

Sections that follow, therefore, present detailed quantitative analysis for those sectors where sufficient data for Elbasan municipality has been found to be available, namely in **public buildings** and **public lighting**. Despite transport and residential buildings consuming the lion's share of energy in the country and the Elbasan municipality, and the existence of high level data, these sectors have not been able to be examined thoroughly in this report. However, it is of note that the majority of immediate public funding allocated through the updated NEEAP nationally is directed at the two sectors analysed in more depth, which present immediate priorities for energy efficiency initiatives in the Elbasan region.

4. Public Buildings

4.1. Research methodology

This report aims to contribute to the evidence-based design of energy efficiency and climate mitigation policies in Albania that target the public building sector, and addresses the following questions:

- For each representative building type, what is the energy demand; the delivered energy by energy source; primary energy consumption; and CO_2 emissions from space heating, water heating, space cooling and ventilation?
- What are the possible retrofitting options and packages of options by representative building type? What are the investment costs per retrofitting measure and per building by representative building type?
- Which building types offer the largest and/or the most cost-effective energy savings? What are the priority sector segments for policy-making?
- How attractive financially are the suggested retrofitting packages? Do they pay back from energy cost savings? How significant are co-benefits of building retrofitting packages if they are monetized?

The report assesses only thermal energy services delivered in the public buildings, namely space heating, space cooling, ventilation, and water heating. We do not cover other energy services. The latter energy services consume a large share of the public-sector balance and therefore it is important to keep in mind that building energy consumption and CO_2 emissions would be higher if they would be considered.

The retrofit options include both the improvement of thermal envelope and the exchange of technical systems, which often imply fuel switch. The improvement of thermal envelope means the retrofit of walls, roofs, floors, and windows. Better technical systems are better systems for water heating, space heating, ventilation, and space cooling. Depending on technical and economic feasibility, household may switch to solar, biomass, LPG, diesel oil, or electricity as energy sources. We do not consider the impact of climate change on space heating and cooling patterns.

The energy consumption is not calibrated to the sector energy balance however building energy demand is calibrated to energy bills.

For environmental impacts, CO_2 emissions were calculated and considered both direct and indirect emissions. Direct emissions are those originating from fuel combustion, which occurs in buildings. Indirect emissions are those, which are produced in the transformation sector and are accounted on the supply side according to the IPCC guidelines (IPCC NGGIP online), but which are associated with energy commodities consumed in energy-using sectors. In our case, indirect emissions include emissions from electricity use.

Top-down calculation methods use data compiled per sector or locally for Elbasan region, as a starting point for the appraisal of the extent of energy saved, and use these to derive a set of energy efficiency indicators. Due to the lack of granularity at product and sub-sectoral levels such indicators are unable to attribute energy savings to specific energy efficiency measures implemented. They can, however, provide a high level indication of the broad trajectory of trends in energy consumption and progress of energy efficiency at a macro-economic level.

Despite its relative simplicity and coarseness, the top-down approach to assessing energy efficiency trends and progress remains reliant on large amounts of data to be meaningful and effective. Such data extends beyond the energy sector to include other macroeconomic and sectoral data sets. The availability of required data sets varies by country and may need modelling or expert judgement to overcome gaps, while the quality will be weakened by a lack of comprehensiveness due, for example, to a large “shadow economy”. The reliability of any results drawn is therefore dependent upon the quality and extensiveness of the source data. This analysis highlights where such limitations are particularly noticeable for Albania.

4.2. Building typology of existing public buildings in the Elbasan Region

There are in total 423 public buildings in Elbasan region, consisting of educational and health institutions (381), municipal offices and cultural buildings (21), cinemas/ theatres (5), church (2), mosque (2), museum (2), library (2), cultural centre (2), clock tower (1), sports centre (5).

Metered consumption was available in most buildings. Although this sample cannot be regarded as representative, the number of surveys was sufficient to draw conclusions about the present state of the public building stock. The surveys served as the basis for creating representative buildings.

In the public building typology, the following building types were distinguished:

- dormitories,
- hospitals,
- kindergartens,
- public offices (includes municipal and governmental offices)
- schools,
- universities.

The following sections summarize the main findings of the surveys and describe the present state of the surveyed public buildings.

i. Dormitories

Construction period and renovation: The surveyed dormitories were built between 1950 and 1975. Most dorms were last renovated 10-15 years ago. Renovation included plastering and the change of windows for aluminium frame single glazed windows. In some dorms also, the boiler was changed.

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.6 W/m^2K. Most schools have flat roof or unused loft with no or limited insulation. Windows are single glazed with aluminium frame.

Technical building systems: a decentralized system with electric radiant heating. Domestic hot water is produced by small electric water heaters (boilers). No ventilation and cooling systems, and no renewables are used.

Use: some dormitories are open all year around, while others close during the summer months. Typically, only the rooms are heated (45-80% of the total floor area) and only for about 5-8 hours a day.

ii. Hospitals

In the recently renovated buildings, windows were changed for double glazed windows with plastic frames, in the earlier renovations for single glazed aluminium frame windows. In some of the hospitals also the heating system was upgraded. In two buildings efficient lighting system was installed.

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.3 W/m^2K. Most schools have flat roof with limited insulation. Windows are either single glazed with aluminium frame or double glazed in recently retrofitted buildings.

Technical building systems: All buildings have central system, mostly supplied by an oil boiler. One recently renovated hospital has a central pellet boiler. In two buildings a secondary, centralized air heating system covers part of the demand based on a heat pump. Hot water is typically produced with decentralized electric boilers. No ventilation systems are used. Cooling typically does not exist; only one recently renovated building has a central chiller, supplemented with decentralized, split type air conditioners.

Use: hospitals are open all year around for 24 hours. Typically, only the rooms are heated (50-80% of the total area) for 10-20 hours a day.

iii. Kindergartens

Construction period and renovation: The kindergartens were built between 1960 and 1990, and most of them renovated in the last decade. Renovation included change of windows for single glazed aluminium frame windows, only in the recent renovations for double glazed windows. Also, the heating system was upgraded.

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.3 W/m^2K. Most kindergartens have flat roof or unused loft with no or limited insulation.

In the recently retrofitted buildings the flat roofs are insulated. Windows are typically single glazed aluminium frame windows or double glazed in the recently retrofitted buildings.

Technical building systems: Decentralized and central heating systems also exist. Decentralized systems are direct electric heating in zone B. Recently renovated buildings have central gas, oil or biomass boilers. Most kindergartens have no DHW system, only a few have electric boilers. No ventilation and cooling systems are installed.

Use: Kindergartens are open on average 220 days annually, about 40 hours a week and close for the summer holiday and on the weekends. Typically, only the rooms are heated (65-90% of the total area) and only for about 5-8 hours a day.

iv. Public offices

Public offices include municipal offices.

Construction period and renovation: The surveyed offices were built between 1952 and 1982, and renovated 5-14 years ago. Renovation included change of windows for single glazed aluminium frame windows and only in one building for double glazed windows. Renovation also included plastering and repair of roof, without any energetic measures.

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.5 W/m^2K. Most offices have flat roof or unused loft with no or limited insulation. Windows are usually single glazed with aluminium frame.

Technical building systems: The surveyed offices have decentralized heating systems supplied with low-efficient heat pump, but also electric direct heating and wood stoves exist. Only one office building has central system with an oil boiler. There is usually no domestic hot water and ventilation system. Cooling is provided by decentralized split type air conditioners.

Use: offices are open on weekdays for 8 hours a day. Typically, only the office rooms are heated (35-80% of the total area) for about 6-8 hours a day.

v. Schools

Construction period and renovation: The schools were built between 1950 and 2000, with most of the buildings built in the 1960s and 1970s. Some of the schools went through a renovation in the last decade, some in the 1990s. Renovation included standard renovation measures such as plastering and rebuilding of roof covering, but some cases energetic measures were applied. Windows were changed in many schools, but usually for single glazed aluminium frame windows, and in some cases for double glazed aluminium or plastic windows. Some schools were additionally insulated with polystyrene, but this is not common a measure. In some buildings, also the heating system was upgraded, and new oil boilers were added. Installation of efficient lighting system is mentioned only in one school.

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.4 W/m^2K. Most schools have flat roof or unused loft with no or limited insulation. Windows are either single glazed with aluminium frame or double glazed in recently retrofitted buildings.

Technical building systems: About half of the surveyed schools have centralized heating system with oil boiler and radiators. The other half has decentralized systems: electric radiant heating is common. No hot water, ventilation and cooling systems are used in schools.

Use: schools are open on average 160-220 days annually, about 40 hours a week and close for the summer holiday and on the weekends. Typically, only the classrooms and offices are heated (50-70% of the total area) and only for about 4-5 hours a day.

vi. Universities

Construction materials: Typical construction materials for walls are plastered solid brick walls with a U-value of around 1.5 W/m^{2}K. The new buildings were built from hollow clay blocks. Most universities have flat roof with no or limited insulation. Windows are either single glazed with aluminium frame or double glazed in recently built buildings.

Technical building systems: Most buildings have centralized heating system with oil boiler or heat pump. One building has decentralized direct electric heating and one decentralized heat pumps with fan coils. Domestic hot water system exists only in three of the buildings, here electric boilers are installed. No ventilation systems exist. For cooling, one of the new buildings has a central cooling system, and some other buildings have decentralized split air conditioners.

Use: Universities are open on average 220 days annually, about 50 hours a week and close for the summer holiday and on the weekends. Typically, only the classrooms and offices are heated (50-70% of the total area) and only for about 4-8 hours a day.

4.3. Calculation of energy demand and savings potentials

The energy calculations included the thermal energy services, i.e. space heating, space cooling, domestic hot water production and in some cases mechanical ventilation. The demand for lighting and appliances was not considered.

Space heating and cooling was calculated according to the quasi-steady-state seasonal method defined in EN ISO 13790:2008. The energy balance includes the following components:

- transmission heat transfer between the conditioned space and the external environment;
- ventilation heat transfer (by natural ventilation or by a mechanical ventilation system);
- transmission and ventilation heat transfer between adjacent zones;
- internal heat gains (e.g. persons, appliances, lighting);
- solar heat gains (direct or indirect);
- storage of heat in, or release of stored heat from, the mass of the building;
- energy need for heating: if the zone is heated, a heating system supplies heat in order to raise the internal temperature to the required minimum level (the set-point for heating);
- energy need for cooling: if the zone is cooled, a cooling system extracts heat in order to lower the internal temperature to the required maximum level (the set-point for cooling).

A quasi-steady-state method considers a sufficiently long period, which enables to take into account the dynamic effects (storage and release of heat) by an empirically determined gain and/or loss utilization factor. For heating, internal and solar heat gains are multiplied by a gain utilization factor to take into account that only part of the gains is utilized to reduce the energy need for heating, and the rest leads to an undesired increase of the internal temperature above set-point. For cooling, we applied a utilization factor for losses (mirror image of the approach for heating) describing the fact that only part of the transmission and ventilation heat transfer is utilized to reduce cooling needs.

