Accelerating zero-emission building sector ambitions in the MENA region (BUILD_ME)

Report on activities in Lebanon from the first project phase of BUILD_ME (2016 – 2018)

Prepared on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety under the International Climate Initiative

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TABLE OF CONTENTS

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This report summarizes the results of the first phase of this project from 2016 to 2018. Any developments after this date are not reflected in this report. Also, some of the results presented in this report reflect the views of individuals interviewed in the course of the project and may therefore not reflect the position of Navigant, it's partners or the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

[1] On October 11, 2019, Guidehouse LLP completed its previously announced acquisition of Navigant Consulting Inc. In the months ahead, we will be working to integrate the Guidehouse and Navigant businesses. In furtherance of that effort, we recently renamed Navigant Consulting Inc. as Guidehouse Inc.

1. INTRODUCTION

This report presents the results of the Lebanese part of the project “Accelerating zero-emission building sector ambitions in the MENA region”, funded by the German Federal Ministry for the Environment and carried out by Navigant, a Guidehouse Company, (formerly Ecofys[2]) together with local partners.

Due to a very fast population growth, extremely high urbanization and strong dependence on energy imports, Lebanon’s most immediate and urgent challenge remains the poor security of electricity supply provided by the national utility. The country has taken steps towards the development of energy efficiency (EE) programs and renewable energy sources (RES) summarized in Lebanon’s National Energy Efficiency Action Plan (NEEAP) 2016-2021. At the 2009 Copenhagen Climate Summit, Lebanon voluntarily pledged to increase its RES share to 12% by 2020. An Energy Conservation Law was also approved by the Council of Ministers in order to regulate the framework for EE issues in Lebanon.

After the project analysed this background (see chapter 2), it conducted an extensive dialogue with the most relevant stakeholder groups in the Lebanese building sector (e.g. public authorities, project developers, banks or consumers). The goal of the stakeholder dialogue was to identify drivers and barriers for the uptake of EE and RES in the residential building sector. Main barriers that were identified included a lack of awareness related to EE technologies, high upfront investments and missing standards and regulations (chapter 3.2).

In parallel, two pilot projects in Byblos (Byblos Seaside Residence) and Bhamdoun (Dolmen Lamartine Hills) were selected in the framework of this project to establish an exchange between policy dialogue and practical aspects in the construction sector. For both projects technical measures including the building envelope, appliances and solar energy were evaluated as well as a set of the most economical and impactful measures to form holistic packages. Both the Byblos project and the Bhamdoun project continue to evaluate the implementation of proposed measures (chapter **Error! Reference source not found.**).

In a next step, potential policy measures to promote EE and RES in buildings in Lebanon were discussed with stakeholder groups. Many of the recommendations aimed at building capacities and awareness at municipalities, project developers, banks and utilities (chapter 4.1). Based on these insights, potential policy measures were evaluated using integrated modelling. In order to prioritize the implementations of policy recommendations in Lebanon, an impact assessment was carried out to analyse the energy saving potential, CO_2 reduction, necessary investments and job effects in comparison to the business-as-usual scenario (chapter 4.2).

[2] Please note that Ecofys Germany GmbH changed its name per 1 January 2019 to Navigant Energy Germany GmbH. Therefore, the current report is prepared under the name of Navigant Energy Germany GmbH.

2. STARTING SITUATION 2016

Population		**Energy and Climate**	
6.0 M	Inhabitants (2015)	96%	Energy Imports (Percentage of demand)
3.55%	Population growth (per annum)	5%	Energy subsidies (share of GDP)
Economy		2.33-13.33 USc/kWh	Average electricity price (2015)
13.9k $	GDP per capita (2017)	0.8 $kgCO_2/kWh$	GHG emissions factor of electricity (2015)
0.8%	Avg. Inflation rate (2013-2015 per annum)	44%	Share of residential GHG emissions (% of total GHG emissions)
10%	Household interest rate (per annum)		

Figure 1: Key macro-economic indicators of Lebanon

2.1 Key Macro-Economic Indicators

With a population of currently six million inhabitants, Lebanon is facing energy challenges related to a combination of very fast population growth, extremely high urbanization and its almost entire dependence on energy imports. The country has taken steps towards the development of energy efficiency programs but could benefit from additional support in implementation.

Electricity prices in Lebanon are low with an average of USc 2.33-13.33 per kWh, and some differentiation (day/night/peak) for high voltage industries. About 5 % of GDP is spent on energy subsidies, but according to the project (BUILD_ME) local partners there is a strong political willingness to reduce energy subsidies. In terms of the financing conditions for energy efficiency measures, Lebanon shows a mixed picture. While interest rates are relatively high at 10 %, the inflation rate has been low at an average of 0.8% over the past three years. Access to finance for private investors was deemed moderately easy by local partners and the country's attractiveness for foreign investors was rated low by local partners. With about USD 13,900 GDP (PPP[3]) per capita per year, Lebanon is the second within the countries that had been assessed in the project.

In Lebanon, building sector emissions are very high at 44 % of total emissions. Lebanon heavily depends on energy imports for 96.5 % of its supply. The most immediate and urgent challenge for the Lebanese energy sector is the very poor security of electricity supply. Only in 64 % of all hours, electricity is supplied reliably.

[3] Purchasing Power Parity

2.2 Starting Situation in the Building Stock

Housing Indicators		Housing Economics	
1.4 M	Number of households (2015)	4.4%	New construction rate (2015)
88%	Share of population living in urban areas (2015)	2.0 M LBP/m²	Average cost of new construction (urban multifamily houses)
40%	Share of population living in the Beirut metropolitan area (% of total population)	17%	Share of rented buildings (% of privately owned res. buildings)
60%	Share of multifamily homes (% of new constructions)	82%	Percentage of households that own the property in which they live (%)

Figure 2: Key statistics on Lebanon's building stock

There are 1.4 million households in Lebanon with an average occupancy of 4.3 inhabitants per household. Urbanization is high with 88 % of population living in urban areas, most notably in the Beirut metropolitan area that accounts for almost 40 % of Lebanon's total population. In terms of real estate floor area, multifamily homes are more common (>1 million households) than single-family homes. Construction costs for urban multifamily homes vary from LBP 1,550,000 per m^2 (low-class project) to LBP 2,550,000 per m^2 (high-class project) with average costs amounting to LBP 2,000,000 per m^2. 17 % of privately-owned residential buildings are rented out, on the other hand 82 % of households own the property that they live in.

Given its fast population growth, also due to the influx of refugees from Syria, and its high urbanization rate, Lebanon has the highest new construction rate among the countries in the group studied (4.4 %). Sixty percent of these constructions are multi-family houses, a value significantly higher than in the other countries studied (except for Jordan, which has a comparable rate). While local partners identify some awareness for energy efficiency, industry involvement is considered very low.

2.3 Current State in Cooling and Heating Technologies

Energy consumption		Air conditioning	
40%	Share of residential final energy consumption (% of total final energy consumption)	42%	Share of multi-family houses with AC (2015)
25.6k	Amount of liquid gas consumed yearly in the Lebanese heating sector (tons)	1.77k	Cooling degree days (Reference: 18°C)

Figure 3: Key metrics of heating and cooling in residential buildings in Lebanon

About 40% of the total national final energy consumption in Lebanon is consumed in the building sector. Emissions in the housing sector account for about 34.9 % of total emissions, the largest share of which (34.8 %) is consumed for energy use. About 25,600 tons of liquid gas are consumed yearly in the Lebanese heating sector. Useful cooling and heating demand in Lebanon differ according to the climate zone of the respective building. In the city of Zahle, a mountainous climatic area, useful cooling demand is estimated at 35 kWh/m^2 a and useful heating demand: 125 kWh/m^2 a. These are not official numbers but numbers coming from local project developers experience.

About 42 % of Lebanese multi-family houses have air conditioning. For cooling, people usually use split air conditioners (53.8 %) and fans (42.3 %), both of which are powered by electricity. The common technologies for space heating in new apartment buildings in Lebanon are gas/oil boilers (27.3 %), reversible split air conditioners, electric fans and resistance heaters (17.8 %), wood/coal fireplaces (17.6 %) and central heating (1.9 %).

It has been estimated that 83 % of all Lebanese households have an electric water heater, resulting in a total number of approximately 953,284 electric water heaters available in households throughout Lebanon. In terms of water heating technologies, instantaneous water heaters (electric element) are the most sold in Lebanon (19.2 %). However, it should be noted that 71.2 % of the Lebanese heating and cooling equipment retailers do not sell hot water technologies.

2.4 Existing Policy Framework for Building Efficiency

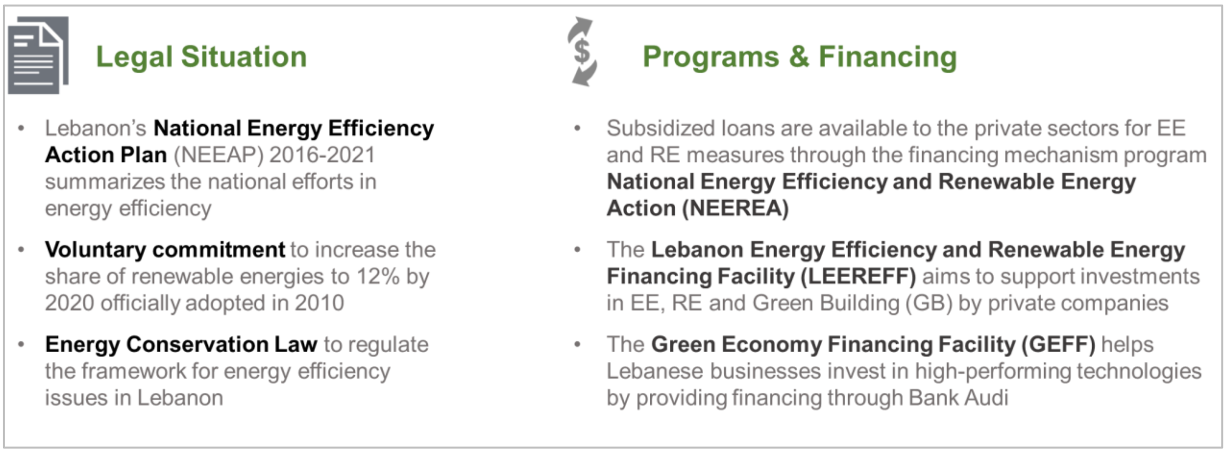


Figure 4: Existing Policy Framework in Lebanon

Legal Situation

Lebanon's National Energy Efficiency Action Plan (NEEAP) 2016-2021 summarizes the national efforts in energy efficiency. Our local partners assessed the current implementation and enforcement to be limited. At the 2009 Copenhagen Climate Summit, Lebanon voluntarily pledged to increase its renewable energy share to 12 % by 2020. This voluntary commitment was affirmed within the "Policy Paper for the Electricity Sector" prepared by the Ministry of Energy and Water (MEW) and officially adopted by the Council of Ministers in June 2010. According to Lebanon NEEAP of 2016-2020, the draft of the ''Energy Conservation Law'' was approved by the Ministry of Energy and Water and was sent to the Council of Ministers but the Law has not been sent yet to the level of the parliament. The law regulates the framework for energy efficiency issues in Lebanon. Technical and institutional capacity is strong, but general problems regarding a lack of regulation in the electricity sector hamper the implementation of energy efficiency frameworks.

It is to be noted that private sector companies have some technical capacity to design, implement, or verify energy efficiency in buildings, the Ministry of Energy and Water (MEW) and specifically LCEC should also have the legal capacity to enforce energy efficiency implementation. However, the energy conservation law did not reach the level of parliamentary discussion for approval, and even though a new energy conservation and renewable energy law is being prepared (including its regulatory impact assessment), the regulatory process will take a long time before enforcing energy efficiency in buildings in Lebanon, especially at the level of large consumers. Additionally, the electricity sector is vertically integrated, with one public establishment (Electricity du Liban) handling generation, transmission and distribution. This leads to the fact that electricity prices in the country are heavily subsidized, offering little incentives for reducing electricity consumption at the level of the end-consumer, which hinders furthermore private-sector investments in energy efficiency.

With respect to energy efficiency in building codes, there are no code for heating and cooling equipment.

With respect to MEPS and energy labels, these have been introduced in Lebanon and are at different stage of development and process of implementation. It is important to note that below standards in Lebanon are standards for testing the performance. There is no threshold applied for minimum acceptable performance currently.

Table 1: MEPS in Lebanon: Current status

Type of equipment	Current status	Stakeholders involved
Solar water heaters + Compact fluorescent lamps	Mandatory Standards for testing performance are in place No threshold is applied for minimum acceptable performance	Council of ministers Ministry of Energy and Water LCEC IRI
Residential appliances e.g Refrigerators, Television, Washing Machine, Electric/Gas Water Heaters, AC split units and Heat Pumps + Electric Motors + Electric Transformers	MEPS in development voluntary standards for testing the performance of electric ACs, heat pumps and chillers are in place. Voluntary programs promote the use of efficient appliances	Ministry of Energy and Water LCEC LIBNOR Italian Ministry of Environment Land and Sea (IMELS) IRI Directorate General of Urban Planning
Refrigerant and AC (all types)	MEPS In development No Voluntary programs promote the use of efficient RAC	Ministry of Environment NOU International and local consortium funded by K-CEP LIBNOR

Programs and Financing

In terms of funding, Lebanon has been successful in triggering private funds through its National Energy Efficiency and Renewable Energy Action Plan.

3. KEY FINDINGS OF THE PROJECT

3.1 Most Relevant Stakeholder Groups and Institutions

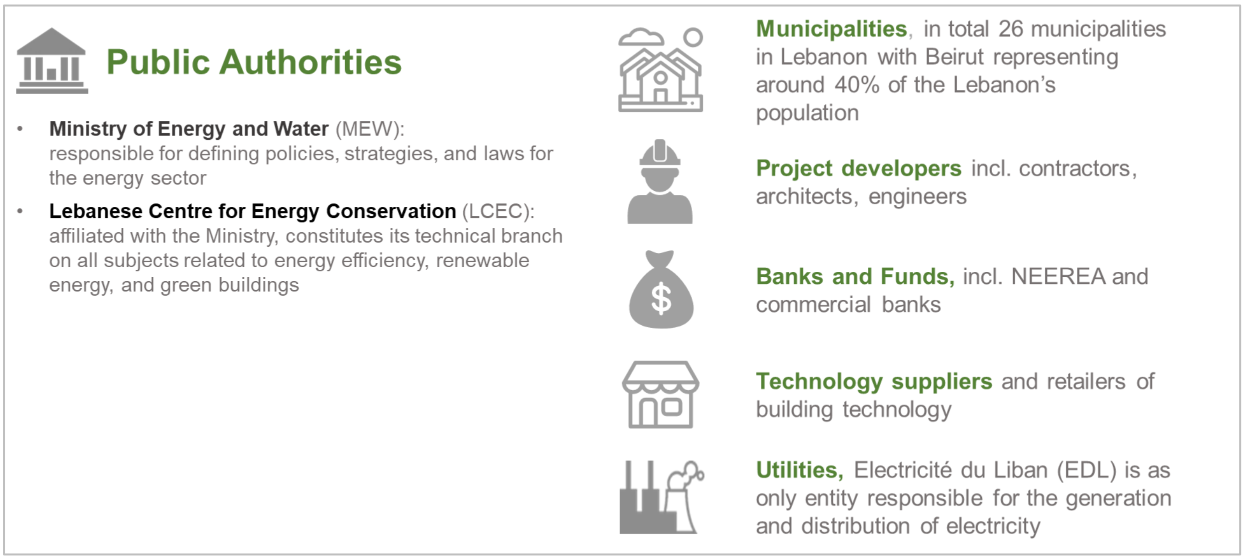


Figure 5: Non-exhaustive list of most relevant stakeholders in the Lebanese buildings sector

3.1.1 Public stakeholders

3.1.1.1 Ministries and Government Agencies

Lebanon's Ministry of Energy and Water is responsible for setting policies, strategies, and laws for the energy sector. The Lebanese Centre for Energy Conservation (LCEC), affiliated with the Ministry, constitutes its technical branch on all subjects related to energy efficiency, renewable energy, and green buildings. LCEC works on setting national strategies and action plans to be adopted by the Lebanese Government; as well as on the implementation and the quality control of national projects and initiatives in the country. LCEC is responsible for various energy consuming sectors (mainly public buildings, service and industrial sectors), for developing markets for energy efficient appliances as well as financial and legislative frameworks for energy efficiency and small-scale renewable energy investments.

3.1.1.2 Municipalities

There are 26 municipalities in Lebanon with Beirut representing around 40 % of the Lebanon's population. The responsibility of municipalities in Lebanon for the residential sector lies in granting permits, enforcing the building codes and surveillance of the implementation. Municipalities in different areas of Lebanon were interviewed, from Tripoli, Koura and Btorram in the North passing by Byblos, Furn El Chebbek, Al Mokhtara and Wadi Al Sett in Mount Lebanon to Nabatieh in the South. Only the Mokhtara municipality had a framework for energy efficiency as they are a part of the covenant of mayors. Their goal is to reach zero CO_2 emissions by 2030.

Urban municipalities have a high number of employees with a maximum in Tripoli that has 691 employees, 13 of which work in the permitting process. Rural municipalities tend to have a low number of employees reaching a maximum of ten, and normally three of them work in the permitting process. All of the municipalities report to the Ministry of Interior and Municipalities. None of the interviewed municipalities had an energy department.

3.1.1.3 Utilities

In Lebanon, Electricité du Liban (EDL) is the only entity responsible for the generation, transmission and distribution of electricity. In 2010, the total electricity demand was estimated at around 15,934 GWh. EDL generated 68 % of this amount, imported 3 % from Egypt and Syria, the hydropower plants generated 6 % and the rest was generated by private generators. In Lebanon, since EDL alone is not able to supply for the country's electricity needs, there is a need for private generators to fill the gap.

The electricity sector in Lebanon faces numerous challenges. Electricity supply is almost completely dependent on fuel oil imports (>95 %) and the Lebanese Government adopted a fixed tariff policy at the cost of an oil barrel in 1994 (USD 20 per ton). Within three decades, financial flows to the national electricity utility, Electricité du Liban (EDL), have drained the state budget with increasing fuel oil prices. Subsidies to EDL increased from USD 60 million in 1998 to USD 3.1 billion in fuel subsidies for the year 2013, representing 7.0 % of Lebanon's Gross Domestic Product (GDP).

The electricity supply in Lebanon is subject to daily cut-off hours that ranges from three hours to twelve hours depending on the region. In order to cover the energy shortage, private diesel generators are being deployed. Residential, commercial, industrial and agricultural facilities in Lebanon are all connected to diesel generators that are used as back-up energy source during the cut-off periods. The diesel generators are either owned by individuals or facility owners for self-consumption, by municipalities or by private investors for communal supply of power in return for a monthly fee. Furthermore, the subscription fee is defined every month by the Ministry of Energy and Water and it is expressed in LBP per 5 Amps. Accordingly, the users pay a fixed amount of money that depends on the subscription capacity in Amps (5 A, 10 A, 15 A, etc.) regardless of the energy consumed in kWh for a specific subscription.