As public buildings are usually not used all day around, correction factors for intermittent heating and cooling were introduced based on the number of heated/cooled hours. In addition, in Albania it is common that only continuously occupied spaces that are heated. This means that for examples in schools only classrooms and offices are heated, while corridors and restrooms, etc. have no heating at all or the heating is not used (Simaku, 2016).

Many public building have no central heating and especially cooling systems. Even if a central system exists, there is usually no automatic regulation. Hence, a simplified method was applied for taking into account partial and intermittent heating (cooling) that multiplies the continuous heating (cooling) need with a correction factor based on the fraction of the heated (cooled) area and the fraction of the number of hours in the week with a normal heating (cooling) set-point. The set-point temperature was assumed to be 20°C for heating and 26°C for cooling.

For building service systems several options were calculated according to the heating system typical for the type of the building and the climate zone. In the baseline option, it was calculated the energy demand of all building types for the climate of Elbasan (climate zone B) and adapted the results to the other climate zones by correction factors based on heating and cooling degree days. As there is a high level of uncertainty in the input data, the results should be regarded as estimates only.

i. System efficiencies

Delivered energy is calculated using the net heating energy demand (Q_{ND}) per energy source:

$$Q_{delivered} = \frac{Q_{ND}}{\eta_t}$$

The system efficiency (η_t) of the energy supply systems was calculated as follows:

$$\eta_t = \eta_b \cdot \eta_p \cdot \eta_c$$

where

η_b = boiler (source) efficiency

η_p = piping (distribution) efficiency

η_p = control (regulation) efficiency

Taking into account that there are no further data concerning the characteristics of heating devices per building type (no survey has been carried out in connection with these data in Albania), in the building type models the most frequent systems were incorporated.

In climate zones A and B, both direct electric heaters and heat pumps are common. To simplify the modelling, these two systems were modelled together with a virtual efficiency calculated according to the ratio of the buildings with direct electric heating and heat pump, assuming an efficiency of 1 for direct electric heating and 2.2 for heat pumps.

ii. Primary energy factors and CO2 emissions

Primary energy consumption ($Q_{primary}$) is the sum of the delivered energy ($Q_{delivered}$) multiplied by the primary energy factors ($f_{p,source}$) of the energywares:

$$Q_{primary} = \sum Q_{delivered} \cdot f_{p,source\ i} \quad \left[{kWh}/{year} \right]$$

Annual CO_2 emissions for space heating and DHW are determined as follows:

$$m_{CO2} = \sum Q_{delivered} \cdot f_{CO2,source\ i} \quad \left[{kg}/{year} \right]$$

where

$f_{CO2,source\ i}$ = the CO_2 emission factor of the energyware used by heat generator i

The conversion factors for the determination of annual primary energy and specific CO_2 emissions per energy carrier are shown in **Error! Reference source not found.**. As there was no information available for the primary energy factors and specific CO_2 emissions, standard values were used for wood and LPG, and the values determined from the electricity sector modelling scenarios for electricity. The low values for electricity can be explained by the fact that electricity supply in Albania is based on hydro generation.

Table 4: Primary energy factors and CO2 emission factors for Albania (IPCC and Szabo et al. 2015)

Energy carrier	**primary-to-final energy factor**	**specific CO_2 emissions**
	[kWh/kWh]	[kg/kWh]
Wood biomass	0.2	0
Electrical energy	1.01	0
LPG	1.1	0.227
Oil	1.2	0.267
Solar energy	0	0

4.4. Definition of retrofitting options

In the model, three renovation options were developed for all building types, two of them representing a complex retrofit package. The complex packages consist of measures for upgrading the building envelope and the heating, cooling and domestic hot water systems.

The "**business as usual" option (BAU improvement)** includes the currently most frequently applied renovation option — that is, most commonly the changing of windows, insulation of roofs and/or attic slabs, installing individual direct electric hot water heaters and low efficiency decentralized split cooling units in some of the rooms. However, it was assumed that in BAU the comfort level is raising. The heating system is used more frequently, the hot water demand is higher (in the current state hot water is not installed in most of the buildings at all), such as cooling.

The **"standard" option (improvement 1)** includes interventions related to each building component in order to comply with the minimum requirements foreseen in the case of major renovation. In the case of buildings constructed before 2000, major renovations are rather likely. The standard option in this case therefore includes a set of interventions for upgrading the building envelope from an insulation point of view. In addition, efficient building service systems are introduced: reversible heat pumps with better coefficient of performance (SCOP=3), efficient wood pellet boilers (85% efficiency), low temperature gas boilers or efficient oil boilers. In terms of water heating, direct electric heating (as for BAU) or if not electric, combined systems with heating are applied. In heating cooling has no additional cost (reversible heat pumps).

The "**ambitious**" **option (improvement 2)** goes beyond building regulations regarding the building envelope. Efficient building service systems are introduced such as reversible heat pumps with better coefficient of performance (SCOP=4), efficient wood pellet boilers (85% efficiency), condensing gas boilers or efficient oil boilers. In terms of water heating heat pumps with high coefficient of performance (SCOP=4, independent from heating), or combined systems with heating are applied. In addition, central solar heating systems are introduced to cover 8-20% of hot water demand (except for schools and universities where solar is not applied). In heating cooling has no additional cost (reversible heat pumps).

i. Insulation

Currently, with the exception of buildings constructed in the last decade, Albanian buildings have limited or no insulation. The U-values in our calculations are the weighted mean values of the survey results. The standard renovation included the addition of 5-10 cm of insulation for walls, roofs and floors, and the changing of windows to double-glazed units. The ambitious option involved 8 cm of insulation for walls, 10 cm for roofs and 5-8 cm for floors, along with triple-glazed windows. In most cases, expanded polystyrene with thermal conductivity in the range of 0.031-0.045 W/mK was assumed.

Additional insulation thicknesses		
BAU renovation	**Improvement 1**	**Improvement 2**
External wall - 0 cm Attic slab - 5 cm Cellar ceiling - 3 cm Arcade slab - 0 cm Flat roof - 3 cm Pitched roof - 10 cm Perimeter insulation - 0 cm Walls to the ground - 3 cm	External wall - 5 cm Attic slab - 10 cm Cellar ceiling - 5 cm Arcade slab - 10 cm Flat roof - 5 cm Pitched roof - 10 cm Perimeter insulation - 5 cm Walls to the ground - 5 cm	External wall - 8 cm Attic slab - 10 cm Cellar ceiling - 8 cm Arcade slab - 10 cm Flat roof - 5 cm Pitched roof - 10 cm Perimeter insulation - 5 cm Walls to the ground - 5 cm

Table 5: Added insulation in the retrofitting options

	Dormitory	Hospital	Kindergarten	Office	School	University
Present state	Limited or no insulation, single glazed windows with metallic frame	Limited or no insulation, single windows with metallic frame and double-glazed windows with wood/plastic frame	Limited or no insulation, single glazed windows with metallic frame	Limited or no insulation, single glazed windows with metallic frame	Limited or no insulation, single or double-glazed windows with metallic frame	Limited or no insulation, single glazed windows with metallic frame

BAU renovation	Additional insulation, single glazed windows with metallic frame	Additional insulation, single windows with metallic frame and double-glazed windows with wood/plastic frame	Additional insulation, single glazed windows with metallic frame	Additional insulation, single glazed windows with metallic frame	Additional insulation, single or double-glazed windows with metallic frame	Additional insulation, single glazed windows with metallic frame
Improvement 1	Additional insulation, double glazed windows with metallic frame and noble gas filling	Additional insulation, double glazed windows with metallic frame and noble gas filling	Additional insulation, double glazed windows with metallic frame and noble gas filling	Additional insulation, double glazed windows with metallic frame and noble gas filling	Additional insulation, double glazed windows with metallic frame and noble gas filling	Additional insulation, double glazed windows with metallic frame and noble gas filling
Improvement 2	Additional insulation, triple glazed windows with metallic frame and noble gas filling	Additional insulation, triple glazed windows with metallic frame and noble gas filling	Additional insulation, triple glazed windows with metallic frame and noble gas filling	Additional insulation, triple glazed windows with metallic frame and noble gas filling	Additional insulation, triple glazed windows with metallic frame and noble gas filling	Additional insulation, triple glazed windows with metallic frame and noble gas filling

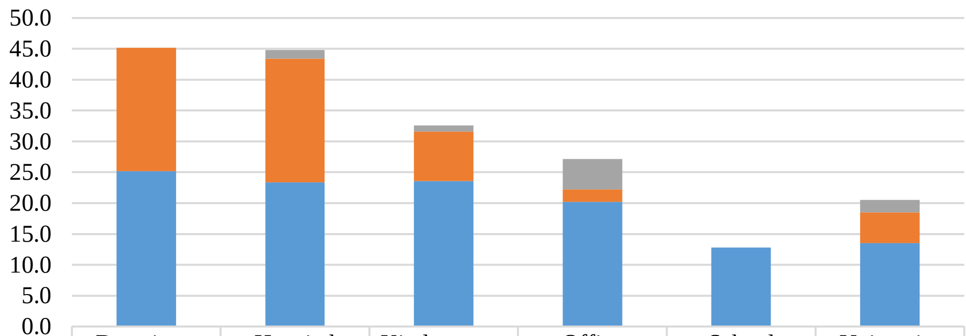
4.5. Model results

As the summary diagrams of the results show, space heating or domestic hot water demand are the most important at present, but the picture strongly depends on the building type. As explained before, in Albanian public buildings intermittent heating and partial heating is typical making the heat demand moderate. It is not exceptional that some rooms are heated only for a couple of hours a day and in the rest of the rooms building users suffer a lower comfort level to save costs. In the calculations we assumed that the number of heated hours are 25-63 hours per week, whilst the heated floor areas are assumed to be 61-78% of the total net floor area.

In some building types, particularly in schools there is no hot water installed at all. On the other hand, in dormitories and hospitals hot water demand is significant because of the particular users' profile. Although the climate is hot, in many public buildings there is no cooling system installed with an exception of public offices where cooling has a notable and increasing share. All values related to users' habits applied in the model have been determined by the Albanian expert panel.

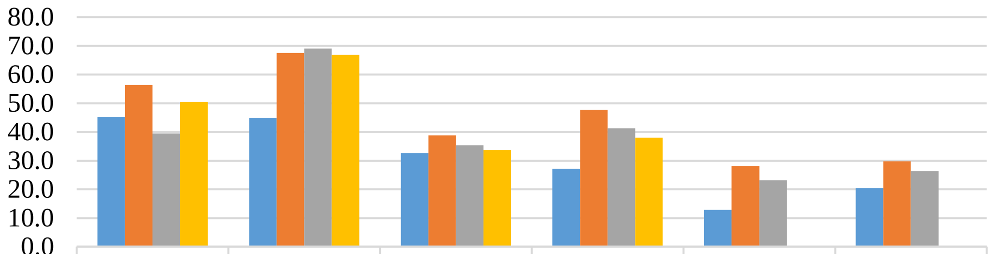
The highest energy demand belongs to hospitals and dormitories, because of the high DHW need. The heating energy demand is also high in these building types, because of the more than double weekly heated hours than those for schools and universities. Heated hours for schools and offices are in the middle. In general, it can be stated that in present state the users' profiles have higher influence on the energy demands than the buildings themselves. However, it should be noted that if comfort demands would increase in the future the energy demands will be significantly higher.

Taking a look at the retrofitting packages, although the performance of the building envelope and the technical building systems is significantly better, this is not reflected in the results of the energy demand, because it is assumed that the comfort level significantly increases in the retrofitted options (see also chapter 3.7): the number of heated, ventilated and cooled hours is increasing with the retrofit, and hot water will be installed in types where originally there was no DHW at all. This is particularly notable for BAU renovation, where only minor energy efficiency measures are taken, but the comfort level rises.



	Dormitory	Hospital	Kindergarten	Office	School	University
Cooling [kWh/m2]	0.0	1.4	1.0	5.0	0.0	2.0
DHW [kWh/m2]	20.0	20.0	8.0	2.0	0.0	5.0
Heating [kWh/m2]	25.2	23.4	23.6	20.2	12.8	13.5

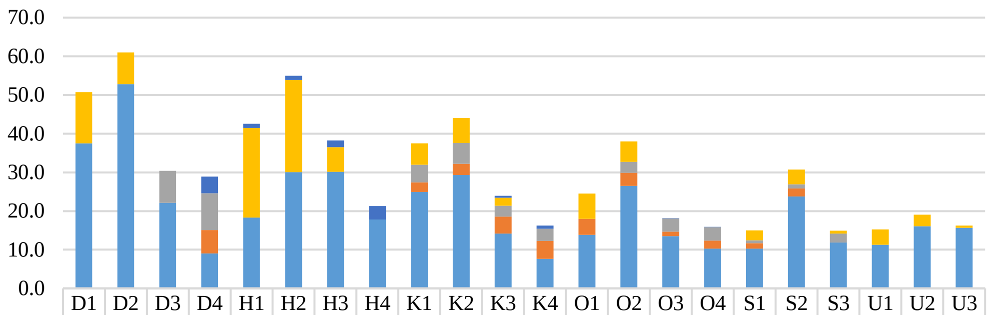
Figure 4: Net energy demand of building types (present state) for climate zone B of Elbasan



	Dormitory	Hospital	Kindergarte n	Office	School	University
Present state	45.2	44.8	32.6	27.2	12.8	20.5
BAU renovation	56.3	67.4	38.8	47.7	28.2	29.8
Improvement 1	39.5	69.0	35.3	41.2	23.1	26.4
Improvement 2	50.4	66.8	33.8	38.0	0.0	0.0

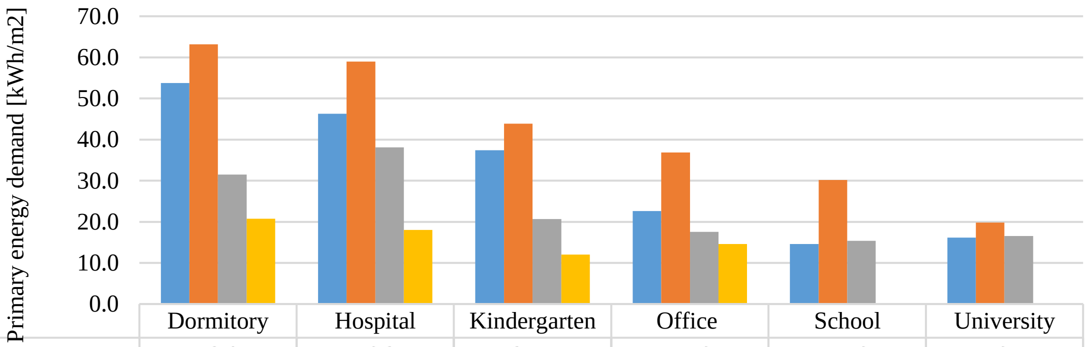
Figure 5: Net energy demand of building types (partial and intermittent heating, zone B, Elbasan)

For the sectoral analysis it is important to know the delivered energy consumption per energy source. Both for the present and the retrofitted states, we used energy mix estimates provided by the Albanian expert panel.



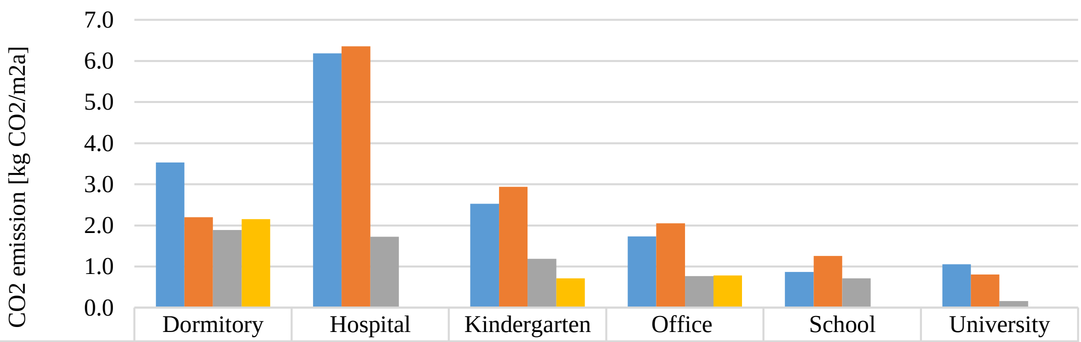
	D1	D2	D3	D4	H1	H2	H3	H4	K1	K2	K3	K4	O1	O2	O3	O4	S1	S2	S3	U1	U2	U3
Solar [kWh/m2]	0.0	0.0	0.0	4.3	1.1	1.1	1.7	3.4	0.0	0.0	0.5	0.9	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Oil [kWh/m2]	13.2	8.2	0.0	0.0	23.2	23.8	6.5	0.0	5.5	6.4	2.1	0.0	6.5	5.3	0.0	0.0	2.6	3.8	0.7	4.0	3.0	0.6
Gas [kWh/m2]	0.0	0.0	8.3	9.5	0.0	0.0	0.0	0.0	4.6	5.4	2.8	3.2	0.0	2.8	3.4	3.5	0.7	1.1	2.2	0.0	0.0	0.0
Wood [kWh/m2]	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	2.4	2.9	4.4	4.6	4.2	3.4	1.2	2.0	1.4	2.1	0.0	0.0	0.0	0.0
Electricity [kWh/m2]	37.5	52.8	22.1	9.1	18.3	30.1	30.1	17.8	24.9	29.3	14.1	7.6	13.8	26.5	13.5	10.3	10.2	23.8	11.9	11.3	16.0	15.7

Figure 6: Delivered energy of building types (zone B) Elbasan



	Dormitory	Hospital	Kindergarten	Office	School	University
Present state	53.8	46.3	37.4	22.6	14.6	16.1
BAU renovation	63.2	59.0	43.8	36.9	30.2	19.8
Improvement 1	31.5	38.1	20.7	17.6	15.4	16.5
Improvement 2	20.8	18.0	12.1	14.6		

Figure 7: Primary energy demand of building types (zone B) Elbasan



	Dormitory	Hospital	Kindergarten	Office	School	University
Present state	3.5	6.2	2.5	1.7	0.9	1.1
BAU renovation	2.2	6.4	2.9	2.1	1.3	0.8
Improvement 1	1.9	1.7	1.2	0.8	0.7	0.2
Improvement 2	2.1	0.0	0.7	0.8		

Figure 8: CO_2 emission of building types (zone B) Elbasan

4.6. Costs of retrofitting options

The building service system prices were provided by Albanian expert panel per building type and measure. Prices include all system elements, although, depending on the present state of the building, there could be some additional work to remove the old installations. Prices include labour costs and VAT. The applied technical building systems reflect the expected national energy mix of the corresponding retrofit level envisaged by the Albanian expert panel. Therefore, the proposed technical solutions are not applicable for a single building (it is not realistic that the national energy mix is applied in one single building), but for a large number of buildings. With other words, this approach is suitable for the objectives of this work (national level extrapolation), but not for conceptual planning of single buildings.

Table 6: Investment costs per measure by insulated/exchanged unit area for standard and ambitious retrofitting, EUR/m²

	BAU renovation	Improvement 1	Improvement 2
External wall	0	5-8	8
Wall to unheated space	0	5	8
Attic slab	5	10	10
Cellar ceiling	3	5	8
Arcade slab	0	10	10
Flat roof	3	5	5
Pitched roof	10	10	10
Floors of heated spaces to ground	0	5	5
External walls between heated spaces and ground	3	5	5
External unglazed doors	80	150	150
Glazed windows, glazed doors 1	0	85	120

Table 7: Investment costs per measure by net floor area for standard and ambitious retrofitting, EUR/m²

BAU renovation	Dormitory	Hospital	Kindergarten	Office	School	University
Cellar ceiling	N/A	0.42	N/A	N/A	0.09	N/A
Flat roof	0.60	0.76	0.50	0.80	0.74	0.76
Pitched roof	1.00	N/A	3.86	1.00	1.22	N/A
External walls between heated spaces and ground	N/A	0.17	N/A	N/A	N/A	N/A
Improvement 1	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**
External wall	3.03	2.12	3.11	3.74	4.45	4.49
Cellar ceiling	N/A	0.70	N/A	N/A	0.15	N/A
Arcade slab	2.43	N/A	N/A	N/A	N/A	N/A
Flat roof	1.01	1.26	0.83	1.33	1.23	1.27
Pitched roof	1.00	N/A	3.86	1.00	1.22	N/A
Floors of heated spaces to ground	1.44	0.50	2.76	1.57	1.64	1.35
External walls between heated spaces and ground	N/A	0.29	N/A	N/A	N/A	N/A

Glazed windows	7.86	10.53	15.25	13.61	12.44	15.58
Improvement 2	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**
External wall	4.84	3.40	4.98	5.99	N/A	N/A
Cellar ceiling	N/A	1.13	N/A	N/A	N/A	N/A
Arcade slab	2.43	N/A	N/A	N/A	N/A	N/A
Flat roof	1.01	1.26	0.83	1.33	N/A	N/A
Pitched roof	1.00	N/A	3.86	1.00	N/A	N/A
Floors of heated spaces to ground	1.44	0.50	2.76	1.57	N/A	N/A
External walls between heated spaces and ground	N/A	0.29	N/A	N/A	N/A	N/A
Glazed windows	11.09	18.58	21.53	19.22	N/A	N/A