Most of the Lebanese residential consumers have two subscriptions, one with EDL and the other with the private generator that is close to them. Both subscriptions are a barrier for accelerating energy efficiency in the country:

1. EDL electricity prices are low and subsidized, consumers are not sensitive to their EDL electricity bill.

2. Private generators price their service on capacity base. As such consumers have no incentive to reduce their energy but to consume power as they are billed on baseload consumption.

In 2018, energy meters have been introduced in certain areas and owners of generators are being paid according to the monthly consumption (kWh) of the user rather than the fixed price of subscription. Therefore, a 5 Amps subscription cost varies depending on the amount of energy consumed.

3.1.2 Private stakeholders

3.1.2.1 Project developers

For the middle to low end market, the final decision of installing energy efficient heating or cooling appliances is taken by the homeowners, for the high-end market, developers are the decision makers. Lebanese companies operating in the real estate field could be separated between different categories:

1. Real estate developers that complete the work from concept to implementation and integrate energy efficiency measures in their designs;

2. Design offices that attend only to specified tasks defined by their clients (which could include heating and cooling);

3. Real estate developers that develop projects without any regards to energy efficiency in order to sell the apartments at competitive prices.

Companies classified under 1 and 2 are involved in the decision making for heating and cooling equipment in their projects while companies classified under 3 leave the decision completely to the end user. Companies that were interested to cooperate in this work were mostly between the first 2 types of companies due to their relative experience in the subject. Based on the answers of the surveyed companies, almost all of them (95 %) recommend future apartment owners to install energy efficient heating and cooling technologies. Only 50 % of the developers are involved in the decision process for the technology to be installed of which only 20 % can take the decision without referring back to their clients. All recommendations take place at the design stage or even, in some cases, in the concept phase.

3.1.2.2 Banks and Funds

NEEREA is a Lebanese financing mechanism developed by BDL. This mechanism started operating in November 2010. It is dedicated to the financing of green projects in Lebanon. Since its initiation, NEEREA has become the cornerstone for energy efficiency and renewable energy development in Lebanon. Since its implementation, NEEREA has financed more than 690 projects with a total sum exceeding USD 400 million for energy efficiency and renewable energy projects. This instrument provides low interest rate loans (around 1 %) for projects under USD 20 million and long repayment periods of up to 14 years to the residential, non-profit, commercial and industrial sectors. The NEEREA loan is an interesting product to the banks since BDL provides liquidity at 150 % of the loan amount. The additional 50 % could be used by the banks for other purposes like housing loans, car loans, personal loans and investment in treasury bills, which usually provides higher interest rates.

The largest commercial banks in Lebanon include Banque Libanaise pour le Commerce, Byblos Bank, Banque Libano-Française, Intercontinental Bank of Lebanon, Fransabank, Credit Libanais, Banque du Liban et d’Outre-Mer and Bank Audi. All interviewed banks give green loans to their customers. This action started in most of the banks with the deployment of the NEEREA initiative. Some banks stated that they face some internal barriers that keep them from investing more in green projects such as the lack of technical experts at the bank. Since 2010, the banks have grown a better understanding in the energy efficiency sector and are working with a more selective group of clients that they have identified as worthy in the field. Productivity is increasing and most banks have witnessed no defaults in payment. Banks that have financed only a small number of projects so far are currently working to launch extensive efforts in order to get more involved in the sector.

3.1.2.3 Suppliers

Lebanese suppliers and retailers are importing most of their technologies from China (80%) followed by South Korea and Germany. Their orderbook in selling higher energy efficient technologies did not change in the last five years but has been observing a slightly decreasing trend.

The majority of interviewed suppliers and retailers import and sell single split air source heat pumps (55%), with an average Coefficient of Performance (COP) of 4.8 varying between 3 and 6. Electric resistance heater and electric fans are the second most sold technology in the Lebanese market, followed by multi-split air source heat pumps with an average COP of 5.4 varying between 3 and 6. Air conditioners and Chillers that are used only for cooling represented a share of 25% in the suppliers and retailers portfolios. Regarding boilers systems, only 12% of the interviewed pool were selling them, the majority selling condensing boilers (80%).

Most of the interviewed suppliers did not sell water heating technologies. A quarter were selling instantaneous water heaters and a very small share solar thermal. It is important to note that suppliers selling solar PV were not interviewed, which can explain why a very small share was selling solar thermal.

3.2 Stakeholder group specific drivers and barriers

3.2.1 Methodology

The Lebanese Center for Energy Conservation conducted 46 interviews with stakeholders in the building sector in Lebanon during the summer and fall of 2017. The interviewees represent different stakeholder groups as outlined in the previous chapter. The aim of the interviews and interaction with stakeholders at roundtables was to:

- Assess barriers for the uptake of efficient and/or renewable energy-based cooling and heating technologies in residential buildings;
- Evaluate what role different stakeholder groups play in the decision process;
- Collect recommendations on how the financial and regulatory framework should be changed to make it easier for homeowners and developers to choose efficient heating and cooling appliances rather than conventional ones.

The market research company GfK conducted the interviews with technology suppliers, building owners and consumers. The chosen method of surveying was Face-to-Face interviewing. A dedicated field force of experienced interviewers used tablets to conduct the interviews and immediately enter the data into the survey system during the interview. To facilitate the B2B survey process, it was decided to conduct interviews both based on appointments as well as walk-ins. In total, over the three target counties, 1,300 survey were completed, of which 300 residents and 50 suppliers in Lebanon. Figure 6 illustrate the numbers of survey conducted in each country and the breakdown for Owner/Occupier and Owner/Landlord.

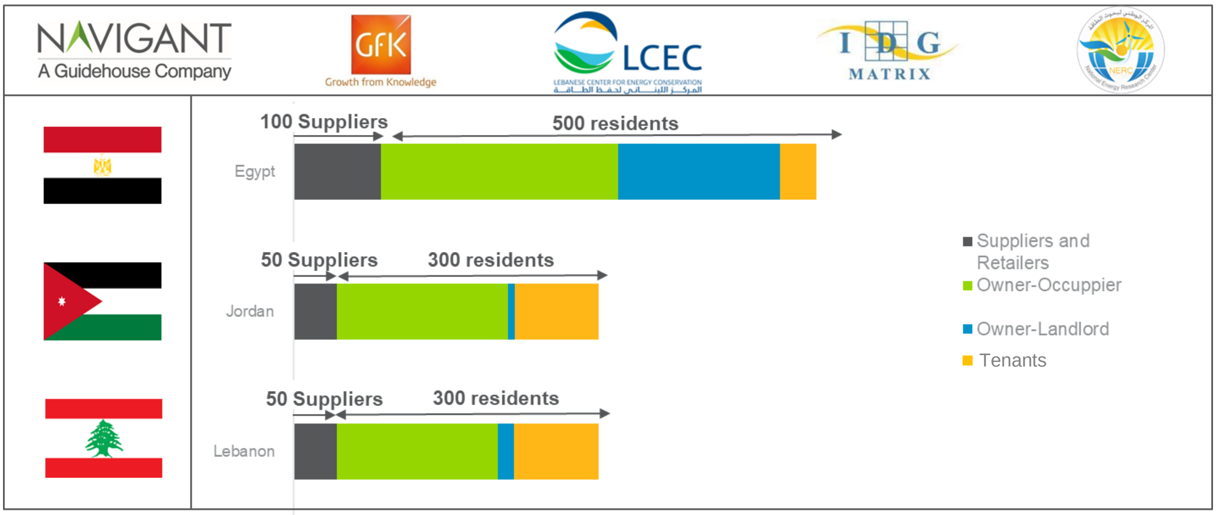


Figure 6: Breakdown of suppliers and residential surveys conducted by GfK across Egypt, Jordan and Lebanon

3.2.2 Drivers and barriers by stakeholder group

In the following figure, all concrete drivers and barriers for energy efficiency in Lebanon that were identified during the stakeholder interviews, are summarized. The drivers and barriers were divided into the following stakeholder groups: project developers, banks, ministries, municipalities and utilities.

Stakeholder Group	Drivers	Barriers
Public Authorities	EDL's **weak financial situation** Energy efficient **target** set by the **government** **Desire of independency** on energy imports	**Lack of awareness** related to the energy efficient technologies Too high **upfront investment** **Regulatory framework** is not strong enough
Municipalities	**Willingness** of most of the municipalities to go for energy efficiency; **Share of experiences** of municipalities that have implemented energy efficiency	**Missing standards** and regulations **No sufficient budget**
Project Developers	Customer desire to **minimize total cost** of ownership and saving potentials over the years Enhanced **image** and receive **green loans**	Customer preference for **minimizing upfront investment** Companies target the **lower class** of Lebanese market build inexpensive apartments
Banks and Funds	**Circular 236** issued by BDL: **NEEREA financing mechanism**	**Lack of expertise** internally and dependence on LCEC/NEEREA team **Long process of NEEREA** loans up to six month
Utilities	Closing the gap between **demand and supply** Implementation of the **net-metering system**	**Low cost** of electricity provided by EDL **Bad state of the grid**; grid capacity not sufficiently simulated Lack of laws and regulations

Figure 7: Drivers and barriers for energy efficiency as learned in stakeholder interviews

3.2.2.1 Public Authorities

While discussing the drivers for the energy efficiency market, 86 % considered EDL's weak financial situation as a very important driver that should push the government to support energy efficiency measures. A total of 86 % said the energy efficiency target set by the government is an important driver. A total of 57 % of the interviewees mentioned Lebanon's dependency on energy imports as an important driver to boost energy efficiency measures. Another 57 % saw that the international energy efficiency trends and reducing the CO_2 emissions were influencing factors. A total of 43 % stated that the ability to attract international donors and a healthier environment in the building sector would help pushing the energy efficiency market forward and 29 % considered energy security to have an essential role in promoting energy efficiency. Electricity prices were mentioned as both a driver and a barrier. It is seen as a driver because it pushes the government to promote and facilitate dealing with energy efficient measures, as the government is currently subsidizing heavily the electricity production of EDL. It is also seen as a barrier because electricity generated by EDL is bought by the consumer at a very low price, where energy efficiency and renewable energy would not be competitive at the customer's level. Another driver identified is the consumer's financial benefit from NEEREA loans along with the Lebanese customer's eagerness to new and luxurious technologies.

Regarding the barriers, interviewees from national Ministries mentioned the following impediments: Firstly, all the interviewees agreed that the lack of awareness is a major barrier. Secondly, 57 % considered that the upfront investment is relatively high and that there is a lack of awareness related to the energy efficient technologies and their financial savings. The same share considered that the regulatory framework is not strong enough and that there is a lack of standards and enforcement for energy efficiency measures. A total of 43 % said that there is a lack of awareness for energy efficiency measures at the level of the engineers, architects and project developers. They also mentioned that the low energy prices at the customer's level due to the high EDL subsidies, do not provide strong financial attractiveness. A total of 29 % raised the lack of customers support as a barrier. The lack of technical know-how among engineers in addition to political instability create barriers for the energy efficiency market. Another 14 % considered the lack of available technologies in the market as well as high bureaucracy in the public sector as an additional problem. Other barriers mentioned included the lack of awareness concerning the need for regulations in the market for energy labels and the lack of testing facilities as technologies entering the Lebanese market are not and cannot be tested in local facilities. Another barrier identified is private diesel generation in Lebanon where consumers pay a fixed rate regardless of their consumption. Hence, consumers tend to maximize consumption while using the diesel generators since there is no metering and it minimizes their electricity bill from the grid.

3.2.2.2 Municipalities

A total of 50% of the municipalities promote energy efficiency measures while only one had an energy efficiency target. Those promoting energy efficiency follow the strategy of the current municipal council, which gives them a better and greener image. The Mokhtara municipality is the only municipality that is interested in energy efficiency measures because they have a CO_2 emission reduction target. The municipalities that do not promote energy efficiency said that it is because they do not have any standards and regulations to follow and they do not have a sufficient budget to spend other than on the works that are essential in the town.

Lebanese municipalities cannot give any facilitations or incentives for energy efficient buildings. The current building code provides the municipalities with the option to give one limited incentive for buildings or the usage of double walls. Some municipalities were interested in giving financial incentives by reducing the municipal fees, but other municipalities were totally against it as it will reduce their income which is already limited.

The representatives of the municipal administration were not very satisfied with the enforcement of the building code. The biggest challenge they face is the central government's requirement to send all documents to the urban planning office for investigation, in order to ensure that the local authority has a better understanding of the projects in their regions and can follow them up more quickly. Other challenges are with the mentality of the people that do not abide by the law and use their connections to bypass the law. Most municipalities consider that they have enough budget to enforce building laws and that the staff is well trained. Nevertheless, they were interested in further trainings.

Drivers for EE are the willingness of most municipalities to provide incentives and promote energy-efficient buildings, and municipalities that have already implemented energy efficiency and renewable energy measures and are willing to share their experience through programmes.

Barriers for EE are that municipalities are bound by legislation which restricts their rights to give explicit incentives to energy efficient buildings. Low municipality budgets are not sufficient to take into account expenditure on promoting energy-efficient measures.

3.2.2.3 Project Developers

A total of 95 % of the companies stated that the efficiency of heating and cooling technologies plays an important role in the decision making. In general, project developers listed several reasons why they opt to install or recommend energy efficient heating and cooling technologies for their customers. These reasons are listed in order of importance:

- Profitability when the savings potential over the years are taken into consideration;
- Companies can receive green loans with low interest for energy efficient and renewable energy measures;
- Companies value the environment;
- Increase of building’s value;
- Companies get higher visibility and enhance their images;
- Customer awareness of environmental concerns and payback periods of energy efficient technologies;
- Companies seek to differentiate their brand and design from competitors;
- Customer desire for comfort and image.

As mentioned above, the one company that did not care about the efficiency of the technologies did not install any type of heating and cooling system in the apartments it sold. Unfortunately, this company represents a good share of the Lebanese market, and the lack of interviews with this share is due to the lack of interest of these companies in energy efficiency. These companies build inexpensive apartments that target the lower and a fraction of the middle class of the Lebanese market. These apartments do not have any of the heating and cooling technologies installed, thus it lowers the upfront investment cost for the buyer who will be deciding on the technologies to install. In this business model, developers do not tend to go into heating, ventilating, and air conditioning (HVAC) technologies, especially energy efficient ones, as they do not see the direct benefit that it may incur. They perceive the initial investment as a waste of money because they will be spending their capital on an upgrade that may lead their targeted customers to find other cheaper properties on the market. This demonstrates the need for customers' awareness for the benefits of energy efficiency measures while making their decisions. However, all companies surveyed have implemented energy efficiency measures that are not dependent on high capital costs, excluding insulation, double glazing, reflective coating on the roof, LED lights and other measures.

3.2.2.4 Banks and Funds

The biggest driver to the sector for the banks is the Circular 236 issued by BDL launching the NEEREA financing mechanism in November 2010. Most of the interviewed banks entered the energy efficiency and renewable energy market after the Central Bank of Lebanon issued circular 313 that introduced new incentives to invest in energy efficiency, renewable energy and green buildings. NEEREA is the financing mechanism that most of the banks rely on in their lending decisions and is thus one of the main drivers in accelerating energy efficiency in residential buildings. The experience of the banks with the NEEREA loans has been a positive one as none of the banks report a default in payment. They see this attribute to be highly reflective of the contempt of their clients with the proposed product and it pushes them forward to give out such loans as they have a high expectancy of payback, and the mechanism itself gives them more liquidity as explained earlier. These drivers altogether are pushing the banks to ask their agents to promote the green loans by telling their clients how they could benefit from it and by directing them towards energy efficiency and renewable energy measures.

Among the barriers listed by the banks for investing in energy efficiency, the most important one is the lack of expertise internally, which makes it possible for them to only rely on the technical advice of the LCEC/NEEREA team. The banks believe that awareness campaigns along with some technical assistance from the LCEC/NEEREA team would be beneficial to develop some knowledge internally and to better pre-assess the files.

The NEEREA loan process passes by several steps before approval. This process can be lengthy sometimes taking up to six months from the beginning to the end. The file has to pass through the commercial banks first, then it is sent to BDL which sends the file to the NEEREA team. At this stage if the NEEREA team has any comments on the file there will be a correspondence time between them and the client after which the file will be sent back to BDL with an assessment report. At this stage BDL will release the corresponding amount to the approved loan.

The banks do not consider the heating and cooling technologies as influencing their lending decision, as in most cases they come as part of a larger project that includes all the information including HVAC equipment. If the complete loan gets approved by the LCEC/NEEREA team, they will give the full loan amount, or they will match the approved amount by the LCEC/NEEREA team or BDL, or the loan can be refused all together.

3.2.2.5 Utilities

Currently, EDL is working on bridging the gap between demand and supply and they are interested in energy efficiency as it will most likely help to reduce the total load and generate more power with renewable energy. The driving forces for the sector are the introduction of the net metering system, which closes the gap between supply and demand, and, according to the current state of the art, energy-efficient systems could be used to obtain a lower producer subscription.

Among the barriers to RES listed by the utilities, the low electricity costs of EDL and the fixed costs of private generators are the most important, regardless of consumption. Load shedding, which does not allow owners of PV systems to exchange with the grid at any time, and the obligation to install additional charge controllers and batteries (which increases the return on investment of the systems) complicate the situation, as does the poor condition of the grid. There is a need for further studies to simulate the impact of renewable energy on the grid and the lack of laws and regulations.

3.2.2.6 Technology suppliers

Most suppliers (81 %) said that increasing demand from customers for EE heating and cooling technologies drives them to import more EE heating and cooling technologies in the future. The most indicated reason for this is individual motivation (i.e. for one's comfort) which appears to be the prevailing driver for respondents in Lebanon. Demanding comfort appears not to be the priority. The second driver mentioned by 50 % of all respondents was the first-mover advantage, which describes that companies intend to be the first in the market to import new products and gain competitive edge. Most suppliers (67 % of respondents) mentioned the current lack of demand as the primary barrier to the implementation of EE technologies. As main reasons behind this, high purchasing costs, governmental restrictions, and the economic and political situation in the country were given.

3.2.2.7 Consumers

When asking what prevents consumers from installing energy efficient (EE) heating and cooling appliances, the lack of consciousness in the choice of the type of appliances was mentioned the most (63.8 %), followed by personal financial reasons (37.6 %). When asked consumers what drives them to install EE heating and cooling appliances, individual motivation (i.e. for one's comfort) appears to be the prevailing driver for respondents in Lebanon.

3.3 Main Results and Learnings from Pilot Projects

Project	Boundary Conditions		Proposed Technical Measures
 Byblos Seaside Residence	20	Expected inhabitants	Reducing window fraction
	567 m²	Conditioned floor area	Adjust set temperature for cooling/ heating
	576 K*d	Heating Degree Days	Solar energy (PV and Solar thermal)
	1,348 K*d	Cooling Degree Days	Additional measures of nZEB package
	1,829 kWh/m²	Solar Irradiation p.a. (horizontal)	
	187 LBP/kWh	Electricity Price	
	87 LBP/kWh	Diesel Price	
 Lamartine Hills Residence	≈ 32	Expected inhabitants	Thermal insulation
	1,408	Conditioned floor area	Energy efficient glazing of windows
	1,517 K*d	Heating Degree Days	Adjust set temperature for cooling/ heating
	1,063 K*d	Cooling Degree Days	Solar energy (PV and Solar thermal)
	1,871 kWh/m²	Solar Irradiation p.a. (horizontal)	Additional measures of nZEB package

Figure 8: Overview of pilot projects conducted in Lebanon

3.3.1 Byblos Seaside Residence

3.3.1.1 General Information

The Byblos Seaside Residence is the second project developed by Forefront Development. For this ambitious project, Forefront gathered a team with a sense of aesthetics and sustainability. The team is composed of Samir Khairallah & Partners architects and Design Engineering Partners. The residence is situated in Byblos at the waterfront and offers chalets including apartments ranging from 70 m² to 180 m². With these offerings, Forefront is responding to the current needs of the Lebanese real estate market. Units can be combined, serving as a functional and flexible solutions for potential clients.