Table 8: Investment costs of building service systems per system floor area for BAU retrofitting, EUR/m2 floor area

BAU renovation	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**
Heating system based on electricity	0	0	0	0	0	0
Heating system based on wood	0	0	0	0	0	0
Heating system based on gas	0	0	0	0	0	0
Heating system based on oil	0	0	0	0	0	0
DHW system based on electricity	0.8	0.8	0.8	0.8	0.8	0.8
DHW system based on wood	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on gas	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on oil	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on solar thermal	3.2	3.2	3.2	3.2	3.2	3.2
Ventilation system	0	0	0	0	0	0
Cooling system	0	0	0	0	0	0
Improvement 1	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**
Heating system based on electricity	40	55	50	50	50	50
Heating system based on wood	60	60	32	32	60	60
Heating system based on gas	40	40	40	40	40	40
Heating system based on oil	40	40	40	40	40	40
DHW system based on electricity	0.8	0.8	0.8	0.8	0.8	0.8
DHW system based on wood	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on gas	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on oil	0.9	0.9	0.9	0.9	0.9	0.9
DHW system based on solar thermal	3.2	3.2	3.2	3.2	3.2	3.2
Ventilation system	1	1	1	1	1	1
Cooling system	15	15	15	15	15	15
Improvement 2	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**
Heating system based on electricity	40	55	55	55	N/A	N/A

Heating system based on wood	60	60	32	32	N/A	N/A
Heating system based on gas	40	40	50	50	N/A	N/A
Heating system based on oil	40	40	50	50	N/A	N/A
DHW system based on electricity	5	5	5	5	N/A	N/A
DHW system based on wood	0.9	0.9	0.9	0.9	N/A	N/A
DHW system based on gas	0.9	0.9	0.9	0.9	N/A	N/A
DHW system based on oil	0.9	0.9	0.9	0.9	N/A	N/A
DHW system based on solar thermal	1.5	1.5	1.5	1.5	N/A	N/A
Ventilation system	20	20	20	20	N/A	N/A
Cooling system	15	15	15	15	N/A	N/A

The table below shows specific technical building system prices as an average of the different systems weighted with the corresponding energy mix. Also, the modifications in the heated/cooled/ventilated floor ratio are taken into account in the prices.

Table 9: Investment costs of building service systems per net floor area for standard and ambitious retrofitting

Climate zone B		Dormitory	Hospital	Kindergarten	Office	School	University
BAU renovation	**Heating system [EUR/m^2]**	0	0	0	0	0	0
	DHW system [EUR/m^2]	0.81	0.96	0.826	0.83	0.8	0.8
	Cooling system [EUR/m^2]	0	0	0	0	0	0
	Ventilation system [EUR/m^2]	0	0	0	0	0	0
Improvement 1	**Heating system [EUR/m^2]**	40	53.5	46.44	47.6	48	49.5
	DHW system [EUR/m^2]	0.82	1.05	0.946	0.94	0.8	0.8
	Cooling system [EUR/m^2]	7.5	12	7.5	13.5	7.5	6
	Ventilation system [EUR/m^2]	0.3	0.4	0.2	0.5	0.5	0.05
Improvement 2	**Heating system [EUR/m^2]**	44	55	50.95	51.7	N/A	N/A
	DHW system [EUR/m^2]	3.48	4.3	3.543	3.49	N/A	N/A
	Cooling system [EUR/m^2]	10.5	13.5	12	15	N/A	N/A
	Ventilation system [EUR/m^2]	10	12	10	12	N/A	N/A

Total cost per floor area

The total specific retrofit costs are the summary of the costs for the building envelope refurbishment and that of the modernization of the technical building system per net floor area unit.

Table 10: Total investment costs per net floor area for all renovation options in all zones

Climate zone B		Dormitory	Hospital	Kindergarten	Office	School	University
BAU renovation	Envelope cost [EUR/m²]	1.60	1.35	4.36	1.80	2.05	0.76
	HVAC system cost [EUR/m²]	0.81	0.96	0.826	0.83	0.8	0.8
	Total cost [EUR/m²]	2.41	2.31	5.18	2.63	2.85	1.56
Improvement 1	Envelope cost [EUR/m²]	16.76	15.40	25.81	21.26	21.14	22.69
	HVAC system cost [EUR/m²]	48.62	66.95	55.086	62.54	56.8	56.35
	Total cost [EUR/m²]	65.38	82.35	80.90	83.80	77.94	79.04
Improvement 2	Envelope cost [EUR/m²]	21.81	25.15	33.96	29.11	N/A	N/A
	HVAC system cost [EUR/m²]	67.98	84.8	76.493	82.19	N/A	N/A
	Total cost [EUR/m²]	89.79	109.95	110.45	111.30	N/A	N/A

4.7. Economic and financial analysis

For the design of successful evidence-based policies targeted to reduce energy demand in buildings, it is important to be informed about the largest energy consuming building types and end-uses, the priority of possible actions in terms of energy saved and their cost-effectiveness, as well as the costs and benefits of such opportunities for the society.

First, we conduct traditional financial analysis based on the comparison of financial inflows and outflows related to the thermal efficiency retrofits of public buildings. The outflows are the associated costs i.e. capital investment, installation and maintenance costs. The inflows are monetized benefits, which include saved energy costs. More information about the financial analysis for public buildings is for instance available in EXERGIA (2013). The analysis includes calculation of such indicators as investment size, simple payback period, net present value (NPV), internal rate of return (IRR), and the benefit-cost ratio:

- The investment size illustrates the total amount of incremental investment required for thermal efficiency improvement of public buildings;
- Simple payback period is the time required (in years) for the repayment of investment through its benefits (not discounted);
- Internal rate of return is a discount rate that equates the present value of the expected outflows with the present value of the expected inflows;
- Net present value is a present value of the project cash flow over the measure lifetime;
- The benefit-cost ratio is the ratio between the net present value of benefits and costs.

Second, there are other benefits of thermal efficiency improvement beyond saved energy costs. Unfortunately, the time frame of the project does not allow us building up our own model to monetize these and therefore we rely on proxies gathered from similar projects implemented in Albania or other comparable countries. These benefits include thermal comfort, avoided CO_2 emissions, avoided economic effects from airborne pollutants, employment, and economic growth. Other benefits are not included into the financial analysis due too little time to make thorough analysis. Still, they can serve as a good argument for policy-makers to pay more attention to the thermal efficiency measures. More information about benefits of energy efficiency could be found in IEA (2014).

Third, it is conducted an analysis using the approach of energy conservation supply curves. In this case, a supply curve of conserved energy characterizes the potential energy savings from a set of thermal energy retrofit packages applied to different building types as a function of the cost per unit. Comparing the cost of energy conserved illustrated by the curve with energy prices allows prioritizing energy savings options or building types in terms of potential energy savings and their cost-effectiveness and suggests the investment schedule. Usually, energy conservation supply curves are prepared on a more granular level for a set of technological measures applied to each building type. In this case, the individual measures were merged into packages applicable to building types. This is because the technical possibilities in public buildings usually enable the implementation of complex measures. The installation of individual measures assessed is technically not feasible because:

- exchanging windows without insulation measures often result in fabric degradation and mould growth;
- improving the building envelope without the modernization of the heating system results in overheating and wasted energy;
- standalone modernization of the heating systems can lead to lower maintained temperatures and in case of poor building shell quality it can lead to fabric degradation and mould growth;
- individual measures are implemented step-by-step result in higher total costs than complex measures carried out at the same time

The cost of energy conserved (CCE_j, EUR/kWh) is estimated as:

$$CEE_j = \frac{\Delta AIC_j - \Delta MC_j}{\Delta FEC_j}$$

where ΔAIC_j is a difference in annualized investment costs, ΔMC_j is a difference in annual maintenance costs, ΔFEC_j is a difference in final energy consumption, and j is a building type

$$\Delta AIC_j = a_j \times \Delta IC_j$$

where ΔIC_j is a difference in investment costs and a_j is annuity factor.

$$a_j = \frac{(1 + DR)^{n_j} \times DR}{(1 + DR)^{n_j} - 1}$$

where DR is a discount rate and n_j is the technology lifetime

Retrofit packages are cost-effective if the energy source price is greater than the cost of energy conserved. More information about energy conservation supply curves is available for instance from (Meier, Wright, and Rosenfeld 1983).

4.8. Assumptions of the financial analysis

The financial analyses are conducted based on real prices i.e. not taking into account the inflation impact. The investment costs of technological options are estimated including the value added tax (and other taxes included in the price). The lifetime of retrofit packages is assumed as 30 years.

The results of the financial and energy conservation supply curve analyses are highly dependent on the assumption of the discount rate. There is a wide range of discount rates used by studies prepared for the analysis of energy efficiency and mitigation programs. This is due to the fact that discount rates are highly dependent on a number of national circumstances and most importantly, there is a difference in defining the discount rates. Studies often use consumer discount rates that are based on expected rates of return of competing investments. Sometimes, somewhat lower discount rates are used to identify the economic potential from a social perspective. (Sathaye and Meyers 1995) propose not to discount costs and benefits of GHG emissions at all because not discounting them assumes the future economic damage which is caused by a GHG increase at the real rate. This is probably true because this effect is likely to be increasing dramatically and is largely unknown. Another approach is setting the discount rate as high as 100% based on observed consumer behaviour (often referred to as 'hurdle' rates) and considering all possible costs associated with implementation of mitigation measures discounting direct investment, operation, and maintenance costs (Rufo 2003).

The European Commission recommends using a social discount rate in order to plan "smart" policies because this usually takes into account costs and benefits from the whole society point of view rather than from the point of view of an individual stakeholder. The Commission recommends a social discount rate of 4% applied to costs and benefits in constant prices and this is why this rate is used in our assessment.

i. Costs of thermal efficiency retrofits

The direct costs of thermal efficiency retrofits of public buildings include:

- Capital and installation costs of thermal efficiency measures;
- Costs of system maintenance over measure lifetime.

The capital and installation costs of thermal efficiency measures are described above. The maintenance costs are estimated by the Albanian expert panel as 0.5 EUR/m^2 floor area for improvement 1 and improvement 2.