Figure 9: Illustration of the Byblos Seaside Residence

The Seaside Residence in Byblos contains residential properties only. On three residential floors (plus garage), one building / chalet consists of six apartments for expected 20 inhabitants. The conditions floor area amounts to 567 m2 with a clear room height of 2.85 m, resulting in a conditioned volume of 2,022 m3. The cooling degree days are two times higher than the heating degree days.

Table 2: General information overview

Criteria	Input
Number of expected inhabitants	20 per chalet
Utilisation	Residential
Year of construction	2018/2019
Number of floors	Four (three residential plus garage)
Number of apartments	6 per chalet
Conditioned floor area	567 m²
Clear room height	2.85 m²
Conditioned volume	2,022 m^3
Roof area	220 m²
Net wall area	450 m²
Floor area	220 m²
Window fraction per orientation (N/E/S/W) in m²	12/82/0/84

3.3.1.2 Baseline and Current Situation

The baseline situation reflects the current state of construction in a respective country, as no building code is enforced in Lebanon. As a result, no thermal insulation has been planned, heating and cooling supply is a reversible split unit with a COP of 2.5, and hot water is supplied by an electric appliance. This approach results in poor thermal quality with a roof U-value of 4 W/m²K, wall U-value of 1 W/m²K, and a floor U-value of 3 W/m²K. The ventilation is natural, and the lighting system is based on LED technology.

The current planning by the project developer, however, includes utilisation of thermal insulation on the roof, windows, and external walls. Additionally, overhangs serve as shading. Furthermore, the heating and cooling system is replaced by a four-pipe heat pump system—COP 3.5 (heating) and COP 3.3 (cooling).

Table 3: Baseline and current status overview

Measure	Baseline	Current Situation
Roof insulation	4 W/m²K	**1 W/m²K**
Wall insulation	1 W/m²K	**0.57 W/m²K**
Floor insulation	3 W/m²K	3 W/m²K
Windows	5.7 W/m²K, G = 0.85	**2.5 W/m²K, G = 0.65**
Window fraction (average)	47 %	47 %
Thermal mass	Medium	Medium
Shading	No	**Overhangs**
Air tightness	0.25 1/h	0.25 1/h
Heating system	Reversible split unit - COP 2.5	**Four pipe heat pump system - COP 3.5**
Cooling system	Reversible split unit - COP 2.5	**Four pipe heat pump system - COP 3.3**
Hot water	Electric	Electric
Ventilation system	Natural	Natural
Lighting system	LED	LED
Renewable energy	No	No
Temperature setpoint: heating	21°C	21°C
Temperature setpoint: cooling	24°C	24°C

Note: Bolded entries indicate those that differ from the baseline values.

3.3.1.3 Variants

Variant 1 – Short Payback

With a payback time of less than 2 years, Variant 1 offers energy savings from highly financially feasible measures. The two main selected measures are: reduced window fraction of 30%, and adjustment of temperature setpoint to 20°C (heating) and 26°C (cooling).

Variant 2 – nZEB

Variant 2 which aims to reach a nearly zero energy building (nZEB) level, consists of the following measures: rooftop PV and solar thermal appliances, efficient windows (U-value 1.2 W/m²K), automatic shading, and an air infiltration rate of 0.25/h. The insulation of the roof and walls is furthermore improved (0.36 W/m²K and 0.4 W/m²K, respectively).

Table 4: Measures of Variant 1 and Variant 2

Measure	Variant 1 (Short PBP)	Variant 2 (nZEB)
Roof insulation	1 W/m²K	**0.36 W/m²K**
Wall insulation	0.57 W/m²K	**0.4 W/m²K**
Floor insulation	3 W/m²K	3 W/m²K
Windows	2.5 W/m²K, G = 0.65	**1.2 W/m²K, G = 0.6**
Window fraction (average)	**30 %**	**30 %**
Thermal mass	Medium	Medium
Shading	Overhangs	**Automatic shading**
Air leakages/infiltration	0.25 1/h	0.25 1/h
Heating system	Four pipe heat pump system - COP 3.5	Four pipe heat pump system - COP 3.5
Cooling system	Four pipe heat pump system - COP 3.3	Four pipe heat pump system - COP 3.3
Hot water	Electric	**Electric and solar thermal**
Ventilation system	Natural	Natural
Lighting system	LED	LED
Renewable energy	No	**PV and solar thermal**
Temperature setpoint: heating	**20°C**	**20°C**
Temperature setpoint: cooling	**26°C**	**26°C**

Note: Bolded entries indicate those that differ from the current situation.

3.3.1.4 Results

The final energy demand, emissions, and energy costs decrease with increasing investment costs, all three show a similar trend. Between baseline, current situation, and Variant 1, each new introduced variant decreases energy demand, emissions, and energy costs by 30%-50%. The gap between Variant 1 and Variant 2 is different. The final energy demand decreases by 12%, emissions decrease by 95%, and energy costs decrease by 47%. The investment costs show stronger fluctuations. The costs rise about 84% from baseline to current situation before they drop for 12% (comparing current situation and Variant 1). The additional measures of Variant 2 result in a 42% increase in investment costs compared with Variant 1.

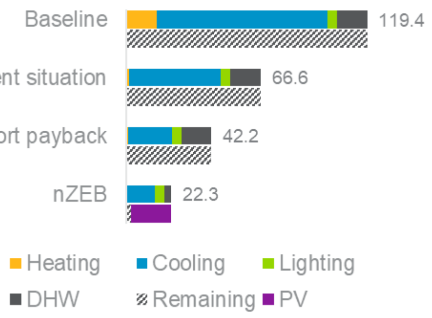


Figure 10: Specific final energy demand [kWh/(m²*a)]

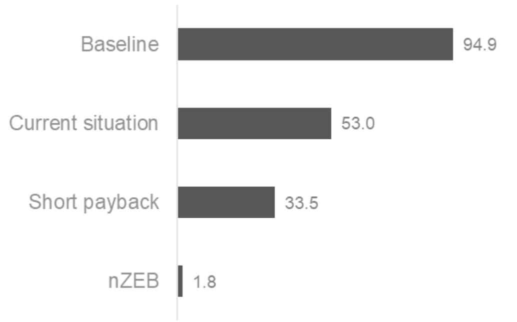


Figure 11: Specific emissions [kg CO2e/(m²*a)]

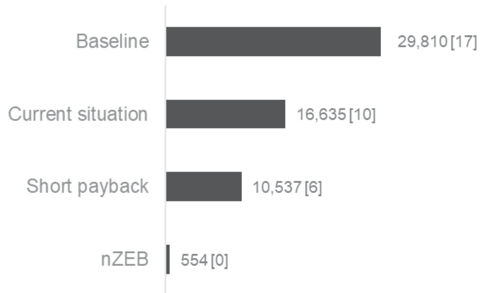


Figure 12: Specific energy costs LBP/(m²*a) [EUR/(m²*a)]

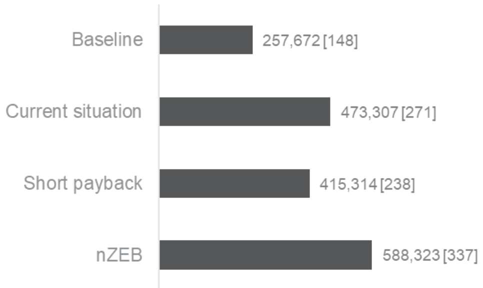


Figure 13: Specific investment costs LBP/(m²*a [EUR/(m²*a)]]

3.3.1.5 Recommendation

Design Engineering Partners (DEP) confirmed consideration for several of the suggested measures related to HVAC and the building envelope for this project, which was still in the design phase as of December 2018. Specifically, the developers are assessing using heat pumps for cooling and heating, employing double walls with insulation, and insulating the roof and installing windows with the recommended U and G values. A differentiation between short-term, mid-term, and long-term considerations must be made. Short-term considerations include the reduction of the window fraction to a maximum of 30% and the appropriate selection of setting temperature. The use of solar energy (PV and solar thermal) builds the mid-term consideration. A long-term recommendation and best case for an nZEB is to market the development as a frontrunner in the Lebanese green built environment.

3.3.2 Dolmen – Lamartine Hills, Bhamdoun

3.3.2.1 General Information

Lamartine Hills Residence is planned by Dolmen Development, which was founded in 1996 as a contracting company and evolved to cover all aspects of real estate projects. The development is planned for the green Lamartine valley in Bhamdoun, which is 18 km southeast of Beirut. The project offers 21 types of apartments in four blocks, with a private staircase and an elevator for each block. Each block is composed of four floors and a basement with a service area. The total plot area of the site is about 600 m² and rises 1050 m above sea level.

Figure 14: Illustration of the Lamartine Hills Residence

The climate at the project site in Bhamdoun is balanced. However, the temperatures can decrease into ranges less than zero during winter. External temperatures range from less than zero to 37°C with average temperatures around 20°C. January is the coldest month, July is the hottest. The minimum temperature level falls to less than 0°C, which means that frost issues play a role in construction project planning. There is slightly greater need for heating demand rather than cooling, as the high number of 1,517 heating degree days indicate. However, the cooling degree days reach 1,063 due to an annual horizontal solar irradiation of 1,871 kWh/(m²) which makes this location temperature-balanced. Thus, a big potential for renewable energy lies within the solar irradiation in Bhamdoun. Horizontal irradiation of 1,871 kWh/(m²*a) and great than 1,000 kWh/(m²*a) for east, south, and west orientation create opportunities for energy generation through solar radiation and solar air conditioning.

Table 5: Main information overview

Criteria	Input
Number of expected inhabitants	~32 per block
Utilisation	Residential
Year of construction	2018/2020
Number of floors	Four and a basement
Number of apartments	Four and a basement
Conditioned floor area	1,408 m²
Clear room height	2.90 m²
Conditioned volume	4,038 m³
Roof area	352 m²
Wall area	704 m²
Floor area	352 m²
Window fraction per orientation (NW/NE/SW) in m²	33/47/27

3.3.2.2 Baseline and Current Situation

The baseline situation reflects the current state of construction in the respective country. Heat supply is realised with diesel boilers and cold supply with split units with a COP of 2.5; and hot water is supplied by an electric instantaneous appliance. Furthermore, no thermal insulation was assumed for the building envelope.

In this baseline scenario, heating energy represents the largest portion of energy demand with a total share of 68%. Domestic hot water demand reaches 11% of total demand, and cooling and lighting reach 17% and 4%, respectively, of total demand. The current situation reaches an energy demand of 131 kWh/(m²*a) and an environmental impact of 61.2 kg CO2e/(m²*a). For a unit of 90 m², the energy cost will reach about EUR 78 per month or LBP 136,380. This data represents the standard building package.

The following current planning has been shared with the BUILD_ME project: Use of thermal insulation in the roof, external walls, floor, and windows to reduce thermal losses; the reduction of solar gains realised through overhangs; and a heating and cooling system exchanged by a gas condensing boiler for heating with an efficiency of 103% and a VRF with COP 3.2 (cooling).

Table 6: Baseline and current situation overview

Measure	Baseline	Current situation
Roof insulation	4 W/m²K	**1.13 W/m²K**
Wall insulation	1 W/m²K	**0.7 W/m²K**
Floor insulation	3 W/m²K	**1.13 W/m²K**
Windows	5.7 W/m²K, G = 0.85	**2.0 W/m²K, G = 0.65**
Window fraction	15 %	15%
Shading	No	**Overhangs**
Air tightness	0.25 1/h	0.25 1/h
Heating system	Diesel boiler	**Gas condensing boiler - 103%**
Cooling system	Split unit - COP 2.5	**VRF - COP 3.2**
Hot water	Electric instantaneous	Electric instantaneous
Ventilation system	Natural	Natural
Lighting system	LED	LED
Renewable energy	No	No
Temperature setpoint: heating	21°C	21°C
Temperature setpoint: cooling	24°C	24°C

Note: Bolded entries indicate those that differ from the baseline values.

3.3.2.3 Variants

Technical Description – Variant 1 – Short PBP

The Variant 1 calculates the energy performance of the easily attainable measures that have a payback of less than 2 years. Compared with the current situation, the thermal insulation of roof, exterior walls, floor, and windows is improved to reduce thermal losses. In addition, the temperature setpoint for heating and cooling is adjusted to 26°C (heating) and 20°C (cooling).

Technical Description – Variant 2 – nZEB

Variant 2 aims to reach a nearly zero energy building (nZEB) level and therefore considers more cost investments than Variant 1. Comparing both variants, Variant 2 includes rooftop PV and solar thermal appliances, efficient windows (U-value 0.8 W/m²K and a G-value 0.5), automatic shading, and an air infiltration rate of 0.05/h. Additionally, the insulation of the roof and walls is further improved (0.36 W/m²K and 0.4 W/m²K).

Table 7: Measures of Variant 1 and Variant 2

Measure	Variant 1 (short PBP)	Variant 2 (nZEB)
Roof insulation	**0.67 W/m²K**	**0.36 W/m²K**
Wall insulation	**0.7 W/m²K**	**0.4 W/m²K**
Floor insulation	1.13 W/m²K	1.13 W/m²K
Windows	**1.2 W/m²K, G = 0.65**	**0.8 W/m²K, G = 0.5**
Window fraction	15 %	15 %
Shading	Overhangs	**Automatic shading**
Air tightness	0.25 1/h	**0.05 1/h**
Heating system	Gas condensing boiler - 103%	Gas condensing boiler - 103%
Cooling system	VRF - COP 3.2	VRF - COP 3.2
Hot water	Electric instantaneous	Electric and **solar thermal**
Ventilation system	Natural	Natural
Lighting system	LED	LED
Renewable energy	No	**PV and solar thermal**
Temperature setpoint: heating	26°C	26°C
Temperature setpoint: cooling	20°C	20°C

Note: Bolded entries indicate those that differ from the current situation.

3.3.2.4 Results

The investment costs of the three variants increase according to the degree of Energy efficiency improvement. In contrast, the final energy demand, emissions, and energy costs decrease with increasing investment costs. For all four variants, the differences between the baseline and current situation range from 40%-55%, between baseline and Variant 1 range from 55%-65%, and between baseline and Variant 2 range from 80%-90%.

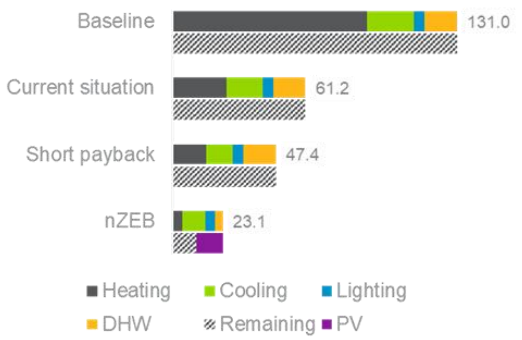


Figure 15: Specific final energy demand [kWh/(m²*a)]

Figure 16: Specific emissions [kg CO2e/(m²*a)]

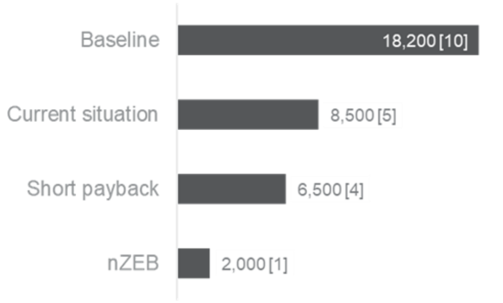


Figure 17: Specific energy costs LBP/(m²*a) [EUR/(m²*a)]

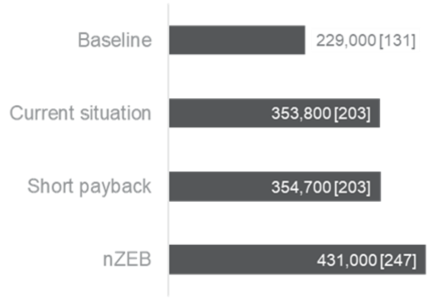


Figure 18: Specific investment costs LBP/(m²*a [EUR/(m²*a)]]

3.3.2.5 Recommendation

To reduce the energy consumption in the Lamartine Hills Residence, three approaches should be considered factoring in their payback. In the short term, all renewable energy measures with a short payback period should be considered, such as reducing the fraction of windows to a maximum of 30% and educating inhabitants to adjust the target temperature for cooling and heating to 26°C and 20°C, respectively. The implementation of these measures to improve renewable energy is almost cost-neutral.

As a medium-term consideration, an unshaded space on the roof facing south should be reserved for the installation of PV and solar thermal collectors. The low payback period of about 5 years and the visibility of solar energy on the roof supports the marketability of the sustainability of the site. In addition, the use of solar energy on the roof increases roof terrace comfort when the solar system is raised at a height of 3 meters.

As a long-term consideration, a test case of an nZEB package could be implemented as a pioneer in the Lebanese building sector. This project could be marketed as a green development in the Lebanese energy sector.

4. PROPOSED MEASURES AND EXPECTED IMPACT

4.1 Proposed Policy Measures to Address Challenges

Based on the key findings of the first project phase, a set of policy modules per stakeholder group was developed to address the identified barriers to the development of the construction sector in Lebanon towards zero emissions. In a three-part approach, the rationale, implementation and impacts were analyzed.

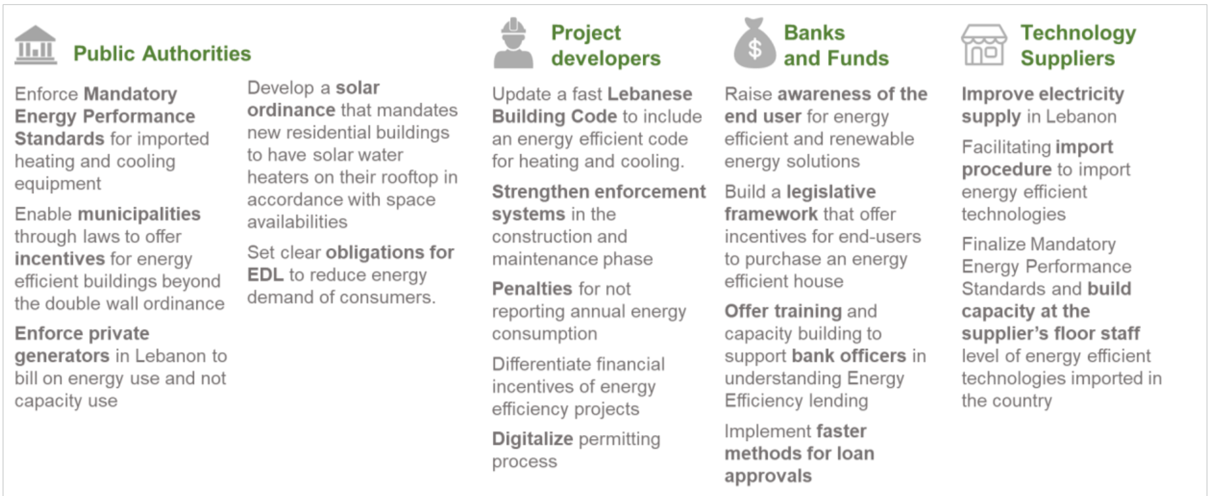


Figure 19: Policy measures proposed by stakeholders in interviews

4.1.1 Public Authorities

4.1.1.1 LEB_PA_01: Enforce Mandatory Energy Performance Standards for heating and cooling equipment being imported in the country

- **Rationale:** One of the main barriers project developers were facing in implementing energy efficient solution was the fear to lose competitive edge with other developers, who chose low cost equipment to sell apartments at minimum upfront cost to their customers. By banning the import of technologies that do not respect the Minimum Energy Performance Standards (MEPS) from entering the market, authorities can ensure to project developers the same level playing field. In addition, MEPS would facilitate the sales of efficient equipment's in retail stores as equipment will be using an energy labelling.

- **Implementation:** LIBNOR

- **Impact:** If implemented, this recommendation will have a high impact as it would guarantee a minimum threshold of efficient products in the country.

4.1.1.2 LEB_PA_02: Regulate laws that enables municipalities to offer incentives for energy efficient buildings beyond the double wall ordinance

- **Rationale:** Municipalities are bound by legislation which restricts their rights to give explicit incentives to energy efficient buildings. The current building code provides the municipalities the option to give one limited incentive for buildings for the usage of double wall.

- **Implementation:** Update the law in order to give municipalities a bigger role in the permitting procedure. The municipality as a local authority, will have a better insight on the projects that are being developed under its jurisdiction. After giving the municipalities this power, they could give incentives for new buildings that are more environmentally friendly by prioritizing their applications and giving them incentives such as higher investment opportunities. This needs to be combined with the need to strengthen enforcement systems in order to discourage any free riders.

- **Impact:** By offering additional incentives to project developers implementing energy efficiency solutions, municipalities can spur market demand.

4.1.1.3 LEB_PA_03: Develop a solar ordinance that mandates new residential buildings to have solar water heaters on their rooftop in accordance with space availabilities, otherwise mandate the installation of a heat pump

- **Rationale:** With the absence of a solar ordinance, real estate developers do not find themselves obliged to equip their buildings with Solar Water Heaters (SWH). This problem makes it difficult for the end user to purchase and install a SWH as he will have to provide a space on the roof along with installing the relevant network for the SWH to reach his household.

- **Implementation:** LCEC is currently developing a solar ordinance in cooperation with the Higher Council of Urban Planning. The solar ordinance will enforce a minimum SWH installation in new buildings. This will be combined with the need to install air-to-water heat pumps in buildings with limited roof availability. After reaching an agreement between both sides, the ordinance will go along the legislative pass in order to become mandatory and to be included in the Lebanese building code. A strong enforcement system needs to be developed as well as intensive capacity building activities for engineers in order to familiarize them with the new requirements.

- **Impact:** Higher share of hot water needs (and to a lesser extent space heating needs) covered by renewable energy.

4.1.2 Project Developers

4.1.2.1 LEB_PD_01: Update Lebanese Building Code to include an energy efficient code for heating and cooling. The code becomes mandatory for all new buildings construction.

- **Rationale:** Engineers in Lebanon oversize heating and cooling systems, prioritizing safety and comfort over efficiency, and do not design control systems to optimize operation and cut energy costs. Heating and cooling load modelling is rarely conducted, back on the envelope calculations are common practice.

- **Implementation:** LIBNOR, the Order of Engineers, LCEC and the Higher Council for Urban Planning cooperate to update and ensure the implementation of the building code. LIBNOR takes the lead to create Lebanese green standards for building codes. The code shall require engineers to submit detail calculation of the heating and cooling demand of the building, considering passive and active measures in energy efficiency and limiting safety factors to international AHRAE standards. LCEC supports LIBNOR in preparing the codes and the OEA forms a technical committee to review the new codes. The Higher Council for Urban Planning is responsible to inspect designs for compliance with code/inspect site for compliance with construction. The four organisations are cooperating already to update the double wall ordinance following the roadmap of the National Energy Efficiency Action Plan 2016-2020 of Lebanon. LIBNOR initiated the process two years ago and is at POC of 40%. Plans to finalize first draft by 2019. The support of international consultants can be requested on demand from the parties.

- **Impact:** Reviewing the building code is crucial for accelerating EE measures at the design level. This recommendation is the base or the starting point for other recommendations such as enforcement, incentives differentiation and accelerating the permitting process as it sets the rules for EE measures and designs.

4.1.2.2 LEB_PD_02: Strengthen enforcement systems in the construction and maintenance phase, applying severe penalties to the engineering design company for non-compliance to the energy efficiency building code and to the facility manager of the residential building for not reporting annual energy consumption

- **Rationale:** Most of the projects present an initial plan for the authorities and then undergo multiple modifications without notice. In addition, municipalities inspectors lack the engineering knowledge to inspect the compliance of innovative energy efficient solutions e.g. air to water heat pumps.

- **Implementation:** The Order of Engineers and Architects Association (OEA), the Ministry of Interior and the Higher Council for Urban Planning forms an independent body of certified inspectors. This third-party will have the responsibility to ensure a reliable inspection and a correct enforcement of the building code for new buildings. The Ministry of Interior must grant the authority to this party to set penalties for non-compliance. The OEA is responsible to certify the inspectors. International consultants can support the OEA for the certification process if requested. This third-party will also be responsible to monitor the annual energy consumption of new buildings and will be granted the authority to request from facility manager annual reporting on the energy consumption of new buildings.

- **Impact:** This recommendation is likely to have a high impact as it ensures the implementation of the EE measures stated at the design level and for which the developers benefited from incentives. It will also provide a new database to authorities in order to monitor the annual energy consumptions of new buildings and verify annual energy savings.

4.1.2.3 LEB_PD_03: Differentiate financial incentives between energy efficiency projects, offering highest incentives for projects with highest ambition, and distribute a standard economic tool that can benchmark applications

- **Rationale:** Financial incentives currently exists in Lebanon for applying energy efficiency measures. The current framework does not give an incentive to reach the highest energy savings, it follows a minimum savings only approach. In addition, the financial calculations conducted by engineers in the NEEREA loan application are not detailed enough and simplistic. There is no standard baseline to compare the benefits of the energy efficiency measure to, which makes it impossible for LCEC to benchmark the applications and screen best in class measures.

- **Implementation:** LCEC should develop a standard tool that conducts the cost benefit calculations of different energy efficiency measures, following a) user specific engineering input on the heating and cooling demand of the building b) capital cost of the energy efficiency measure c) technical efficiency of the measure. The tool should be apt to categorize the measures in Bronze, Silver or Gold packages according to the (dynamic) payback period. Measures with shortest payback period are sorted in Bronze, longest payback Gold. Higher incentives (e.g. increasing grace period, lower interest, increasing floor area) should be granted to Gold package. These measures will be the ones with the highest Net Present Value (NPV). International consultant can support LCEC in developing the tool if requested and train engineers how to use it.

- **Impact:** This measure is likely to have a high impact, as energy efficiency measures with highest NPV are the measures that saves the highest energy over lifetime. However, with longer paybacks they do not get chosen. If incentives exist now to push these, then engineers will choose the technologies with highest impact.

4.1.2.4 LEB_PD_04: Digitalize permitting process

- **Rationale:** Bureaucratic procedures slow down the permitting process and increase cost on the side of project developers. Once an energy efficiency building code is put in place, the process of assessment for compliance with the new code and enforcement needs to be as transparent and clear as possible. Thus the need to digitalize the whole process to ensure adequate enforcement.

- **Implementation:** Identify funding and third party to prepare an online platform and application system to be adopted by the relevant authorities in collaboration with the OEA, the Higher Council for Urban Planning and local authorities. This third party will be responsible to computerize the building design review and permitting process by implementing new software with online applications and machine verification processes. In this process, faster measures can be implemented for projects with energy efficiency measures. Lessons can be learned from the Ministry of Finance and Ministry of Telecommunication where digitalization has proven to enhance operation.

- **Impact:** Decrease administrative burden for applying energy efficient measures, increase transparency at the permitting level and accelerate the rate of new energy efficient constructions in the country.

4.1.3 Suppliers

4.1.3.1 LEB_S_01: Improve electricity supply in Lebanon in order to reduce energy subsidies and improve the business case of energy efficiency technologies

- **Rationale***:* Electricity tariffs levels are set below cost recovery in Lebanon. The cost of electricity generation by EDL reached 22.73 US c/kWh while electricity tariffs ranges from 2.33 to 13.33 US c/kWh depending on consumption bands. Tariffs need to be gradually increased with the improvements in electricity supply. This will give a boost for energy efficiency measures, which will pay back faster and have a higher NPV compared to a baseline.

- **Implementation:** The Policy Paper for the Electricity Sector, published by the Ministry of Energy and Water, includes a specific plan to gradually restructure and increase the electricity tariff in conjunction with the increase of supply. It also includes the adoption of special tariffs for low income consumers and productive sectors, and to implement Time of Use (TOU) tariffs in conjunction with the implementation of Automatic Meter Reading (AMR) schemes. These tariffs are to be regularly reviewed to reflect actual costs without causing further deficit to the National Treasury.

- **Impact:** Increasing awareness of consumers on their energy consumption. Improvement of the business case of energy efficient measures. Improvement of revenues of energy utilities. Electrification of heating sector. Decrease in use of boilers

4.1.3.2 LEB_S_02: Incentivize suppliers to import energy efficient technologies by facilitating import procedure

- **Rationale:** One of the main barriers suppliers were facing in importing energy efficient technologies was the fear to loose competitive edge with other suppliers, who chose low cost equipment to sell at minimum upfront cost to their customers. By banning the import of technologies that do not respect the Mandatory Energy Performance Standards (MEPS) from entering the market, authorities can ensure to suppliers the same level playing field. In addition, MEPS would facilitate the sales of efficient equipment's in retail stores as equipment will be using an energy labelling.

- **Implementation:** The first step would be to impose high fines on products not meeting requirements or producers' labels, then to enforce MEPS to ban products with low energy performance. Furthermore, to upgrade IRI laboratory facilities to facilitate the testing procedures and standards, then to upgrade IRI's testing facility to test energy performance measures (IRI to follow international standards and certifications to reduce the level and time of testing), and to increase its capacity in order to decrease response time. In the meantime, LIBNOR would prepare standards for efficiency requirements. Products that are already certified from accredited laboratories abroad, and that have the correct energy performance labels would benefit from reduced testing requirements.

- **Impact:** Ensuring European labelling or equivalent on products entering the market will impose a certain minimum level of safety and performance. Giving Incentives to products with an energy efficient European label (or equivalent) will ensure that importers target the right quality of technologies.

4.1.3.3 LEB_S_03: Finalize Mandatory Energy Performance Standards and build capacity at the supplier's floor staff level on the economic and environmental benefits of energy efficient technologies imported in the country

- **Rationale:** Our interviews with 300 consumers in Lebanon proved that the biggest driver for them to purchase an energy efficient heating or cooling technology at a retail store is the ability of the vendor to present convincing arguments to defend the case. Vendors should guide customers in their purchase, explaining that the benefits of energy efficiency pay off over the lifecycle of the equipment and how the present value of the technology should be their decision factor for a profitable investment. They should inform them about the possibility of financing mechanism to cover the additional upfront cost. The second factor driving consumers in Lebanon to purchase energy efficient technologies was the presence of an energy efficiency label, hence the importance of finalizing the MEPS in Lebanon.

- **Implementation:** Intensive capacity building activities for the suppliers' floor staff level is needed to equip them with the correct knowledge to better sell and favour heating and cooling technologies with higher energy efficiency even at higher costs, informing consumers about available financing options. This needs to be combined with a labelling scheme and a widespread public awareness campaign.

- **Impact:** Increasing demand for energy efficient products and wider use of available financial incentives.

4.1.4 Banks

4.1.4.1 LEB_B_01: Raise awareness of the end user on the social, economic and environmental benefits of energy efficient and renewable energy solutions in the building sector and the NEEREA applications

- **Rationale:** Lack of awareness on the added benefits for the country for every kWh saved or produced with renewable power compared to business as usual and how reduction in energy subsidies could translate in improved public services. Lack of awareness on the impacts of climate change in Lebanon for future generations. Lack of awareness of end-users on the existence of the NEEREA loan and the possibility to retrofit their residents to reduce their energy consumption.

- **Implementation:** The Ministry of Energy and the Central Bank should lead nation-wide campaign to alter the customer mindset and drives market demand for NEEREA loans from the end-user. Advertisements should raise the awareness of citizens in their role in reducing the public debt of the country by reducing their energy consumption by investing today in energy efficient and renewable solutions. A national website grouping all information on the potential of energy efficiency measures in residential households and the contacts of certified ESCOs able to implement these measures should be built. Lessons from the campaign "Deutschland Macht Effizienz" (Germany goes for Efficiency) can be transferred. To be most effective at changing traditional ideologies, campaign should target universities and schools and introduce curriculums on impacts of climate change and mitigation measures. Finally, all new public buildings should have at their entrance their Energy Performance Certificate and market how energy efficient solutions are reducing the energy bill of the building and saving CO_2 emissions. This measure has been taken in Germany and proven to be effective at raising awareness.

- **Impact:** Increasing awareness of the end-user, driving increasing applications for NEEREA loans, which in turn pushes project developers to apply energy efficient solutions

4.1.4.2 LEB_B_02: Build a legislative framework that offer incentives for end-users to purchase an energy efficient house

- **Rationale:** The NEEREA loan does not offer a low interest loan for end-users who wish to purchase an energy efficient apartment/household available in the market. It offers a low interest loan for investing in single energy efficient or renewable energy measures in your own property or it offers a low interest loan for a project developer that plans to take energy efficiency measures in his project to be sold to a client. There exists hence no direct incentive for an outside buyer to buy an energy efficient apartment. If a project developer is able to raise funds from investors without a NEEREA loan to implement energy efficient solutions in his new project, the existence of direct incentives for end-users in purchasing an energy efficient house would facilitate considerably the sales of his apartments. To avoid the Central Bank from excessive subsidies, new apartments built by a project developer who benefitted from a NEEREA loan cannot benefit again from direct low interest loans to end-user.

- **Implementation:** The central bank of Lebanon issues a circular to commercial banks similar to circulate 316 issued in 2010. Citizens can benefit from a low interest loans to purchase energy efficient apartments under the condition that the project developer did not benefit previously from a NEEREA loan and that the apartment is LEED or BREEAM certified with a A+ standard

- **Impact:** Increase directly market demand for energy efficient houses in the country.

4.1.4.3 LEB_B_03: Offer training and capacity building to support bank officers in understanding the context and business opportunities of Energy Efficiency lending, with a focus on efficient heating and cooling technologies

- **Rationale:** Because of the non-conventionality of the cash flows of an energy efficient asset, bankers do not understand how to value energy efficient solutions and considers their applications similar to normal goods, instead of depreciable assets.

- **Implementation:** International consultants can train bankers in understanding the impact of bank loans on the value of energy efficiency measures and how to categorize these from least to highest impact with respect to financial indicators. This training goes in line recommendation IV from project developers in differentiating incentives for energy efficient measures with respect to ambition.

- **Impact:** Providing such training will improve the ability of bankers to turn EE lending into innovative banking products, reducing lending risks and opening new market segments, e.g. ESCOs

4.1.4.4 LEB_B_04: Implement faster methods for loan approvals

- **Rationale:** The application for a NEEREA loan can be time consuming. Applications need to go first through a commercial bank, then to BDL for approval and then BDL transfers the technical report to LCEC who acts as the technical arm for BDL and reviews the applications. The application is then reviewed and shared back and forth between the consultant in charge of the application and LCEC. Bankers lacked the knowledge to take an educated opinion once they received the application and transfer any issue to LCEC. Since there existed no list of eligible technologies and products that could qualify for a NEEREA loan at the time when the loan was initiated, every application came with a new technology from a certain supplier. LCEC had to cross check quality of supply and ensure that applications from the consultants are complete and up to standard, which may have caused delays in application approval.

- **Implementation:** The European Investment Bank and the AFD (Agence Francaise de Development) are introducing a new financing mechanism in Lebanon knows as LEEREFF. LEEREFF will benefit from NEEREA lessons and offer an easier application process and faster approval process. The process will include a pre-qualified list of technologies that will have a simplified approval method. The international consultant GFA are commissioned to implement the mechanism and train bankers to understand the different facets of an application and take informed decisions themselves to reduce the workload on LCEC.

- **Impact:** LEEREFF Loan applications are expected to take less than 2 months, which will accelerate the uptake of energy efficient measures in the country. The downtime of NEEREA applications is expected to follow.

4.2 Impact Assessment of Proposed Policy Measures

4.2.1 Methodology

General approach:

The rough overall approach to the impact assessment is:

- Development of policy modules containing a description of the different measures, their qualitative impacts and approach how to implement.
- For each of these measures, the impact on the future system distribution in new constructions will be assumed (determining shares) for three periods and the affected share of all new constructions for the envisaged future distribution of space heating technologies, hot water generators, space cooling systems, ventilation systems and different envelope measures. Our assumptions are based on a) the results of the interview conducted with stakeholders b) data collected from pilot projects c) Navigant CBA tool to estimate which technologies will be most cost-effective given future energy prices and capital cost development of EE technologies d) guest estimates on market parameters which were not possible to quantify in the scope of our project.
- Considering the different technology distributions, efficiencies and affected shares, we use our Building Energy Performance (BEP) Model to calculate the energy demand and resulting emissions of the different building configurations.
- Combining these results of the efficiency cases (measures) with results of the Business-As-Usual (BAU) case then allows the calculation of energy and emission reductions.
- For determining the number of new constructions in the three countries, we use our Global Building Stock Model that contains building stock data and projections of these stocks for all countries of the world until 2050 and beyond.