In addition, there are other costs which relate to these retrofits if the retrofits are conducted within a program designed and implemented by the government. They include:

- On the state level: pre-feasibility evaluation, the program design and preparation, technical assistance, outreach, administration, monitoring, and evaluation
- On the local level (municipalities): energy audits, energy performance contracting, detailed design, supervision, implementation, and evaluation

Typically, the other costs are around 10% of the investment costs. In the currently planned program under the National Energy Efficiency Action Plan of Albania, the other costs are 15% of the investment costs.

ii. Benefits of thermal retrofits and assumptions to monetize them

Energy is a “commodity” that is not demanded for its own sake, but for the various services it provides. Similarly, improving energy efficiency is rarely a policy goal in its own right: it is rather used as a vehicle to arrive at other important social, political and economic ends. Some of the most frequently benefits of improved energy efficiency are the energy costs savings for consumers; thermal comfort especially given that many public buildings of Albania are not served or served inadequately with space heating, space cooling, and water heating; the reduced needs for energy especially electricity given the growing demand in industry and commerce needed for the country’s economic growth; the reduced exploitation on finite natural resources; health benefits due to reduced air pollution and better compliance with health standards; higher economic growth due to the investment into the construction sector performing the works and multiplying effects; the related reduction of greenhouse gas (GHG) emissions; and other numerous benefits.

While it is very tricky to calculate the impact of these benefits in monetary terms, we tried to identify a few of these important benefits. Since our timeframe does not allow to build an own model to estimate all benefits, we calculate benefits based on studies prepared for Albania and other countries with similar conditions. These include a study on green energy-efficient schools for Albania prepared by Arizona State University (Arizona State University 2015) and a study on the development of an investment programme for building rehabilitation of public building prepared for Romania within the JASPERS financing tool of the European Investment Bank (EXERGIA S.A. 2013).

iii. Thermal comfort

As mentioned before, a big challenge for Albania is that at present the level of energy services delivered in public buildings is inadequately low. Despite low temperatures in the cold season, a large share of public buildings does not have space heating. In heated buildings the floor space is heated partially leaving out corridors, staircases, toilets and other secondary functions. In many buildings, there is not hot water service because of the absence of appropriate facilities (e.g. schools).

In case of business-as-usual renovation of public buildings, the level of these services increases but remains low. In case of more ambitious renovations, we assume that Albania moves towards the level of thermal services which are in line with minimum health and comfort standards required by these facilities and typical for the European Union.

Due to higher thermal comfort provided in retrofitted buildings their real estate value grows. Based EXERGIA (2013), we assume this growth as 2%. The assumed estate value is EUR 300/m^2 based on the statistics provided by Albanian Statistical Office online (INSTAT).

iv. Saved energy costs

One of the most common reasons for conducting thermal efficiency in buildings is to save on energy bills. In this regard, there are two challenges how to make the right estimates of energy cost savings. This is, first, how to make the right assumption about the amount of energy demand reduced for policy-makers and, second, how to make the right assumption about the expected energy prices.

As discussed in the previous section, more ambitious renovations assumed higher levels of thermal services than the current levels or those observed in case of the business-as-usual retrofits. Having higher energy service levels in case of ambitious renovations makes energy savings much smaller, but it is the reality of Albania increasing its welfare. In order to make the recommended advanced packages i.e. improvements 1 and 2 comparable the business-as-usual renovations, it was prepared a country-wide analysis according to the level of comfort suggested by these advanced retrofit packages.

There is no single source or agency which collects, reports, and forecasts the dynamics of energy and fuel prices in Albania. Therefore, the current energy source prices were gathered from different sources; when the information was missing an estimation was made. All future dynamics of energy prices is estimated for the purposes of this research. The current energy source prices and their forecasts are presented in table below.

v. Energy source prices

Energy sources	Energy source price		
	2016 [EUR/kWh]	**2045 [EUR/kWh]**	**annual growth [%]**
Electricity	0.104	0.160	1.5%
Wood	0.024	0.037	1.5%
LPG	0.061	0.247	5%
Diesel oil	0.117	0.473	5%

The present price of electricity for budgetary consumers is 0.10 EUR/kWh (Enti rregullator I Energjisë online). This price only insignificantly higher than the electricity wholesale price calculated in the electricity decarbonisation model prepared within our project (Szabo et al. 2015). Electricity has been historically regulated for its consumers in Albania. If consumers do not pay for the full costs of their energy services, it obviously hinders the investments in efficient building retrofits. This means that regulated energy prices, which are lower than those reflecting the full cost of energy and externalities provide insufficient incentive for the attention and time given to energy efficiency for the policy-makers.

When the Albanian market will be liberalized and integrated to the EU market, the electricity price will likely to grow. Even though, there is a large uncertainty associated with the future dynamics of electricity price prices, in agreement with the Albanian expert panel, the electricity price is assumed to grow by 1.5%/yr. in real terms and reach therefore 0.16 EUR EUR/kWh in 30 years.

The current price of the liquefied petroleum gas (LPG) price and diesel oil is 0.41 EUR/liter and 0.17 EUR/liter respectively (Global petrol prices online). It was assumed that in the future the LPG and diesel oil price will grow in line with the oil price. The oil price is assumed to grow at 5%/yr. Within the next 30 years according to the forecast of energy commodity prices provided by the World Bank (World Bank 2016).

The current price for wood was estimated as 35 EUR/m3. Since the electricity is the main substitute of wood in the building sector, it was assumed that the price for wood will increase with the same trend as the price for electricity.

vi. Reduction in air pollution and health

Energy efficiency improves air quality contributing to better public health (e.g. increased life expectancy, reduced emergency room visits, reduced asthma attacks, fewer lost work days, and others) and avoidance of structural damage to buildings and public works.

EXERGIA (2013) assessed and monetized the benefit of lower incidence level of illness caused by air pollution. In line with this study we assume that the avoided emissions of airborne pollutants result in benefits of EUR 1.38 Euro/MWh/year saved.

vii. Climate change mitigation

Energy savings result in a reduction of GHG emissions. Only CO_2 emission reductions are calculated in our project. CO_2 emission reductions could be also monetized applying CO_2 price. Based on EXERGIA (2013), it was assumed that CO_2 cost will increase from the current level to EUR 45/tCO2 in 2030. The CO_2 price was kept constant after this year.

viii. Employment creation

Most studies agree that energy-efficiency investments will have positive effects on employment, by creating new business opportunities and thus jobs via domestically produced energy-efficient technologies and services, and through the economic multiplier effects of spending in other ways the money saved on energy costs. Further, a national policy that promotes both the production and the use of energy-efficient technologies helps all sectors of the country to compete internationally, thus contributing to economic development and job creation. The effects of employment could be:

- Direct due to the employment in the construction industry as well as in the associated services related to renovation works. The direct employment also includes energy auditors, engineers, contractors, and managers related to activities listed in other costs
- Indirect due to jobs created indirectly for manufacturing materials, equipment, and other suppliers of building renovation
- Induced due to employment caused by higher demand for services such as retail, healthcare, food etc. due to higher earnings of employed people due to direct and indirect effects.

The researchers of the Arizona State University (2015) prepared an input-output model for Albania, based on which they estimated the impacts of converting Albanian schools to green and energy efficient. The study assumed four tiers of building improvement. Our retrofit packages correspond to the combination of the tier 1, 2, and 3 and therefore we used the proxies calculated from the impact of these tiers. The table below presents the proxies, which we used for the quantification of employment effects.

Table 11: Proxies for the quantification of multiplier effects for employment

Effect	Unit	Value
Labour income	[EUR/EUR]	0.30
direct	[EUR/EUR]	0.17
multiplier effects	[EUR/EUR]	0.13
Annual employment	[jobs/million EUR]	148
Employment	[jobs/million EUR]	85
multiplier effects	[jobs/million EUR]	63

Source: assumed based on Arizona State University 2015

ix. Economic growth

One of the most important effects of thermal retrofit works is their contribution to the economic growth. Similar to employment effects, the experts of the Arizona State University (2015) also calculated the increase in value added due to retrofit works. Similar, from this study it was calculated the proxies to make an estimate of multiplier effects for GDP due to thermal efficiency retrofits of the public sector. The table below presents the proxies, which we used for the quantification of GDP effects.

Table 12: Proxies for the quantification of multiplier effects for GDP

Effect	Unit	Value
GDP increase	[EUR/EUR]	0.65
direct	[EUR/EUR]	0.30
multiplier effects	[EUR/EUR]	0.35

Source: assumed based on (Arizona State University 2015)

4.9. Interpretations and Conclusions: Cost and benefits by retrofit package: improvement 1

The table below presents the costs of retrofits by building type and climate zone for improvement 1. The table illustrates that investment costs per m2 are the lowest among building types for dormitories, followed by kindergartens and schools.

The building types requiring the highest investment on the national scale are kindergartens and schools followed by offices and hospitals.

Table 13: Costs of thermal energy efficiency retrofits by building type and climate zone of Elbasan, improvement 1

Building type->	Dormitory	Hospital	Kindergarten	Office	School	University	
Investment cost, EUR/m²							**Average**
Climate zone B Elbasan	63	80	76	81	75	77	**76**
Maintenance cost, EUR/m²/yr							**Average**
Average	0.5	0.5	0.5	0.5	0.5	0.5	**0.5**
Investment cost, million EUR							**Total**
Climate zone B Elbasan	0.1	17	48	20	46	0.2	**131**

The table presents the reduction in primary and final energy demand as well as potential CO_2 emission reductions by building type and climate zone B for improvement 1. The highest primary and energy demand savings per m^2 are in dormitories, hospitals, offices in different ranking order for these indicators among climate zones.

Table 14: Energy demand savings and CO_2 emission reductions by building type, improvement 1

Building type->	Dormitory	Hospital	Kindergarten	Office	School	University	
CO_2 emissions reductions, gCO_2/ m²							**Average**
Climate zone B Elbasan	4,655	9,133	2,248	2,734	964	1,995	3,621
Primary energy demand savings, kWh/m²							**Average**
	83	54	31	28	22	11	38
Final energy demand savings, kWh/m²							**Average**
	79	47	28	32	23	10	36
CO_2 reductions, tCO_2							**Total**
	0	1,904	1,415	669	591	5	4,584
Primary energy demand savings, GWh							**Total**

	0.19	11	19	7	13	0.03	51
Primary energy demand savings, ktoe							**Total**
	0.02	0.97	1.66	0.60	1.15	0.00	4.40
Final energy demand savings, GWh							**Total**
	0.2	10	17	8	14	0.0	49
Final energy demand savings, ktoe							**Total**
	0.02	0.84	1.49	0.66	1.22	0.00	4.23

In terms of the potential CO_2 emission savings, the largest potential is in kindergartens.

Table 15 below presents saved energy costs per m^2 by building type and climate zone in case of improvement 1. The table attests that the highest energy cost savings per m^2 are offered by hospitals and dormitories. The largest absolute energy cost savings could be achieved in kindergartens, schools.

Table 15: Saved energy costs by building type and climate zone, improvement 1

	Dormitory	**Hospital**	**Kindergarten**	**Office**	**School**	**University**	**Total**
	Total over measure lifetime (NPV), EUR/m^2						
Climate zone B Elbasan	218.1	163.5	71.8	80.1	52.9	33.9	77.6
	Annual over measure lifetime, EUR/m2						
	12.6	9.5	4.2	4.6	3.1	2.0	4.5
	Total over measure lifetime (NPV), million EUR						
	0.5	34.1	45.2	19.6	32.4	0.09	132
	Annual over measure lifetime, million EUR						
	0.03	2.0	2.6	1.1	1.9	0.01	8

Below table presents the results of the financial analysis.