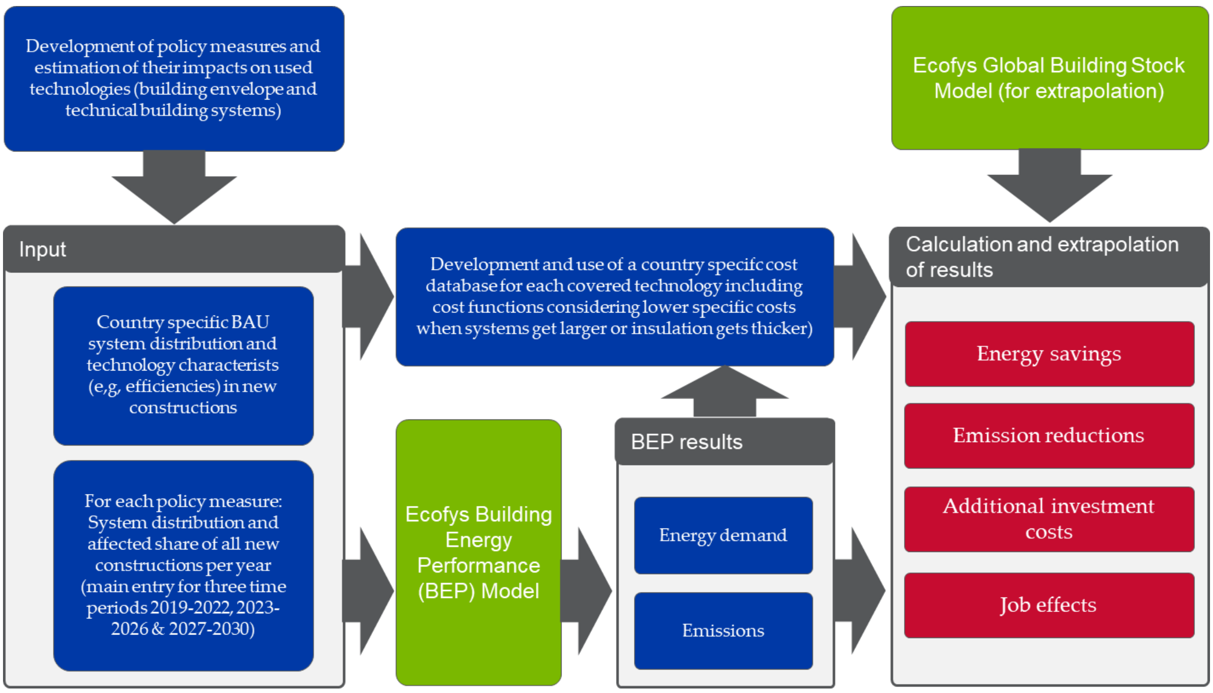


Figure 20: Definition of BAU path

The BAU path has been defined as a „Frozen Technology Reference Level ", meaning that the energetic quality of todays new constructions remain stable until 2030.

Navigant Building Energy Performance (BEP) Model:

The logic of our BEP model is illustrated in the figure below. The calculation core for calculating the useful net energy demand of a building is based on ISO 13790 (currently being updated to ISO 50016). To run the hourly calculations, the model is using a reference building and also needs other information such as climate data of the specific location of the building we extract from METEONORM.

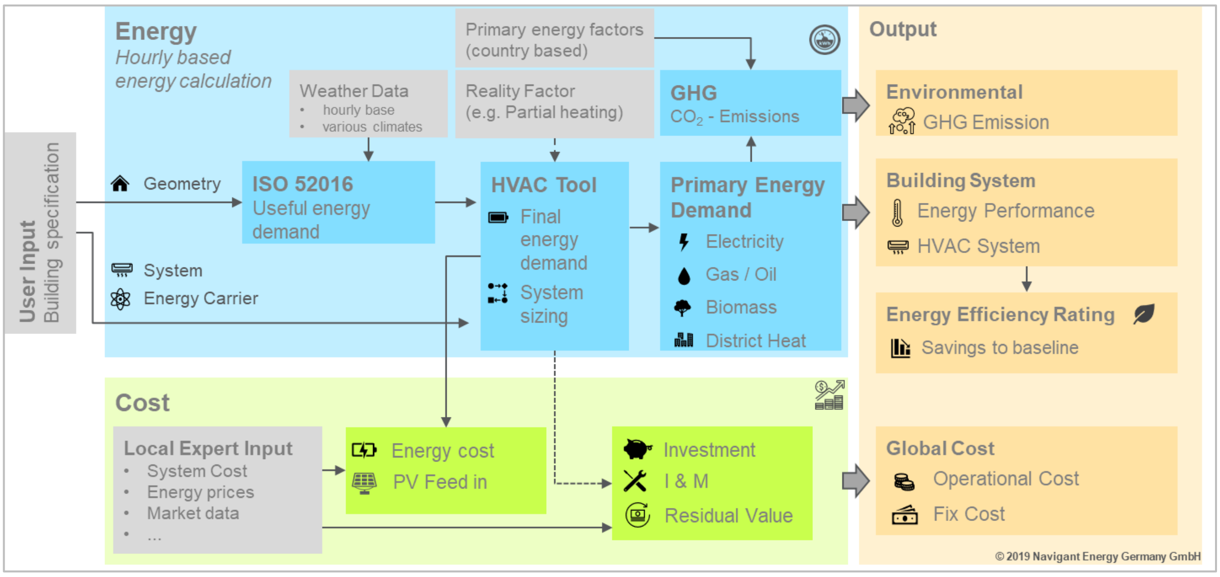


Figure 21: Navigant Building Energy Performance (BEP) Model

Navigant Global Building Stock (GLOBUS) Model:

The Navigant Global Building Stock Model uses an algorithm for calculating the size of the building stock applying correlations between economic strength (measured in GDP/capita) and available floor space per capita based on literature and own research projects. Population growth data is extracted from the "United States Census Bureau" and GDP growth assumptions from the IEA World Energy Outlook (WEO).

The methodology allows the calculation of residential and non-residential floor space separately and is based on Navigant` experiences in building stock research. The model and its underlying formulas are based on building stock statistics from about 50 countries worldwide and has continuously improved over recent years.

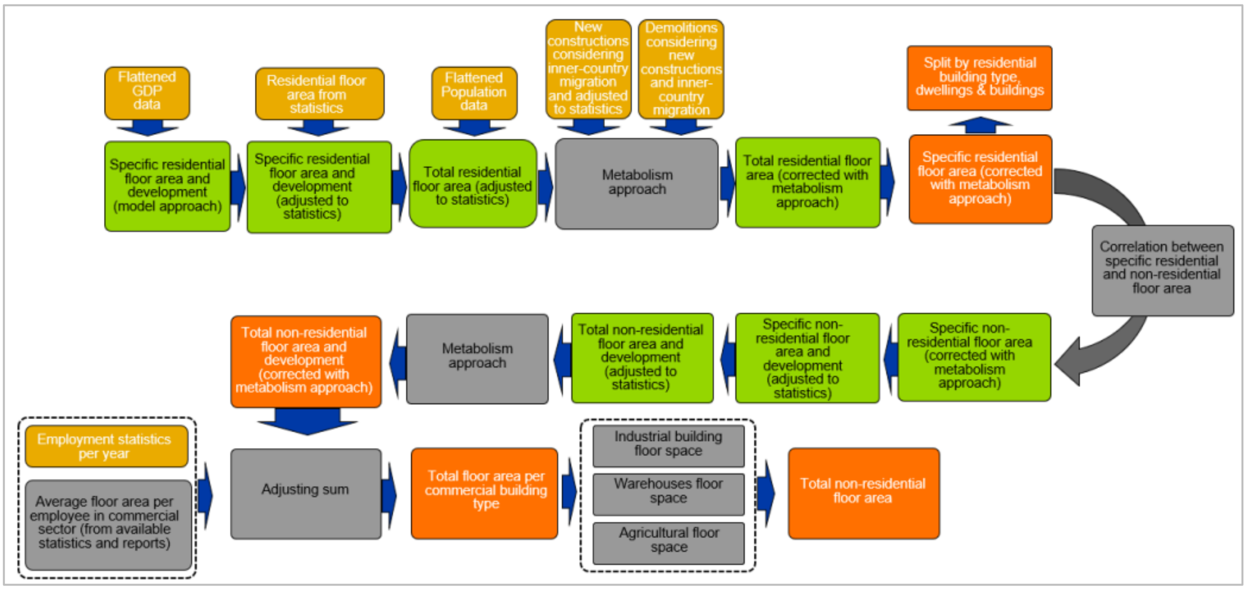


Figure 22: Illustration of the overall approach of Navigant's Global Building Stock (GLOBUS) Model

Reference building specifications:

We considered information from partners and experiences from other building sector related projects in the MENA region and therefrom designed one reference building with an average geometry that suits the requirements of the impact assessment and allows calculating representative results. It is a 6 story multi-family house with one attached wall as often constructed in the urban centers of the MENA region. The details of the geometry etc. are presented in the table below.

Table 8: Reference building

Building parameter	Unit	Value
Inhabitants	-	69
Shading factor for static external objects	-	0.90
Thermal building class	-	Very light (80,000 J/K)
Building levels (floors)	-	6
Floor height (Floor to ceiling)	m	2.90
Net floor area (i.e. living area)	m²	2,073
Roof area	m²	350
Façade area opaque	m²	928
Thereof north	m²	382
Thereof east	m²	0
Thereof south	m²	382
Thereof west	m²	164
Window area transparent	m²	242
Thereof north	m²	92
Thereof east	m²	0
Thereof south	m²	100
Thereof west	m²	50
Area floor slap	m²	350

Determination of future technology distributions and affected shares:

For each of the developed measures we assume future technology distributions and the affected shares of all new constructions. Our assumptions are based on a) the results of the interview conducted with stakeholders b) data collected from pilot projects c) CBA tool developed by Navigant to estimate which technologies will be most cost effective given future energy prices and capital cost development of EE technologies d) guest estimates on market parameters which were not possible to quantify in the scope of our project

Starting point for the future distributions is the current BAU distribution in the countries. BAU distribution in this sense means the currently present shares of different technologies that in average can be found in all new constructions of one year. Based on the type of measure, we then exchanged with our national partners on the effect of these measures on the technologies to be used in the future. As an example: In case, the measure is promotion program for Solar Water Heaters (SWH), the impact direction is clear. You could assume 100% SWH, then just still need to think about the affected share of this measure. Considering the size of the measure (e.g. program) but also the addressed stakeholder target group and implementation strategy for example the assumption could be that the program will affect 20% of all new constructions. This would mean, that the model would use a 20% share of all new constructions using the 100% SWH technology distribution and 80% BAU distribution.

In our overall calculation approach, we distinguish between three periods:

- 2019-2023
- 2024-2026
- 2027-2030

This way, we also allow a "movement" in the future development of the impacts of the measures. Related to the technology distributions and affected shares this means that the model requires input to all three periods. For some of the measures, this option can be used to consider a potential change in the future distribution. But also, the affected shares of the measures can be adjusted. An example could be that it is assumed that a measure is just starting slowly e.g. due to different market barriers or the initially small size of the program but then over time is getting more and more important, therefore the assumed affected share is growing.

Calculation of greenhouse gas abatement costs:

The results of the impact assessment also comprise the calculated abatement costs. For the calculation, the following approach has been used:

1. Sum of all additional investments (compared to BAU) taken between 2018 and 2030, annualized assuming a loan period of 25 years (assumed average between demand and supply side measures) and discount rates of 0%, 3% and 5%. This way we also present a small set of sensitivities.

2. Sum of energy cost savings (compared to BAU) of the newly constructed buildings in the year of construction between 2018 and 2030, also considering energy price developments

3. Sum of mitigated emissions (compared to BAU) of the newly constructed buildings in the year of construction between 2018 and 2030

The result presents the emission abatement costs in EURO for mitigating one ton of carbon dioxide equivalent [EUR/CO_{2e}].

4.2.1.1 Country Specific

Since Beirut compromises most of Lebanon's population, this city was chosen to serve as a reference climate for impact assessment modelling. Hence, temperatures in Beirut historically range from above 5°C to about 35"C with a mean temperature of ~21°C. Cooling degree days of more than 1,400 CDD compared to only 320 heating degree days indicate high cooling loads and low need for heating. With dry summers and rainy winters, the average relative humidity is ~65%.

The building stock is set to grow at 0.25% per annum on average from 2018 to 2030. This leads to a residential building stock of 167 million m^2 in 2030, up from 149 million m^2 in 2015 and estimated 162 million m^2 in 2018. Renovation rate is assumed to stay constant at 1.5% over this period.

4.2.2 Estimated Impacts

Energy and Emissions

In the Business-as-usual ("BAU") scenario, specific final energy demand of new built residential housing stays constant at 54 kWh/m^2. The results of the impact assessment show that two of the measures discussed in chapter 3.1 can significantly cut this to below 22 kWh/m^2, if implemented on a stand-alone basis:

- Update Lebanese Building Code to include an energy efficient code for heating and cooling. The code becomes mandatory in for all new building constructions.

- Enforce private generators in Lebanon to bill on energy use and not capacity use

Accordingly, the two measures listed above also present the highest CO_2 abatement potential of all measures. If implemented as stand-alone measures, each one would save cumulated almost 400 kt CO_2 in the period from 2018 to 2030.

Investment Costs and Job Effects

In the BAU scenario, investment cost for residential new construction are projected to contract from EUR 153 million in 2018 to EUR 86 million in 2030. The measures listed above that present the largest energy and emissions savings, consequently, also significantly increase investment costs. If one of the two measures were introduced on a stand-alone basis, annual investment in 2030 would increase to EUR 239 – 262 million. On the other hand, each of the measures would also reduce annual energy cost by EUR 5.4 million by 2030.

Increasing investment in the building stock also has an effect on employment in the sector. In the BAU scenario, employment is decreasing in line with shrinking investment volumes by a total of 263 jobs lost by 2030. In contrast, the two measures discussed in this section would create around 1,700 jobs each from 2018 to 2030 on a stand-alone basis.

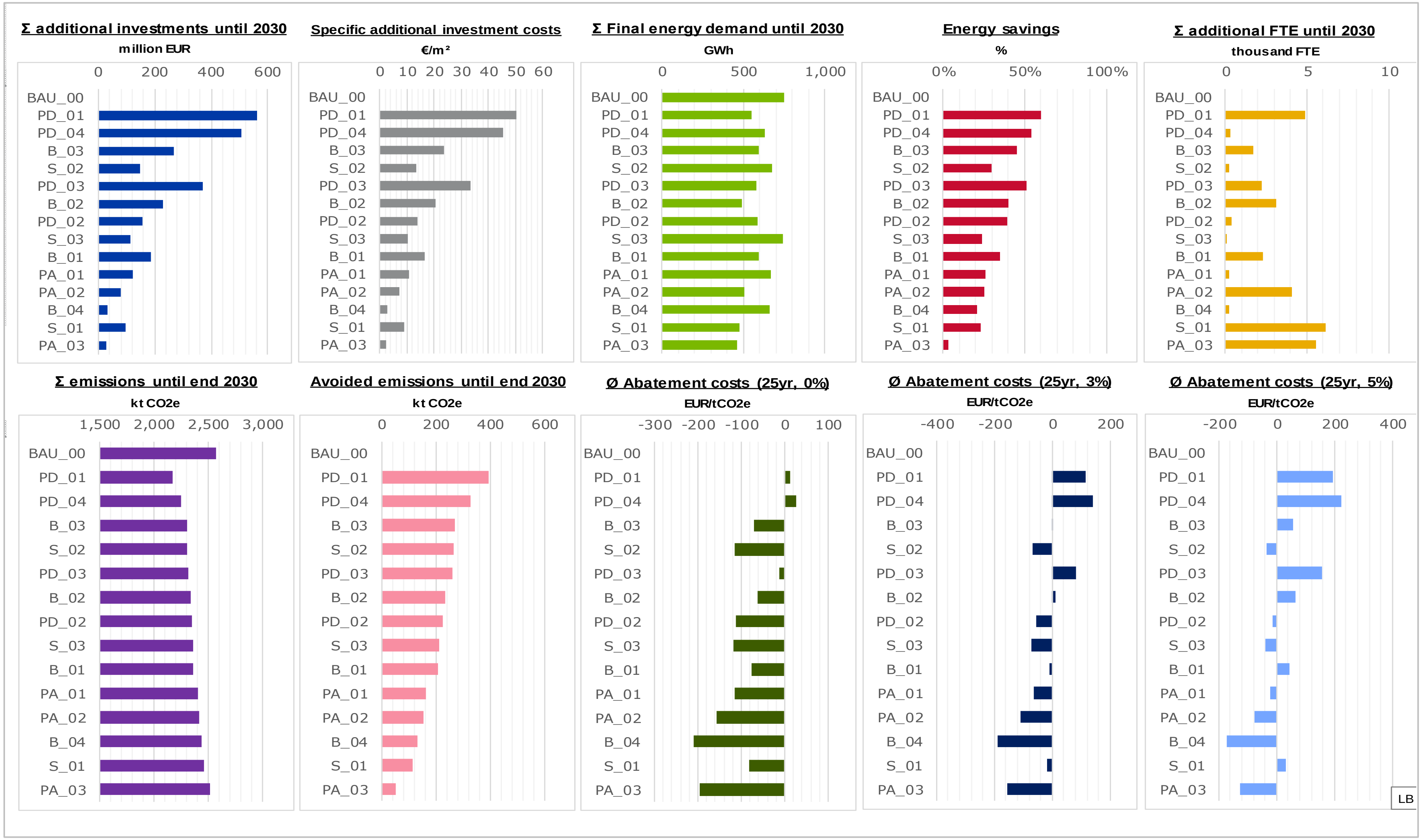


Figure 23: Summary of estimated impacts per policy module

5. KEY RECOMMENDATIONS TO BE ADDRESSED IN PHASE 2

The following table summarizes project findings for key stakeholder groups and lay down policy recommendations for accelerating energy efficiency in buildings in Lebanon. These recommendations have been derived from a round of 144 interviews with key stakeholders including suppliers, 500 representative surveys with local residents and two round-table workshops conducted in Lebanon with relevant stakeholders in 2017 and 2018 from the following groups:

Table 9: Summary of key recommendations in stakeholder groups

Stakeholder groups	Key recommendations
Public Authorities	• Establish Minimum Energy Performance Standards for heating and cooling equipment • Extend incentives for energy efficiency buildings beyond the double wall ordinance • Mandate solar water heaters with respect to rooftop availability on new buildings, with alternative the installation of a heat pump
Project Developers	• Update the Lebanese Building Code including an energy efficiency code for heating and cooling • Strengthen enforcement systems in the construction phase • Tailor existing financial incentives offerings to energy efficiency ambitions • Digitalize the permitting process
Suppliers	• Increase electricity prices to enhance the business case of energy efficiency measures • Facilitate import procedure for energy efficient products • Capacity building at the supplier floor level staff
Banks	• Raise awareness on energy efficiency and NEEREA low interest loans • Legislate a new framework to offer financial incentives directly to the end-user • Capacity training of bank officer for Energy Efficiency Lending • Implement faster methods for loan approvals

Supported by:

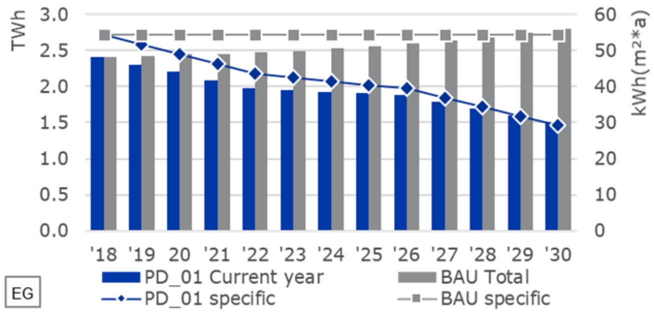
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

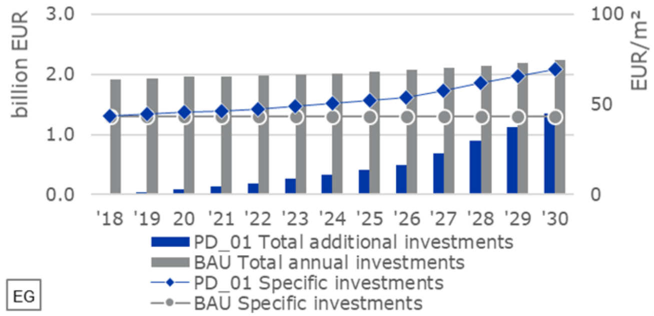
APPENDIX A. ASSESSED QUANTITATIVE IMPACTS OF POLICY MEASURES

The following pages show more detailed results for each developed policy measure. The results are presented in the following format:

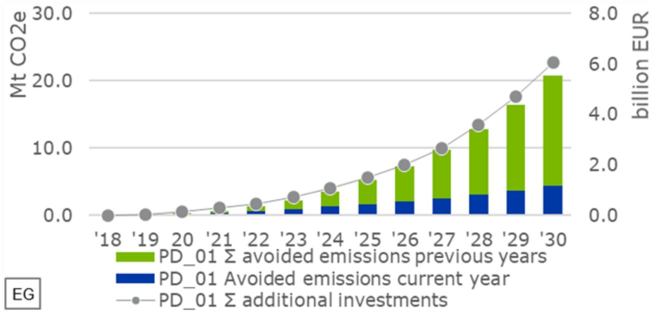
Specific Final Energy Demand



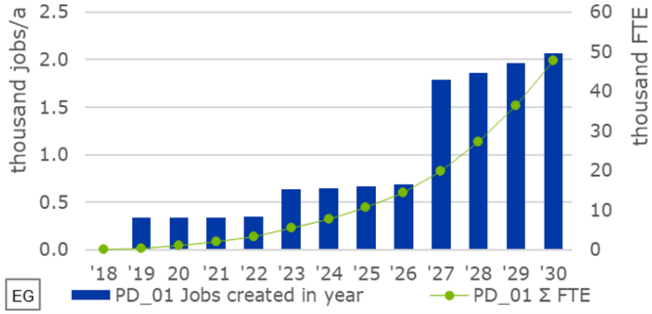
Investment Cost



GHG Emissions



Job Effects



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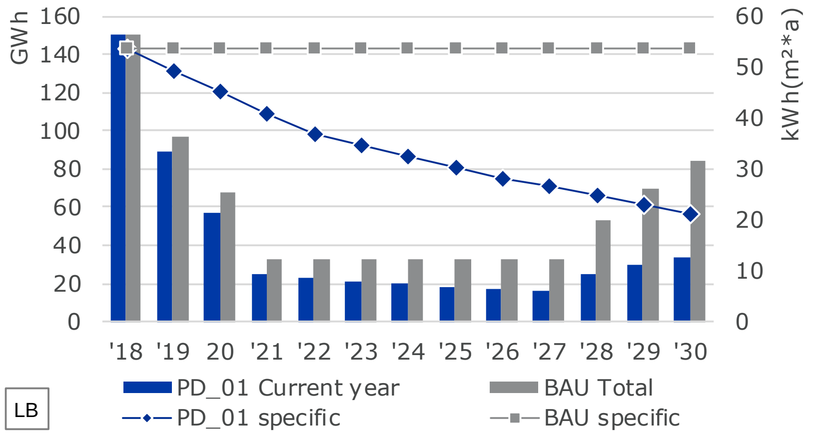
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

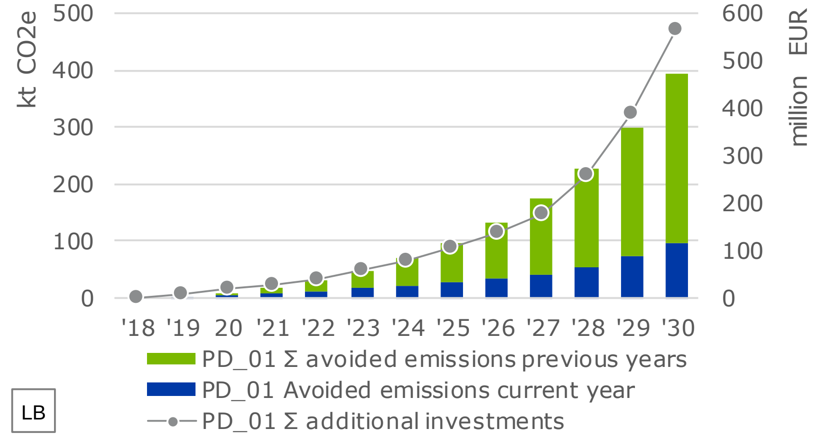
LEB_PD_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



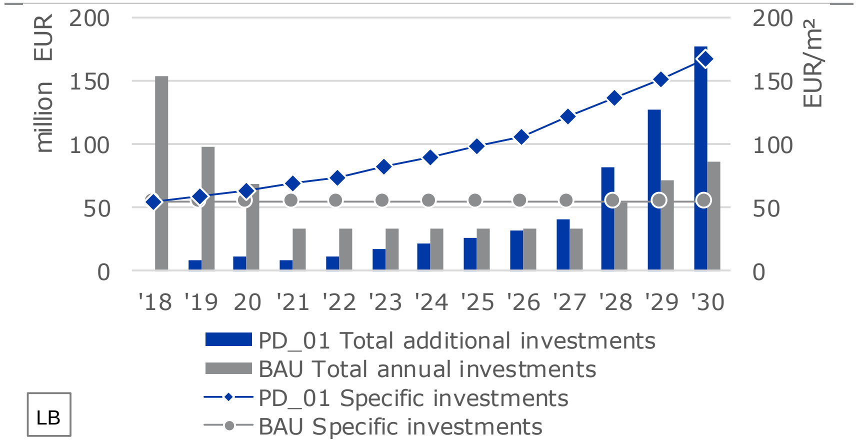
• **Energy demand of new constructions can be reduced by ~60% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



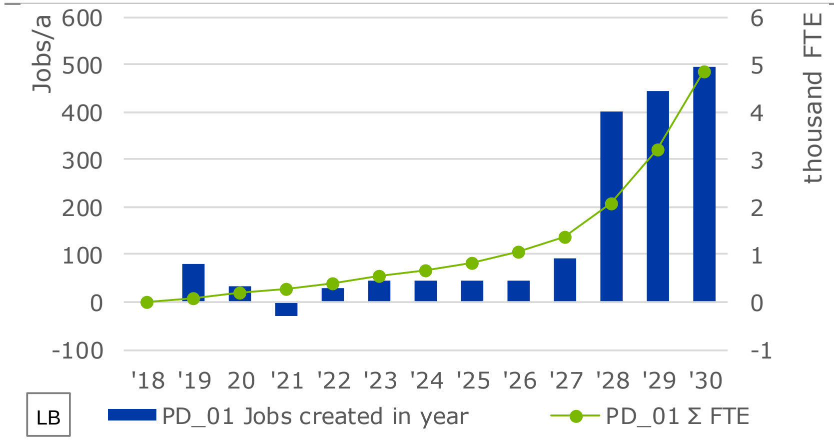
• **~90 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~47 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



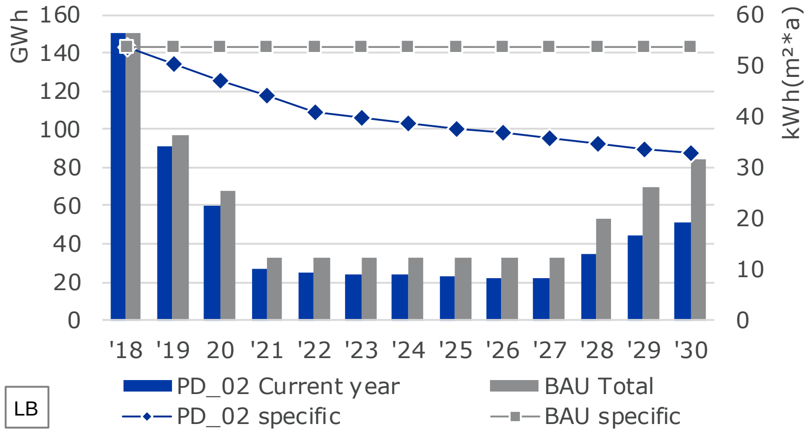
• **~1,734 jobs can be created until 2030**

LEB_PD_01: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	50%	0%	75%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	50%	0%	75%	0%	100%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	100%	50%	100%	40%	100%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	20%	++	30%	++	40%
Windows		o	50%	+	70%	++	100%
Infiltration rate		o	10%	+	30%	++	50%
Insulation Thickness	Facade	o	50%	+	70%	++	100%
	Rooftop	++	50%	++	70%	++	100%
	Ground	o	50%	+	70%	++	100%
Shadowing measures (window shading)		o	30%	+	50%	++	70%

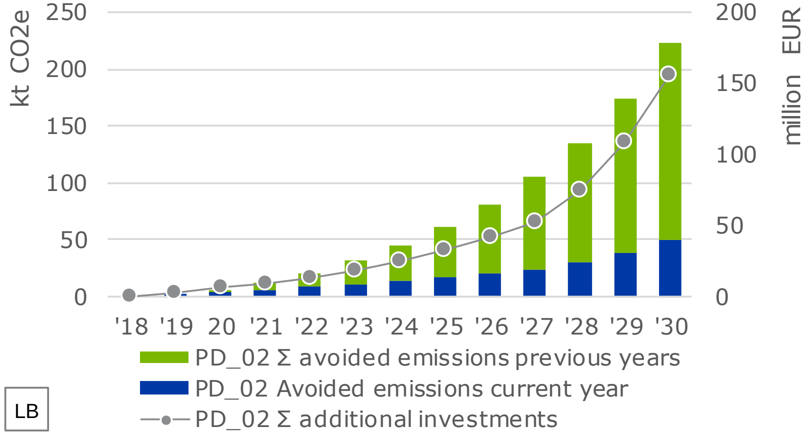
LEB_PD_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



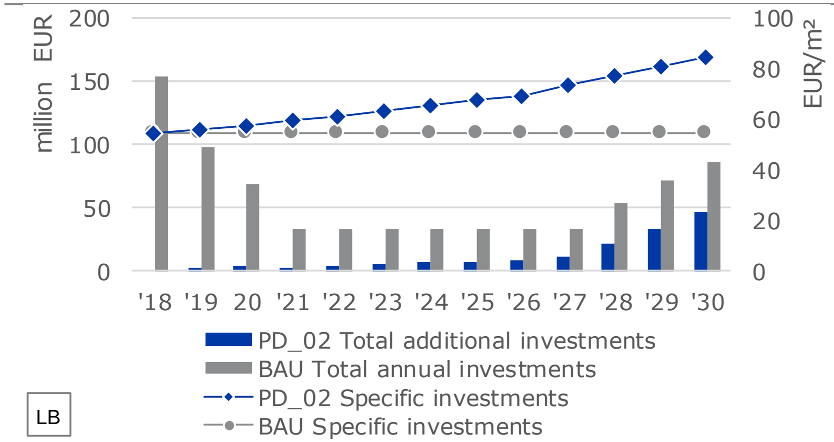
- **Energy demand of new constructions can be reduced by ~39% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



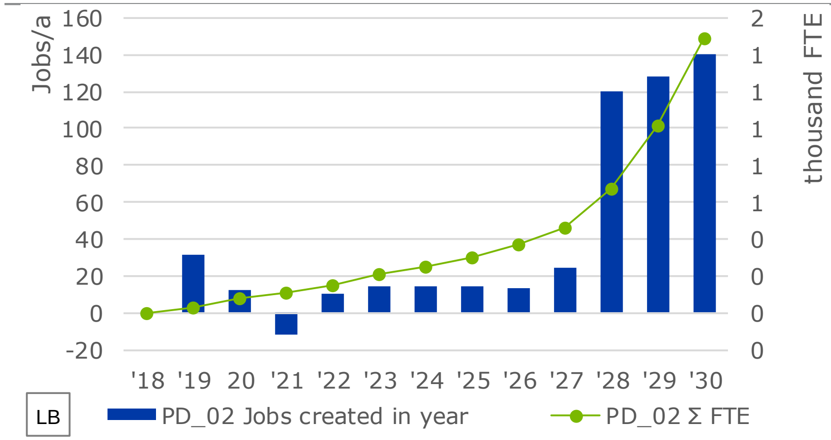
- **~40 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~13 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~512 jobs can be created until 2030**

LEB_PD_02: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	5%	0%	8%	0%	10%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	10%	0%	15%	0%	20%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	40%	50%	40%	40%	40%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	6%	++	9%	++	12%
Windows		o	10%	+	14%	++	20%
Infiltration rate		o	9%	+	27%	++	45%
Insulation Thickness	Facade	o	35%	+	49%	++	70%
	Rooftop	++	35%	++	49%	++	70%
	Ground	o	35%	+	49%	++	70%
Shadowing measures (window shading)		o	3%	+	5%	++	7%

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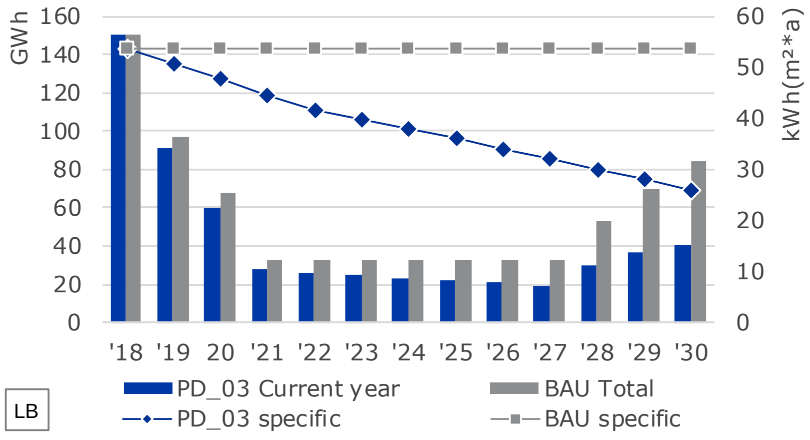
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

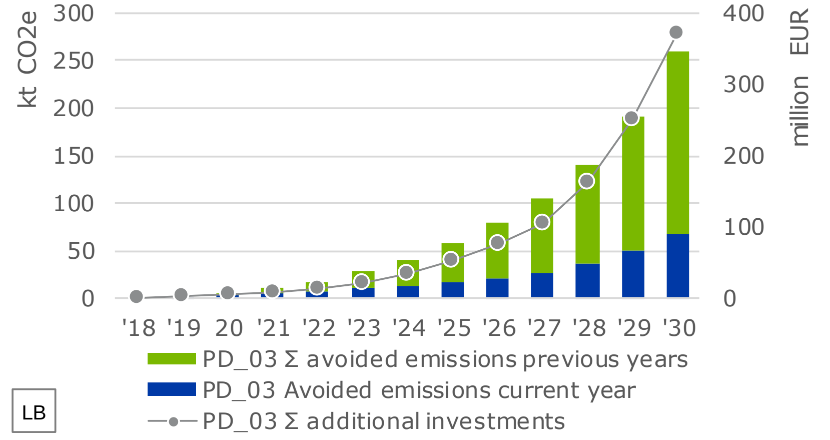
LEB_PD_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



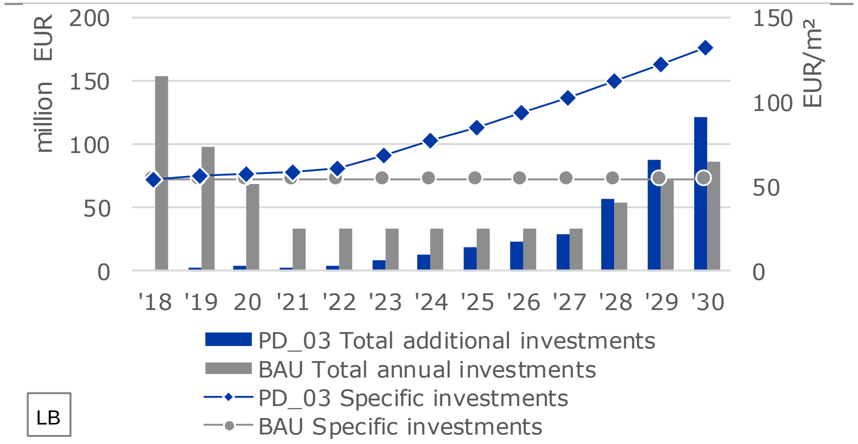
- **Energy demand of new constructions can be reduced by ~51% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



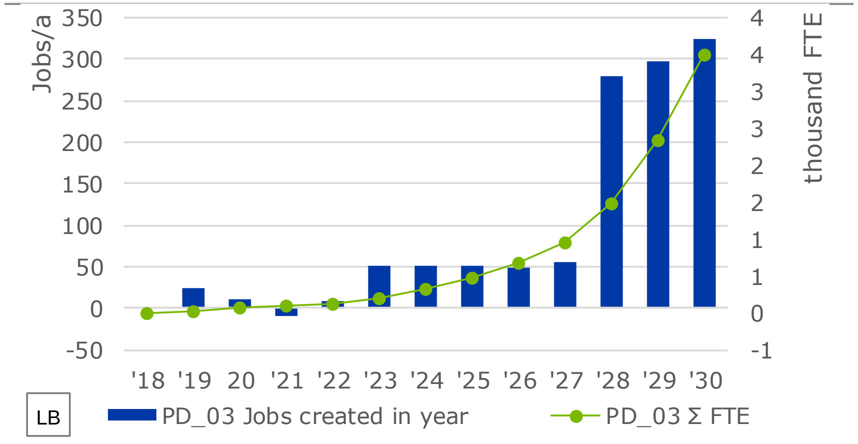
- **~60 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~31 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~1,189 jobs can be created until 2030**

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INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

LEB_PD_03: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	15%	0%	38%	0%	70%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	15%	0%	38%	0%	70%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	30%	50%	50%	40%	70%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	6%	++	15%	++	28%
Windows		o	15%	++	35%	++	70%
Infiltration rate		o	3%	++	15%	++	35%
Insulation Thickness	Facade	o	15%	++	35%	++	70%
	Rooftop	++	15%	++	35%	++	70%
	Ground	o	15%	++	35%	++	70%
Shadowing measures (window shading)		o	9%	+	25%	++	49%

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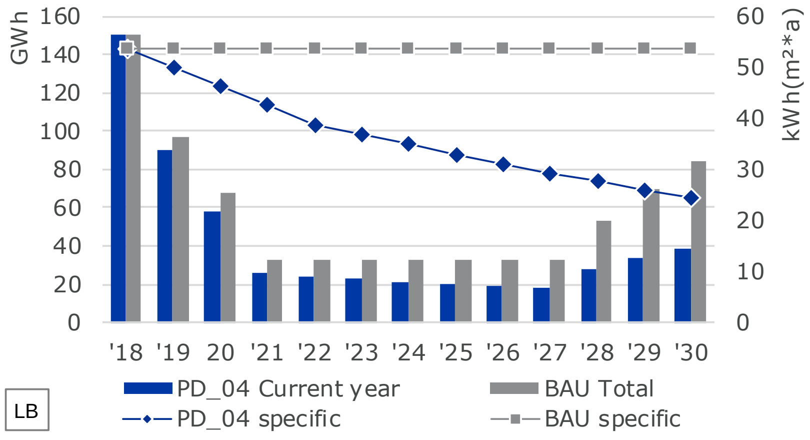
INTERNATIONALE
KLIMASCHUTZINITIATIVE (IKI)