Table 16: Financial analysis, improvement 1

Financial analysis	**Dormitory**	**Hospital**	**Kindergarten**	**Office**	**School**	**University**	**Total**
Simple payback, years	5	7	20	17	27	n/a	17
Internal rate of return (IRR), %	15.7%	11.1%	3.0%	4.0%	1.1%	-0.2%	3.9%
Net present value (NPV), EUR/m^2	1.3	83.2	-25.8	0.2	-63.3	-0.4	-4.8
Cost - benefit ratio	0.3	0.4	1.2	1.0	1.5	2.1	1.0

Table 17 below presents the results of monetizing other benefits of thermal efficiency retrofits than energy cost savings. The table illustrates that these benefits cumulatively comparable to saved energy costs. Especially high are effects on GDP and employment. It should be noted that we quantified only a limited number of co-benefits. If all of these benefits would be taken into account in the financial analysis, the cost-effectiveness of thermal efficiency retrofit of all types of public buildings would be much higher.

Table 17: Co-benefits of thermal efficiency retrofits of public buildings, improvement 1

Analysis of co-benefits	Dormitory	Hospital	Kindergarten	Office	School	University	Average
Per m²							
GDP increase, EUR/m²	42	52	49	52	49	51	50
Labour income, EUR/m²	19	24	22	24	23	23	23
Employment, jobs/m²	0.01	0.01	0.01	0.01	0.01	0.01	0.07
CO2 avoided, EUR/m²	2.8	5	1.0	1.3	0.5	1.1	1
Air quality, EUR/m²	2.0	1.4	0.7	0.9	0.6	0.3	1
Improved comfort, EUR/m²	6	6	6	6	6	6	6
For the whole floor area							
GDP increase, million EUR	0.4	39.4	123.0	44.2	121.6	0.6	329
Labour income, million EUR	0.2	18.1	56.4	20.3	55.8	0.3	151
Employment, jobs	85	8,963	27,969	10,048	27,652	127	74,844
CO_2 avoided, million EUR	0.02	4.1	2.4	1.2	1.2	0.0	9
Air quality, million EUR	0.0	1.1	1.8	0.8	1.4	0.0	5
Improved comfort, million EUR	0.1	4.6	15.2	5.1	14.8	0.1	40

Table Below present the cost of energy conserved per m^2 of saved energy for the whole country.

Table 18: Cost of energy conserved, improvement 1, EUR/kWh

Building type->	Dormitory	Hospital	Kindergarten	Office	School	University	Average
Average	0.05	0.09	0.16	0.14	0.21	0.35	0.15
Climate zone B	0.05	0.11	0.17	0.16	0.21	0.52	0.16

5. Public Lighting in Elbasan

5.1. Existing Situation

Public lighting in the Municipality of Elbasan extends to the motorway axes, pedestrian streets, urban squares, parks and public buildings (their external lighting). Public lighting is a significant expense of annual spending from the municipal budget. Part of the existing lighting system has been operating for 15-18 years and normally amortization and deterioration has had a direct impact on the quality of service delivery as well as on the low power performance of this system as a whole.

Currently, the Municipality of Elbasan offers street lighting by managing a total system extending along the 108km linear illuminated road network, which is distributed in 247 road axes, with only 34 axes pertaining to administrative units and the rest of the city of Elbasan. There are 2,538 pillars and 3,501 lamps illuminating the space, of which 362 are LED lamps on 175 LED poles. Further to thoroughfares, about 28 buildings are illuminated by the public lighting service, along with 5 urban squares, 4 flower gardens and the protected façade of the fortress wall.

Parts of the lights are placed on concrete pillars under the administration of the Transmission System Operator, and there are also luminaires placed on certain walls or corners of buildings near the main roads.

New investments or even partial interventions for the renewal of the existing network have been carried out mainly during the construction of new roads in the city or as investments by private construction operators as part of the measures for infrastructure arrangement on new construction work in the city (e.g. Rehabilitation The access road to the city or even the rehabilitation of the central park). All new investments made by private investors are connected to the existing network and supplied with energy by the Municipality. Due to the lack of maintenance and replacement of lighting lamps, the lighting system is degrading and lighting performance continues to deteriorate.

Table 19: Lighting infrastructure in Elbasan

Type of Lamp	Power (W)	Units	Total Power	Real Consumption
Metal Halide (MH)	400	14	5.6 kW	6.412
High Pressure Sodium (HPS)	250	1,834	458.5 kW	531.860
High Pressure Sodium (HPS)	200	1	0.2 kW	0.227
High Pressure Sodium (HPS)	150	424	63.6 kW	72.504
High Pressure Sodium (HPS)	125	371	46.37 kW	48.972
High Pressure Sodium (HPS)	120	28	3.36 kW	3.612
LED	100	362	36.2 kW	36.562
Low Pressure Sodium (LPS)	70	11	0.77 kW	0.825
Low Pressure Sodium (LPS)	40	6	0.24 kW	0.264
Low Pressure Sodium (LPS)	30	74	2.22 kW	2.442
Low Pressure Sodium (LPS)	25	129	3.22 kW	3.483
Low Pressure Sodium (LPS)	7	107	0.75 kW	0.936
Total		**3361**	**621 kW**	**710**

The municipality has also identified a substantial list of main, secondary and tertiary roads, mainly in peripheral areas and new informal areas, where extension a street lighting system is needed. This constitutes one of the local targets for improving infrastructure and public services in these new areas of the city. A full map of the extent of the street lighting service is provided as follows:

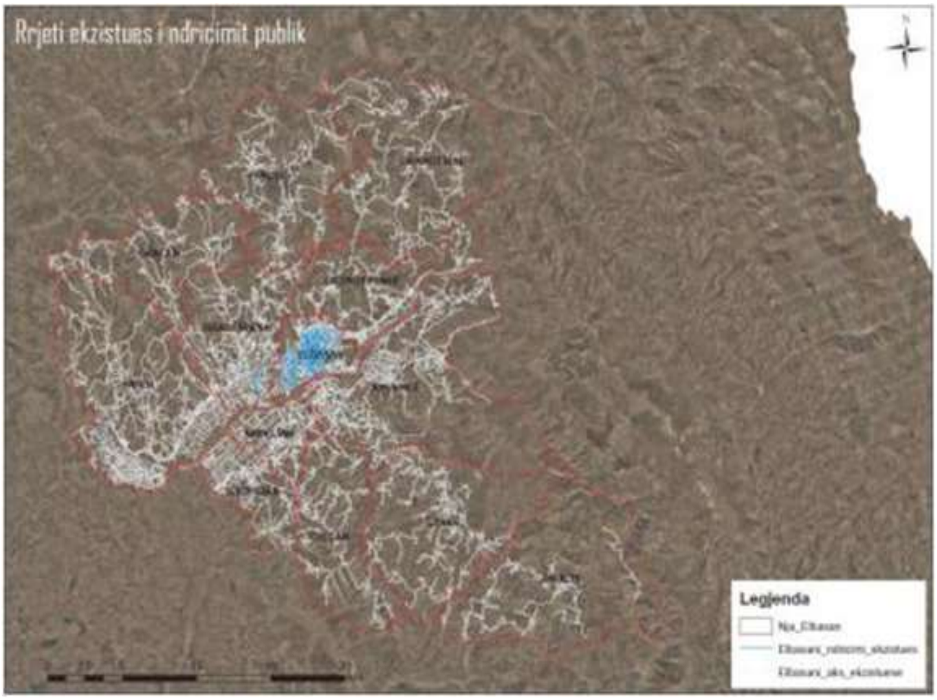


Figure 9: map of the extent of the street lighting service

It is to be noted that inside the city of Elbasan the public lighting network functions better than in the administrative units (former municipalities) which provide this service, these are the administration units of Bradashesh, Papër, and Tregan. The installed power currently reaches its peak at 710kW, where it is distributed in a total of 88km of illuminated street axes out of the total 2,965 km of roads that are in the territory of the municipality.

From a preliminary estimate, we can say that currently, public spaces and illuminated streets in the Municipality of Elbasan are about 0.421km2 of which 0.153km2 are outside Elbasan city, dispersed in the villages of other units.

At the present time in the Municipality of Elbasan, the following lighting fees are applied according to DCM no.106 dt.24/12/2015:

Table 20: Lighting Fees

Lighting Fee for Big business	*ALL/year*	5.000
Lighting Fee for Small business	*ALL/Vit*	1.000
Lighting Fee for External Counter business	*ALL/Vit*	500
Lighting Fee for VIP business	*ALL/Vit*	100.000
Lighting Fee for citizens	*ALL/Vit*	500

Table 21: Planning for the collection of lighting tariffs for 2016

	Albanian Leks (ALL)	**Euro**
Forecasts for the total cost of public lighting service	44,719,726	335,165
Municipality budget contribution	20,000,000	149,895
TOTAL Difference	24,719,726	485,060

From these figures it is worth mentioning that the main issue remains the collection of the fee by the Municipality, where currently it fails to cover even 55% of the total cost of this service.

Specifically, the consumption of electricity accounts for about 75-80% of the total costs of public lighting service. The consumption of electricity by the public lighting system during the last four years is increased due to two main factors:

1. Amortisation of lighting fittings and large losses that contribute to the thermal level in the lamp rather than the light being generated;
2. New installations that have increased system capacity.

The current lighting infrastructure suffers from frequent burning out of lamps that need to be replaced by the municipal utility of the city. Moreover, a large proportion of HPS lamps do not provide enough lighting performance due to the loss of lighting output after 3 years and due to their lack of timely replacement. From site visits, it has been noted that lighting performance in many streets of the city is low, where there are streets or many areas illuminated, or badly lit or not uniformly illuminated streets.

Due to the lack of standards for placement of lighting pillars, lighting infrastructure (such as distance and height of lighting poles) differs from street to street. For example, in the lighting system built before the 2000s, the distance between the lighting poles ranges from every 40 meters on one side mainly to the secondary and tertiary roads to every 50-60m alternating on the two sides for the main roads. Meanwhile, in the roads built in recent years, the distance between the poles varies from 25 to 30m on one side for secondary and tertiary roads or up to 35-45m alternating or facing on both sides of the main roads.

As mentioned above, the current lighting performance of the current system is poor and is continuing to deteriorate, due to HPS lamps specifications, lack of maintenance and replacement. To this end, renovation of the lighting system has become a necessity for the municipality. Only 37% of the city's road network is illuminated, which is comparatively low. Although most of the streets were equipped with lighting systems after the 1990s (around 203 streets were illuminated after the 1990s, and only 10 streets were illuminated before that) it should be mentioned that the street lighting network in some parts is highly degraded and its failure to function is estimated at about 10-15%.