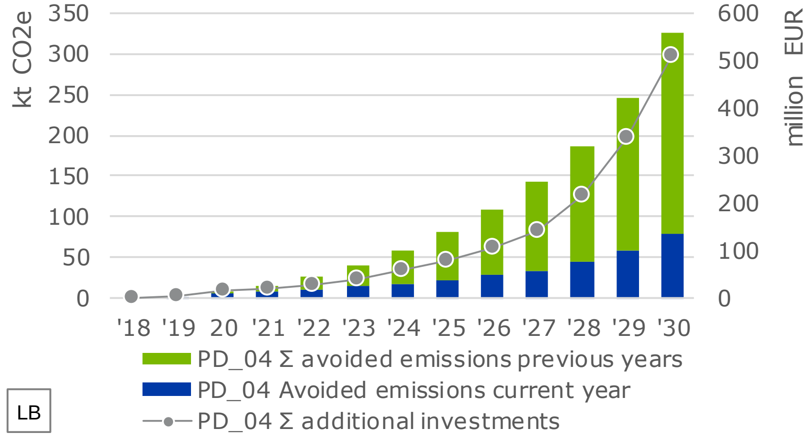
LEB_PD_04: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



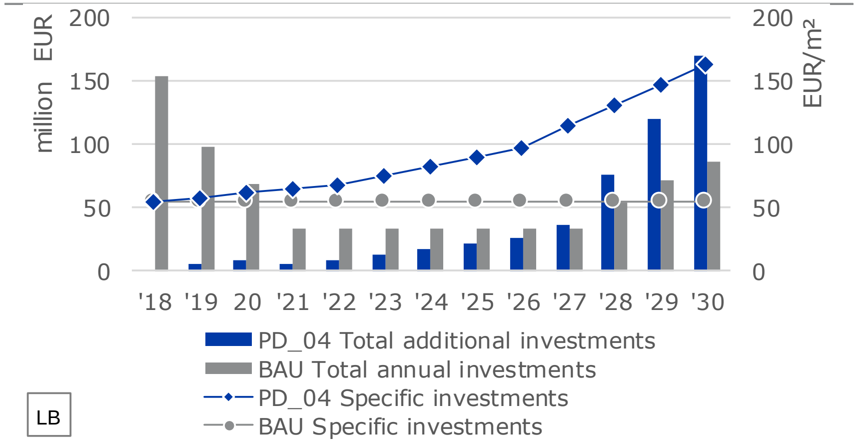
• **Energy demand of new constructions can be reduced by ~54% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



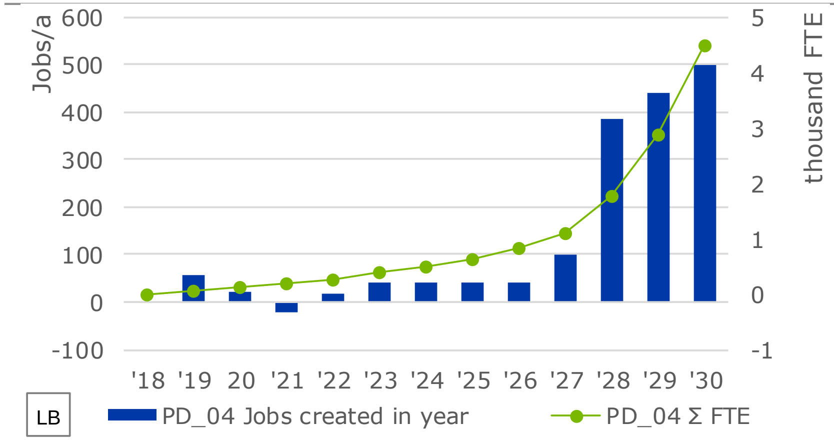
• **~70 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~41 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



• **~1,667 jobs can be created until 2030**

LEB_PD_04: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	35%	0%	64%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	35%	0%	64%	0%	100%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	70%	50%	85%	40%	100%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	14%	++	25.5%	++	40%
Windows		o	35%	+	59.5%	++	100%
Infiltration rate		o	7%	+	25.5%	++	50%
Insulation Thickness	Facade	o	35%	+	59.5%	++	100%
	Rooftop	++	35%	++	59.5%	++	100%
	Ground	o	35%	+	59.5%	++	100%
Shadowing measures (window shading)		o	21%	o	42.5%	o	70%

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INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

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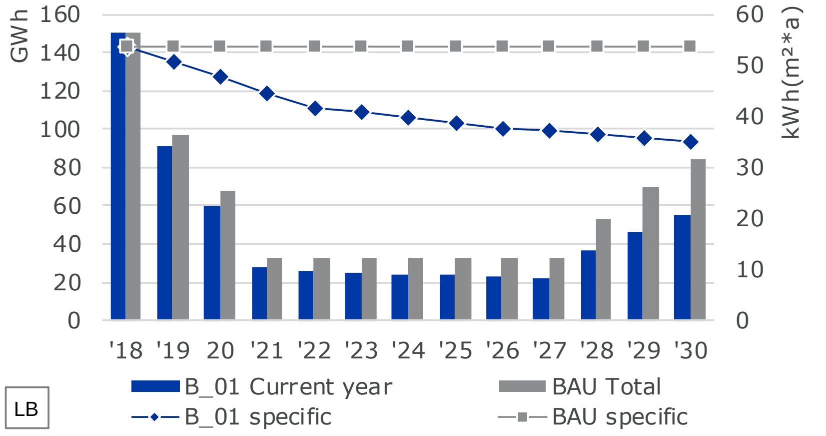
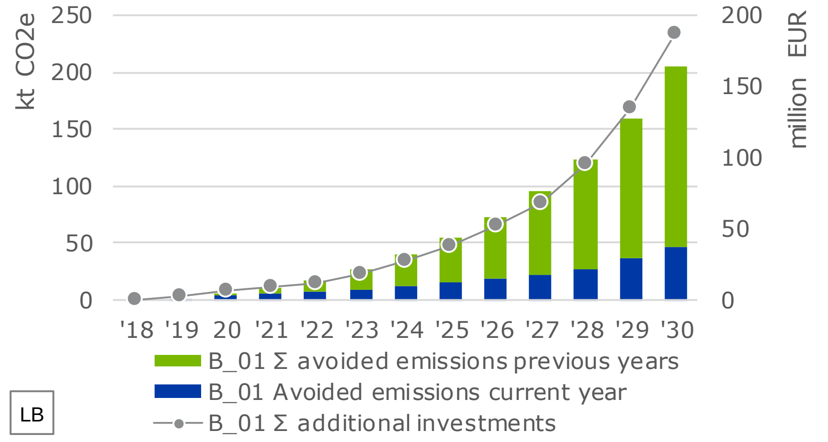
LEB_B_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



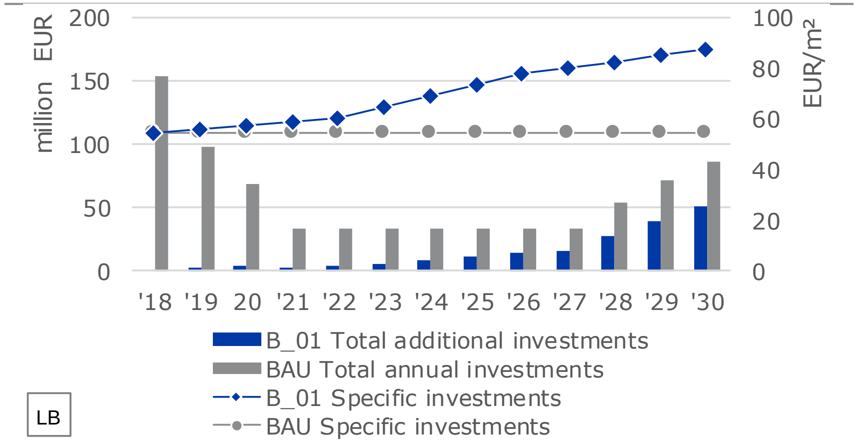
• **Energy demand of new constructions can be reduced by ~35% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



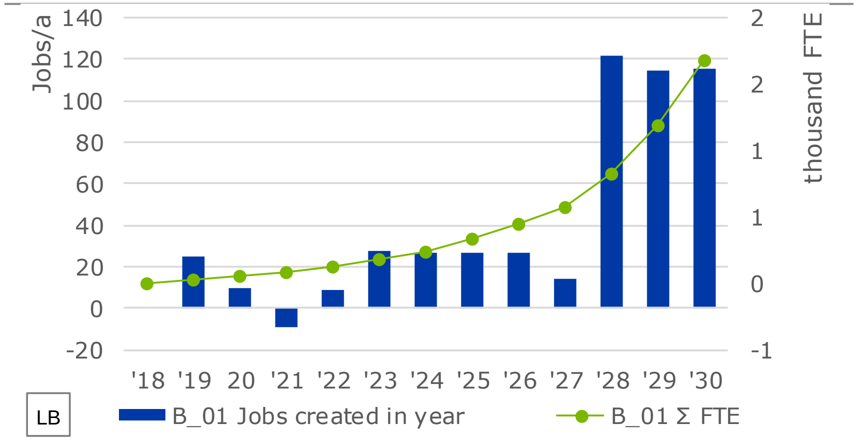
• **~40 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~16 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



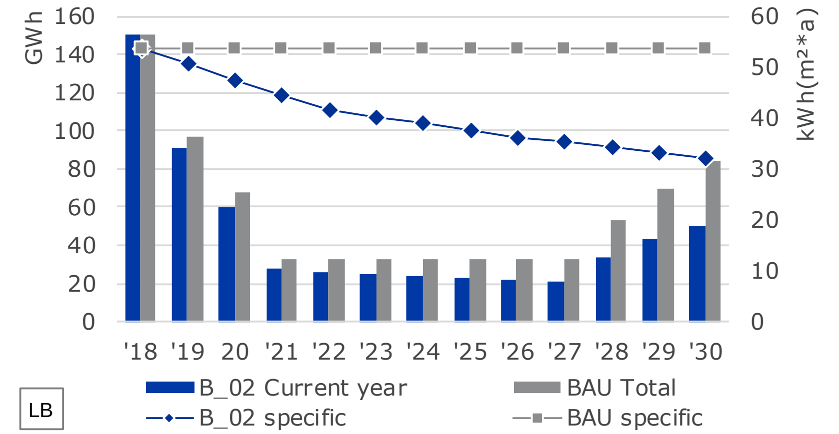
• **~505 jobs can be created until 2030**

LEB_B_01: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	15%	0%	23%	0%	30%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	15%	0%	22.5%	0%	30%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	30%	50%	30%	40%	30%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	6%	++	9%	++	12%
Windows		o	15%	++	21%	++	30%
Infiltration rate		o	3%	++	9%	++	15%
Insulation Thickness	Facade	o	15%	++	21%	++	30%
	Rooftop	++	15%	++	21%	++	30%
	Ground	o	15%	++	21%	++	30%
Shadowing measures (window shading)		o	9%	+	15%	++	21%

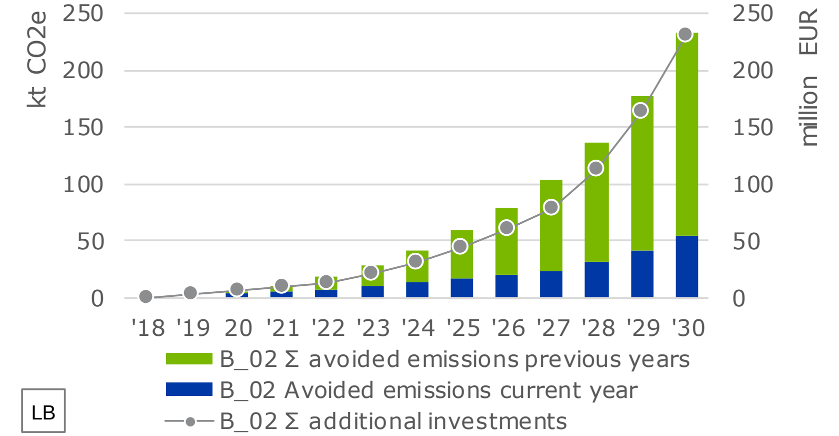
LEB_B_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



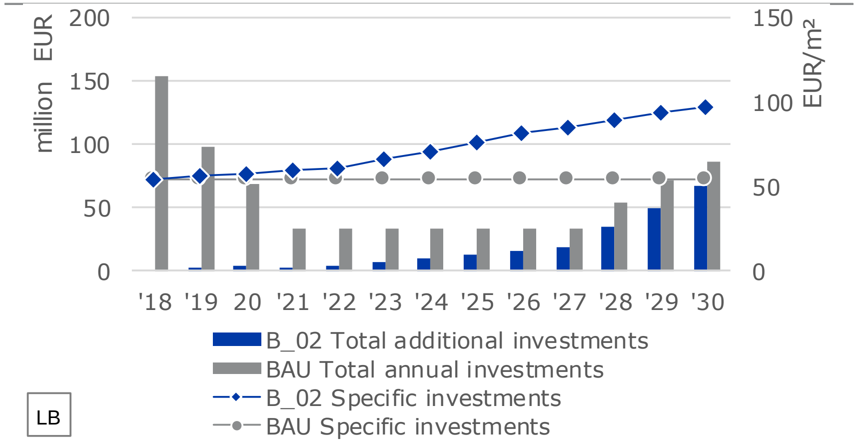
- **Energy demand of new constructions can be reduced by ~40% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



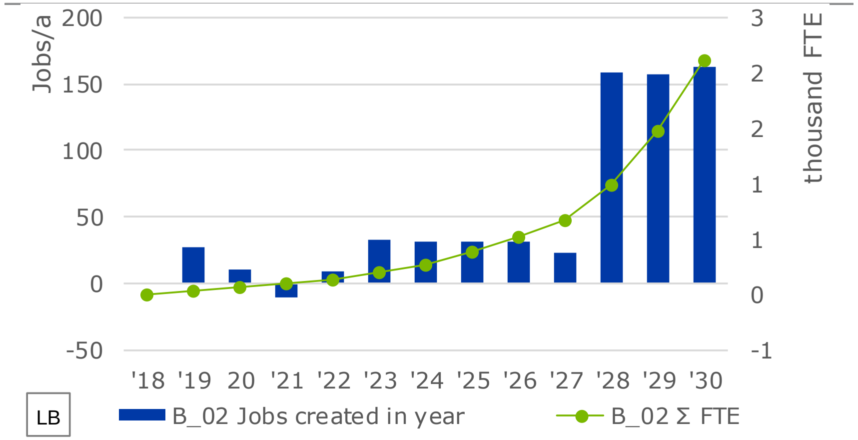
- **~50 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~20 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~665 jobs can be created until 2030**

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INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

LEB_B_02: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	0%	10%	0%	20%	0%	30%
	Gas boilers - condensing	50%		40%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	0%		0%		0%	
	Heat Pumps (any source) - COP 5	40%		50%		60%	
	Solar water heaters	10%		10%		10%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	10%	0%	20%	0%	30%
	Fossil - efficient	20%		20%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	80%		80%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	0%	10%	0%	20%	0%	30%
	Mechanical ventilation w heat recovery 50%	50%		30%		10%	
	Mechanical ventilation w heat recovery 90%	50%		70%		90%	
Space cooling technologies	AC or Chillers COP > 4	++	10%	++	20%	++	30%
Windows		o	10%	++	20%	++	30%
Infiltration rate		o	10%	++	20%	++	30%
Insulation Thickness	Facade	o	10%	++	20%	++	30%
	Rooftop	++	10%	++	20%	++	30%
	Ground	o	10%	++	20%	++	30%
Shadowing measures (window shading)		o	10%	+	20%	++	30%

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INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

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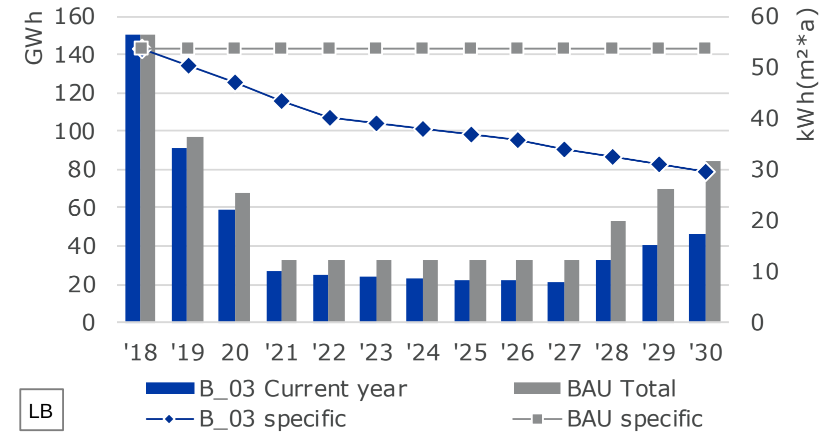
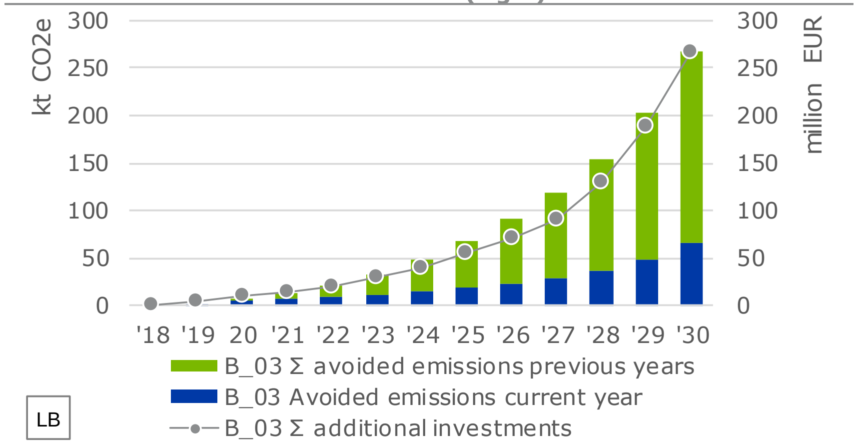
LEB_B_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



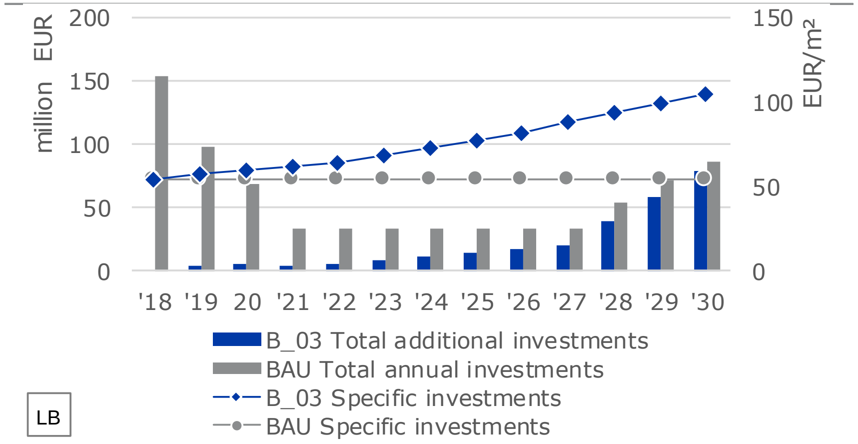
• Energy demand of new constructions can be reduced by ~45% until 2030

Accumulated avoided emissions (left) and additional accumulated investments (right)