It should be noted that a good part of the lines is out of function due to the theft of the cable that transmits energy, the damage of the lines or even as a consequence of the high price they represent to replace by the public enterprise of public lighting.

The lighting system works around 4100 hours a year or about 11.2 hours a day on average. The system switches on and off with the photo element.

The main issues of the lighting network in degraded areas relate to:

- low voltage,
- insufficient lighting of the streets (low lighting quality),
- breakdown of machines that automatically operate the lighting system,
- damage to the lighting system Electric cable
- burning out/failure of lamps.

Electricity consumption is estimated to be between 2,040,000 – 2,350,000 kWh/year, this consumption is reduced after the intervention in which photo light controllers were installed that turn on the automatic ignition and switch off of the lights depending on the intensity of natural light. However, it is worth noting that these devices are not always accurate.

Bradashesh Administrative Unit

This administrative unit provides public lighting service in three villages:

- Kusarth,
- New House
- Bradashesh

The street lighting network at Bradashesh has a length of 11.2 km linear, length in which are placed 222 lighting pylons and about 300 lights. The lighting system is not in good shape where about 35% of the street lighting sections are not working. Problems are more frequent and pronounced in secondary and tertiary roads.

Papër Administrative Unit

In the administrative unit Papër, the public lighting service is provided only in three villages: Papër, Valas and Brokë. The network extends over a length of 3 km, in which there are about 50 lighting poles and 60 luminaires are currently distributed. Currently, only a small part of this system is in operation due to damage and depreciation.

Tregan Administrative Unit

In this unit the public lighting service is offered only in the village of Tregan at a distance of 1.2 km, near the bathing area. In this segment are located 40 columns and 40 illuminators, of which only one part is in function.

The Public Services Department of Elbasan, which also covers the public lighting sector, faces some difficulties consisting in both the performance of the work and the quality of service delivery. Among the most important issues are:

- Theft and damage of the materials installed in the lighting network (cables, lights, etc.)
- Large network losses due to the use of low energy efficiency lamps.
- Extreme degradation at 9% of the total existing system.
- Lack of uniformity of lighting and creation of black spots due to lack of lighting in most of the main axes.
- Frequent burns of illuminators and ballast damage in the lighting unit
- The partial collection of the service charge fee impacts the coverage of service costs
- The budgets of recent years are mainly foreseen to cover service costs and very little for new investments.
- Some key axes have lighting problems as a good part of the lines are damaged or stolen and as a result, no physical lighting infrastructure is available.
- Of the 70 cabins where the energy is measured, 8 of them have consumption = 0kwh / month
- The lighting system does not operate with efficient hours: it is turned on too early, spending unnecessary energy while natural light is more than enough and in places stays on until the late afternoon.
- Where lighting is provided, the system consumes full capacity even though it would only be necessary for a specific part of the evening, whereas during the late night the system could operate well with 40-35% of capacity.

6. Comments and data for other high impact energy use sectors in Elbasan

6.1. Transport

There was very limited specific availability of data identified for the Elbasan region, making further analysis of the sector difficult in this report. The number of cars registered is approx. 7,830 in the Elbasan Municipality, and 4,428 cars in Elbasan city. There is no data about the number of cars for 2015-2016. In the wider municipality, there are six routes of public urban transport operated by 14 buses, and a number of daily inter-city routes of varying frequencies.

The transport task in Albania has been increasing rapidly since 2000 and the penetration of car ownership is increasing every year, from 55 cars/1,000 inhabitants to an estimated 120.8 cars/1,000 inhabitants in 2010. For Albania as a whole, energy used by car equivalent has increased over the course of the review period. Besides the increased number of vehicles the infrastructure is being improved so the total traffic load can continue to grow. The transport sector consumes significant quantities of energy (mostly in the form of petroleum and gasoline) and accounts for the largest share of final energy consumption in the Elbasan region and in Albania. This has remained relatively consistent over the review period at between 41% and 43% of total consumption and is overwhelmingly driven by road transport as opposed to rail and inland waterways. The overall share of transport share is particularly high by European standards and was forecasted to fall in the 1st NEEAP to approximately 36% by 2014 and below 30% by 2018, though current data show no consistent pattern or trend in the use of energy in transport . In absolute terms, this sector's energy consumption was 8% higher in 2014 than in 2009.

Data supplied by the Institute of Transport for the years 2010-2014 shows that passenger km travelled and goods transported have also increased as shown in Table 22. The table includes additional indicators for "energy consumption of cars and buses in grams of oil equivalent per passenger-km (goe/pkm)" as well as "energy consumption of trucks and light vehicles in goe per tonne-km". The result savings in ktoe are presented in Table 22. To derive this data an assumption of a split in fuel consumption of 30% trucks, 60% cars and 10% buses has been adopted.

Table 22: Estimated passenger and goods transported

	Unit	2009	2010	2011	2012	2013	2014
Passenger travels	M.p.km	N/A	7665	8359	8468	8030	8432
Goods transported	M.t.km	N/A	1661	2010	1860	1949	2077

Source: Institute of Transport

Table 23: Amended transport sector indicators

Indicator	Unit	2009	2010	2011	2012	2013	2014
Cars and buses	goe/p.km	N/A	66.5	60.6	57.6	65.1	64.7
Trucks and light vehicles	goe/t.km	N/A	131.6	108.1	112.3	114.9	112.6

The figures indicate that despite the reduction in the number of goods vehicles registered between 2010 and 2011, there was sharp increase in the volume of freight transported. 2011 also saw a notable increase in passenger-km despite only a marginal rise in the volume of cars and a reduction in the number of buses. The result provides a very different picture to the standard indicator, showing instead a large increase in energy efficiency in the year 2011, followed by a sharp decrease in the year 2013.

6.2. Residential buildings

The residential sector accounts for the second largest share of final energy consumption in Elbasan after transport. The sector has accounted for a relatively consistent proportion of the total final energy consumption over the review period of 2014 – 2016, varying between 26% and 30% with no clear trend over time.

Energy consumption in the residential sector accounts for a variety of energy services including space heating, air conditioning, domestic hot water, and cooking, lighting, and electrical appliances. Prior to, and ongoing through, the review period there has been a trend towards the use of electricity for heating purposes rather than fuel wood and thus greater strain on the power sector infrastructure. This trend could be observed in the results that show an increasing proportion of final energy consumption in the residential sector delivered through electricity. In 2013, 54% of residential final energy consumption was through non-electrical energy use, declining to 44% in 2016.

Data from the Albanian Institute for Statistics (INSTAT) indicates that Albania's housing stock is dominated by concrete-framed structures in urban areas, many of which are multi-family residences, and wooden, single-family homes in rural areas. Preliminary data from the 2011 census indicates that the total number of residences in Albania has increased by 37 percent since 2001. Approximately 56 percent of new construction in Albania from 1995-2012 was for residential projects, with a significant increase in detached houses in the 2001-2011 period. Table 24 below shows the age of Albania's housing stock from the 2011 census.

Table 24: Age of Housing Stock (2011 Census Data, INSTAT)

Pre- 1960	1961-1980	1981-1990	1991-2000	2001-2005	2006-2011	Unknown
7%	13%	11%	21%	10%	8%	30%

Space and water heating account for the bulk of energy consumption in the residential sector: more than half is used for space heating and around 86% of the energy used for water heating is covered by electricity. In addition to the overloading caused to the networks, such high levels of electricity consumption are a cost burden for citizens. Thus, the availability and access to safe, efficient and affordable heating and cooking alternatives are of primary importance for households. Locally sourced and relatively cheap fuel-wood is widely used for space heating in rural areas. This is, for the most part, used inefficiently and the larger volumes required have caused concerns about unregulated harvesting and the sustainability of the biomass resource. Recent assessments of the potential for rehabilitation of district heating systems built in the 1960s in some of the main cities of Albania, that were abandoned in the early 1990s owing largely to the lack of maintenance and high operational costs, have concluded that retrofitting is not economically attractive and that new systems would be required.

Approximately 96% of the residential building stock in Albania is privately owned (mass privatisation of flats took place in 1993–1994) and around 40% of the total building stock consists of multi-family apartment buildings. The housing construction sector began to develop in the early 1990s; by 2005 the construction industry was producing 60% of the entire GDP by private commercial ventures. A law on condominium management was approved in 2009. It is expected that this law will enforce some rules for the management of common areas in buildings, including registration of non-registered apartments and that it will facilitate the implementation of energy efficiency measures in existing buildings.

Main part of energy consumption is for heating. According to INSTAT, the main source of heating used by family economic units in the region of Elbasan is burning timber. 77% of family units of Elbasan region use heating by timber, 13 % heating by gas, and 7 % heating by electricity.

Table 25: Family units divided by the heating source, urban and rural areas

Heating source	Family economic units		
	Urban	Rural	**Total**
Timber	15,750	40,254	**56,004**
Electricity from the net	4,646	237	**4,883**
Gas	9,095	560	**9,655**
Other, oil, coal, solar	125	78	**203**
No heating	1,948	351	**2,299**
Total	**31,564**	**41,480**	**73,044**

Source: Strategy of Territory Development Elbasan Municipality (2016)

The calculations done for the purpose of the Strategy of Territory Development Elbasan Municipality (2016), consist of division of number of population per square km by the total consumption of electricity. The total consumption of Electricity in Albania in 2011 is 2,587,907 MWh. The total number of family economic units, (mainly consisted of 4 people) is 722,600.

The approx. consumption of one family economic unit is: 2,587,907 MWh/nr. of units (722,600) = 3,6 MWh.

6.3. Industry

The proportion of final energy consumption in the industrial sector was higher in 2014 at approximately 20% of total final energy consumption, than in 2009 when the equivalent figure was 16%. However, the rise was neither steady nor consistent across the five-year review period and thus cannot be declared with confidence to represent a clear trend. Nevertheless, it is noted the 1st NEEAP did forecast a rise in the share to above 20% by 2018 after largely holding steady between 2010 and 2016 at 15% to 16%. So, an increased share was forecast but at a later date than observed in the data. In absolute terms the final energy consumption in the industrial sector was 52% higher in 2014 than in 2009.

The industrial sector is divided in the updated document of the Albanian National Strategy of Energy into the following sub sectors: Metallurgy, Chemical, Building Materials, Mining, Food/Beverage/Tobacco, Textile/Leather/Shows, Wood/Paper/Printing, Mechanical, and others. Energy sources in the industrial sector are consumed for motive power, for process heating at low and high temperatures, and for different electrolysis processes. Among the industrial sector, iron and steel (ferrochromium production), cement, food, and the building materials (bricks, tiles) sub-sectors are the main energy consumers.

Little specific data is available on industrial energy use in Elbasan A large proportion of the increased energy use in 2014 compared to earlier years comes from the Iron and Steel sector where variances in the operations of the Kurum steel plant in Elbasan have a significant impact on energy demand. The food, drink and tobacco industries as well as the textile, leather and clothing industries saw steadier increases in energy use over the review period. While value added to the economy also increased for both these groupings of industries, in the case of food, drink and tobacco this was not sufficient to enable an improvement in energy efficiency (energy intensity per unit of value added).

7. Recommended measures for the Regional Energy Efficiency Action Plan

The expected approval of the Law on Energy Efficiency and pending approval of the Law on Energy Performance of Buildings provide the basis upon which a new strategy for energy efficiency can be established in Albania. This covers the creation of an Agency for Energy Efficiency (AEE) and Energy Efficiency Fund, the development of necessary secondary legislation and regulatory tools, and most importantly implementation of a series of new measures as proposed in the NEEAP.

7.1. Public Buildings

Public Buildings have been closely examined in Part 5 of this study and the following detailed recommendations are made:

- Modelling shows a positive net present value for interventions targeting hospitals and dormitories, especially after co-benefits of energy efficiency are also valued, with measures to introduce insulation and efficient building service systems such as reversible heat pumps with better coefficient of performance (SCOP=3), efficient wood pellet boilers (85% efficiency), low temperature gas boilers or efficient oil boilers. Kindergartens and schools also show high potential for efficiency savings, but measures are estimated to be potentially less cost-effective. There is also large potential to improve the efficiency of heating systems.
- There is a suite of possibilities for action available to Elbasan Municipality to action this recommendation. These include:
  - Introducing energy performance standards for new buildings and energy performance criteria for renovation of existing public building stock planned at the national level will deliver improvements to the thermal performance of the building stock in Elbasan. The delivery of training programs that target energy managers, energy auditors and construction companies will help drive the transition to energy efficiency improvements in new and existing building stock.
  - Developing a strategy to renovate existing buildings starting with municipal buildings to lead by example, then focusing on residential buildings, using experience from the European Union with adaptation to local conditions.
  - Showcasing the energy savings and multiple benefits from improving energy efficiency of a sample of both public buildings may further accelerate the uptake of energy efficiency practices in the building sector. For example, benefits accruing from building efficiency improvements of hospitals, dormitories and selected kindergartens could be showcased and utilised as a model for further replication.
  - Elbasan could showcase its leadership in energy efficiency through green public procurement for purchasing products, services and buildings that are energy efficient, demonstrating good practice for the private sector to follow. For example, technical specifications could be included in tender documents to purchase efficient products such as heating, ventilation and air conditioning, lighting, office equipment.
- Financing should be developed for public sector retrofitting, drawing in the wide array of experience in financing municipal retrofit programs including energy performance contracting, establishment of Energy Efficiency Funds/revolving funds, and the issuance of partial guarantees and/or concessional development finance.

7.2. Public Lighting

There is substantial opportunity for improved efficiency of the public lighting system in Elbasan, based on a) the poor performance of the existing system, and b) the plans to expand service to a wide range of new areas. Converting the current system to a full LED system, even without using world's best practice, would see an improvement in overall system power draw of over 50% and free up energy system capacity for regional economic growth.

Standards and Regulations - covering a collection of related requirements defining which products can be sold and those that should be blocked from the market. Standards and regulations form the foundation from which to ensure the success of any efficient lighting transition strategy and Elbasan can establish guidelines for procurement of lighting products in line with the standards.

Supporting Policies — are necessary to ensure the smooth implementation of standards and regulations, and to achieve a broad public acceptance. Supporting policies include labelling schemes and other market-based instruments, often initiated and promoted by regulatory incentives, and information and communication campaigns that inform end users in order to change or modify their behaviour.

Finance and Financial Delivery Mechanisms — addressing high first-cost challenges with efficient light sources, looking at economic instruments and fiscal instruments and incentives.

Monitoring, Verification and Enforcement (MVE) — successful market transition depends on effective monitoring (i.e. verify product efficiency), verification (i.e. verify declarations of conformance); and enforcement (i.e. actions taken against noncompliant suppliers) of the regulations (MEPS). Enhancing the capacity of various countries and the sharing of information and skills between countries and across regions provides an effective means through which to promote best practice, quickly and thoroughly.

Environmentally Sound Management of Lighting Products — mercury and other hazardous substance content standards should be established in line with global best practice in order to minimize any environmental or health impact. Special attention should be given to the development of a legal framework for environmentally sound, end-of-life activities.

There are many examples of procurement processes available for Elbasan to utilise should it wish to explore this option.

7.3. Transport

Transportation and especially road transport represents a significant portion of energy use in Albania and in the Elbasan municipality, and is a growing contribution to total emissions. Albania's transit sector emissions are growing due to a large increase in car ownership and an increase in car ridership. The National Transport Plan is focused on improving traffic and road conditions[3], however suggested measures to directly target transport efficiency could be expanded in Elbasan and include:

- Improved enforcement of fuel standards in line with EU directives, to remove high emission vehicles from the roads.

[3] European Commission. (June 2010) *First Five-Year Review of Albanian National Transport Plan.* Retrieved from: http://www.seetoint.org/wp-content/uploads/downloads/2014/01/Albania_Transport-Strategy-2010.pdf

- A Transport Master Plan that includes efficiency strategies and plans to support the development of an integrated transport system and delivers a fast, efficient, safe and more reliable service for the city's residents and visitors. This can be supported by launching a mobility visioning process in key cities to educate and get feedback from communities on their vision for a transit future. The system requires the infrastructure to allow a hierarchy of transport options – walk, cycle, metro, buses, private transport and freight. Best practices on urban mobility planning can be leveraged from programmatic guidance from the European Commission, which provides technical and financial support for cities looking to develop a full Sustainable Urban Mobility Plan.
- Parking restrictions can be incrementally implemented and enforced, starting with awareness-raising campaigns, small pilot zones and subsequent monitoring of the impacts.
- Transit-oriented development helps to ensure that compact and mixed-use development occurs within a short walk of high quality transit options. This creates "urban villages" where commonly used services (shops, restaurants, schools, parks, etc.) and a significant number of jobs are easily accessible without a car.
- Communication and provision of consumer information will be important to support the uptake of public transport. For example, the application of smart technologies, including: electronic displays or applications for smart phones showing routes, schedules, fares, discounts, incentives, real-time arrivals and warnings of delays. Education in several key areas will yield benefits:
  - Public transport and strategies to improve ridership
  - Education on bicycling options, such as bike share programs[4] and existing safe cycling paths
  - Driver education to share roads with pedestrians and bikers
  - Outreach around carpooling
- Consideration of fiscal measures to encourage efficient transport, such as
  - Establishing a new environmental charge for motor vehicles (annual tax)
  - Financial incentives for purchasing fuel efficient vehicles
- Improving intermodal passenger and freight transport
- Modernization of the traffic light system and the introduction of automated traffic management

7.4. Residential Buildings

There are a range of measures for Elbasan to consider in improving the efficiency of residential buildings including:

- Minimum Energy Performance Standards for appliances – standards for key energy-using residential appliances such as air-conditioners, refrigerators, televisions, washing machines.
- Building envelope measures – along with ongoing rollout of lighting retrofit and efficiency programs Elbasan could in partnership with utilities aim to redirect spending on household-level building material provision (insulation, roofing materials) to create improvements for better efficiency. The role of utilities as key implementation partners and information providers can be enhanced given their uniquely

[4] Ecovolis. (2011) *Public Bike Scheme as Social Business.* Ecovolis Website. Retrieved from: http://www.eco-bike.org/home.html#

placement at the customer interface, where they can play an important role in information provision and energy efficiency awareness. Experience in other countries suggests that provision of energy usage information and targeted advice is a cost-effective way to achieve a reduction in energy use.

- Specific EE programs for low-income households – consideration can be given to the types of measures that may be most beneficial and practical to low income households, in an effort to ensure relevance to the majority of the residential sector, and as a way of integrating the EE and economic productivity objectives of government.
- Inclusion of residential measures in building code – while this is more difficult than for municipal/office buildings, based on less stringent controls and enforcement for standards of residential housing, building code standards for EE of new residential buildings can be introduced. Once Building Energy Code and standards are adopted at the national level, an implementation strategy is needed for their effective enforcement at the city level. Ideally, it should be accompanied with building energy performance certification and labelling, as well as incentives for developers to go beyond the Building Energy Code.

7.5. Industry

While industry in Elbasan is not a large energy using sector, significant actions can be taken to improve efficiency including:

- Energy savings agreements for energy intensive industry: energy audits for industrial enterprises categorized as large energy consumers, that according to the obligatory scheme, sign a voluntary agreement in line with Article 12 of law 124/2015 "On energy Efficiency".
- Support is needed for small and medium enterprises to improve energy efficiency through establishment of targeted training and networks to share experiences.
- Currently, there are no official qualification, accreditation and certification schemes for industry in Albania. It is important that the country and the Elbasan municipality develop a pool of qualified experts on energy management systems and energy efficiency technologies to support the transition in the industrial sector.
- Free or low-priced energy audits to identify potential energy efficiency improvements to large, medium and small customers along with encouragement to implement recommendations. These audits are likely to trigger investments.
- Encouraging greater adoption of energy management systems in Elbasan's industrial sector to better understand consumption patterns, encourage change in consumption behaviour, optimise equipment efficiency and identify technical opportunities.
- Stricter emission controls to ensure reduced effluent of environmental pollutants.

7.6. Future Pathways

Given available budget and time for preparation of this draft REEAP, recommendations to be taken forward by Elbasan remain at a relatively high level. However, many savings opportunities have been identified, and many examples of best practice exist that relate directly to those opportunities that Elbasan could leverage.

If commitment to proceed with energy efficiency measures is established through this report, a further process of consultation is needed to decide the length and breadth of the resultant energy efficiency implementation program that Elbasan will undertake. Similarly, the Municipality must also decide the extent to which this consultation must be conducted. The purposes of consultation would be:

- To present the REEAP recommendations to local authorities and stakeholders, including of the two other regions of Tirana and Durres;
- To build interest and incentive for the preparation of a wider REEAP of the three regions;
- To get feedback, suggestions and recommendations to be included in the final REEAP;
- To get the commitment of local authorities and other stakeholders of the Elbasan region for the including of the REEAP to their actions and policies
- To contribute to the local awareness raising on the importance of reflecting the potential and global objectives of energy efficiency at the local level.

A clear additional recommendation is for a plan to be made to source additional data on the key parameters of energy use, so that modelling can be undertaken on the potential savings and cost effectiveness to be derived from particular measures.

The report authors are aware of and able to deliver substantial assistance in terms of policy input, information and connection to service and technology providers that can help deliver on the decided scope of the Elbasan energy efficiency implementation plan. Depending on the initiatives and technology deployments outlined, there is also connection to the possibility of discussions regarding financing models such that the work can be funded and successfully executed.