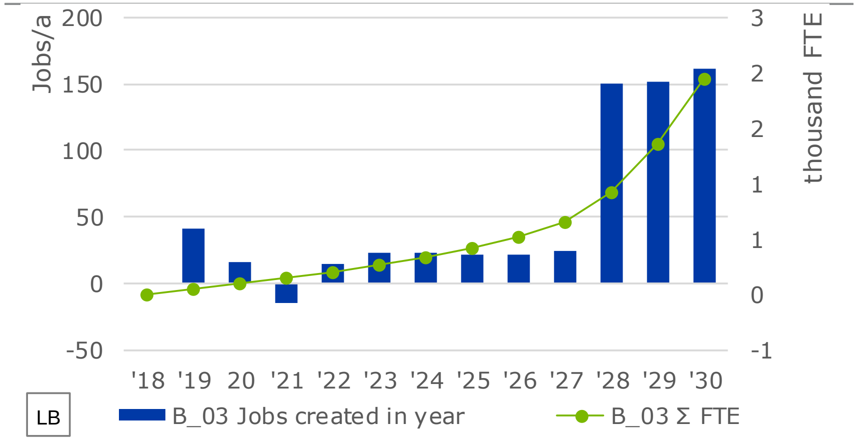
• ~60 ktCO2e can be mitigated by 2030

Total (left) and specific (right) investments per year



• Average additional investment costs between 2019-2030 are ~23 EUR/m² new building floor space

Newly created jobs per year (left) and accumulated FTE (right)



• ~632 jobs can be created until 2030

LEB_B_03: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	25%	0%	56.25%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	25%	0%	56.25%	0%	100%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	50%	50%	75%	40%	100%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	10%	++	22.5%	++	40%
Windows		o	0	o	0	o	0
Infiltration rate		o	0	o	0	o	0
Insulation Thickness	Facade	o	0	o	0	o	0
	Rooftop	++	25%	++	52.5%	++	100%
	Ground	o	0	o	0	o	0
Shadowing measures (window shading)		o	0	o	0	o	0

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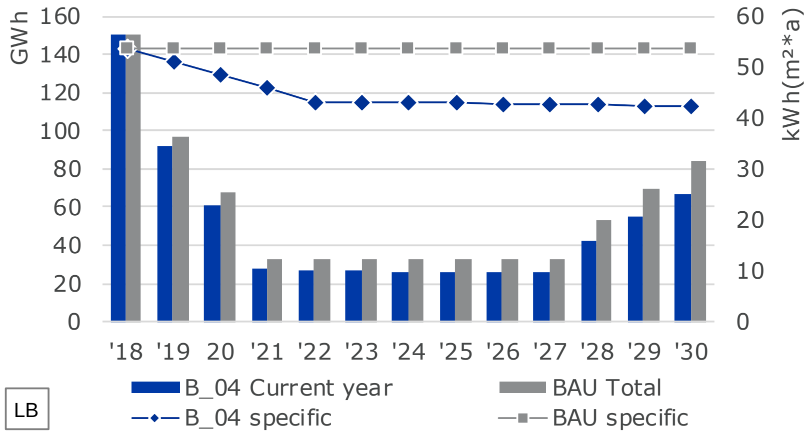
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

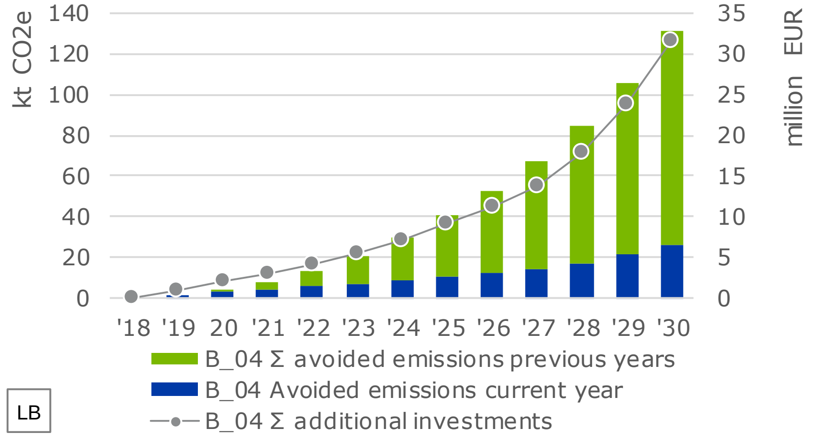
LEB_B_04: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



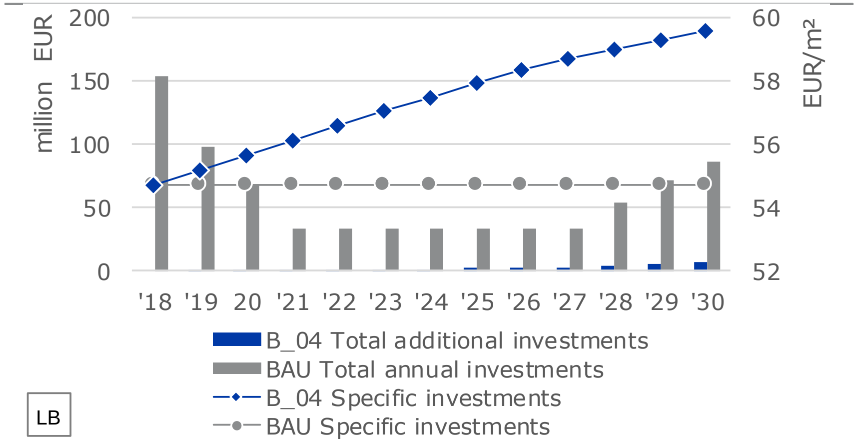
• **Energy demand of new constructions can be reduced by ~21% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



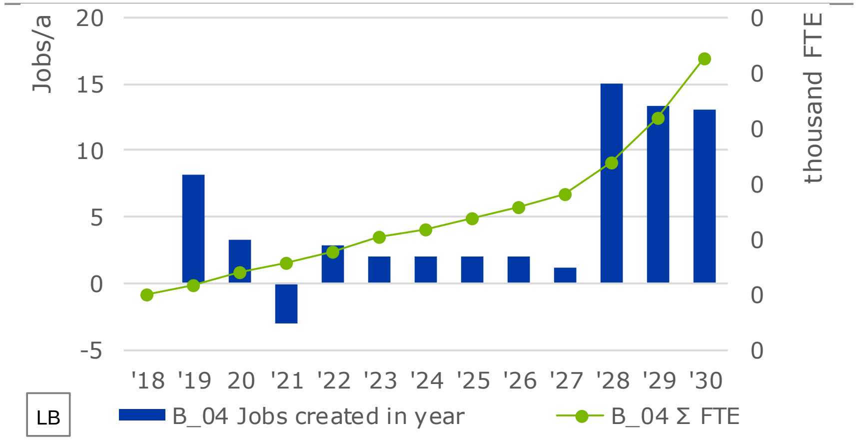
• **~20 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~3 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



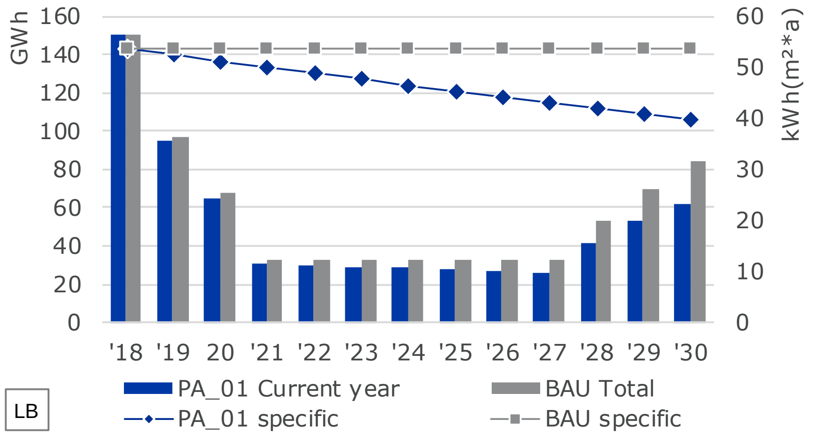
• **~62 jobs can be created until 2030**

LEB_B_04: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	5%	0%	7.5%	0%	10%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	5%	0%	7.5%	0%	10%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	10%	50%	10%	40%	10%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	2%	++	3%	++	4%
Windows		o	5%	o	7%	o	10%
Infiltration rate		o	1%	o	3%	o	5%
Insulation Thickness	Facade	o	5%	o	7%	o	10%
	Rooftop	++	5%	++	7%	++	10%
	Ground	o	5%	o	7%	o	10%
Shadowing measures (window shading)		o	3%	o	5%	o	7%

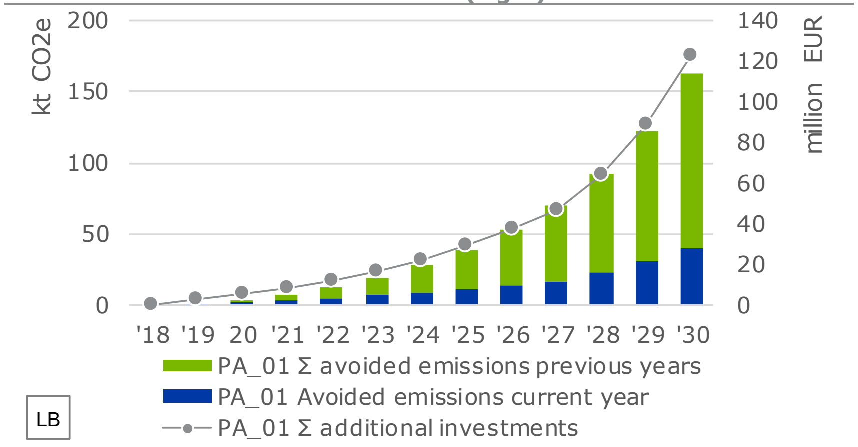
LEB_PA_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



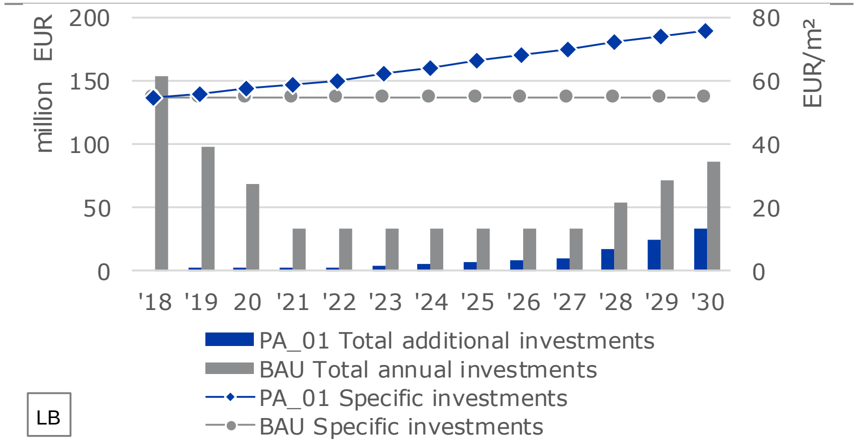
• **Energy demand of new constructions can be reduced by ~26% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



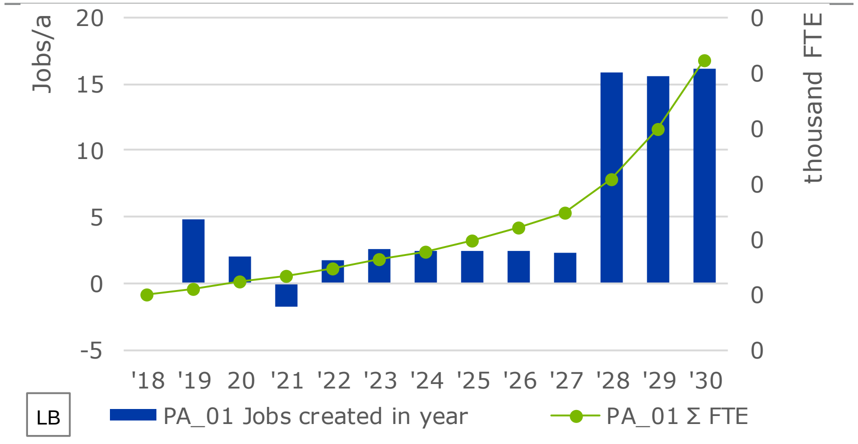
• **~40 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~11 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



• **~66 jobs can be created until 2030**

ANNEX_LEB_PA_01: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	50%	0%	75%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	50%	0%	75%	0%	100%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	100%	0%%	100%	0%	100%	0%
	Mechanical ventilation w heat recovery 50%	0%		0%		0%	
	Mechanical ventilation w heat recovery 90%	0%		0%		0%	
Space cooling technologies	AC or Chillers COP > 4	++	20%	++	30%	++	40%
Windows		o	0%	o	0%	o	0%
Infiltration rate		o	0%	o	0%	o	0%
Insulation Thickness	Facade	o	0%	o	0%	o	0%
	Rooftop	o	0%	o	0%	o	0%
	Ground	o	0%	o	0%	o	0%
Shadowing measures (window shading)		o	0%	o	0%	o	0%

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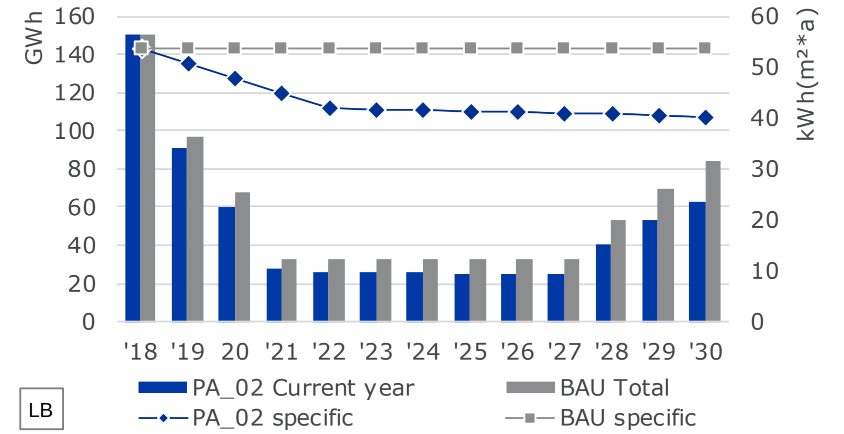
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

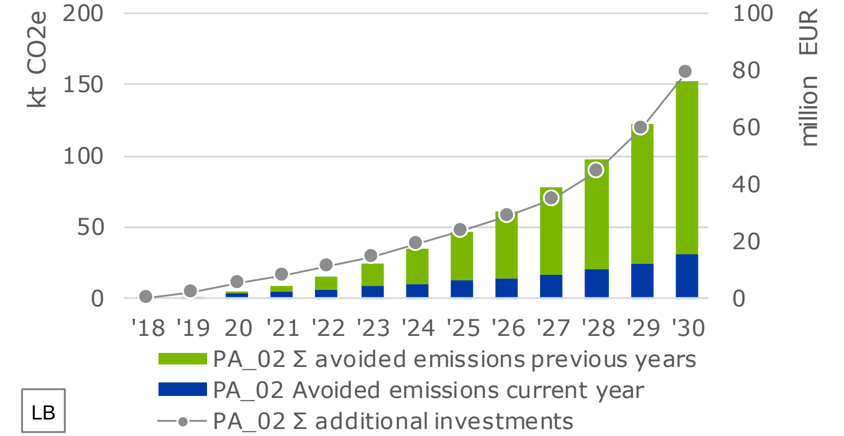
LEB_PA_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



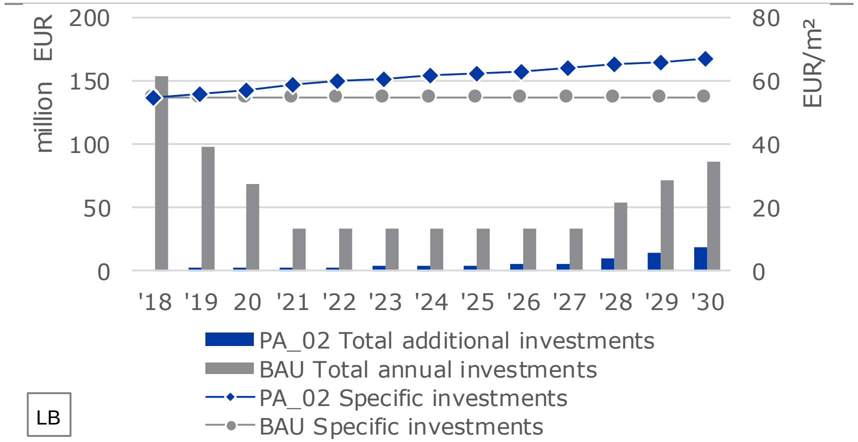
- **Energy demand of new constructions can be reduced by ~25% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



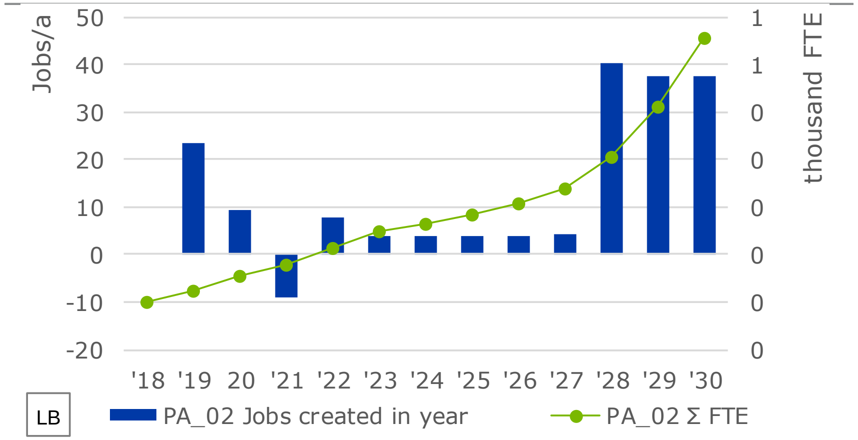
- **~30 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~7 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~168 jobs can be created until 2030**

ANNEX_LEB_PA_02: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	49%	15%	34%	22.5%	19%	30%
	Gas boilers - condensing	18%		21%		25%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	25%		33%		41%	
	Heat Pumps (any source) - COP 4	5%		7%		9%	
	Heat Pumps (any source) - COP 5	3%		5%		6%	
	Solar water heaters	0%		0%		0%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	38%	15%	21%	22.5%	5%	30%
	Fossil - efficient	3%		4%		5%	
	Electric	10%		10%		11%	
	Solar water heaters	49%		64%		79%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	72%	30%	57%	30%	43%	30%
	Mechanical ventilation w heat recovery 50%	14%		21%		29%	
	Mechanical ventilation w heat recovery 90%	14%		21%		29%	
Space cooling technologies	AC or Chillers COP > 4	++	6%	++	9%	++	12%
Windows		o	15%	o	15%	o	15%
Infiltration rate		o	3%	o	3%	o	3%
Insulation Thickness	Facade	++	15%	++	15%	++	15%
	Rooftop	o	15%	o	15%	o	15%
	Ground	o	15%	o	15%	o	15%
Shadowing measures (window shading)		o	9%	o	15%	o	21%

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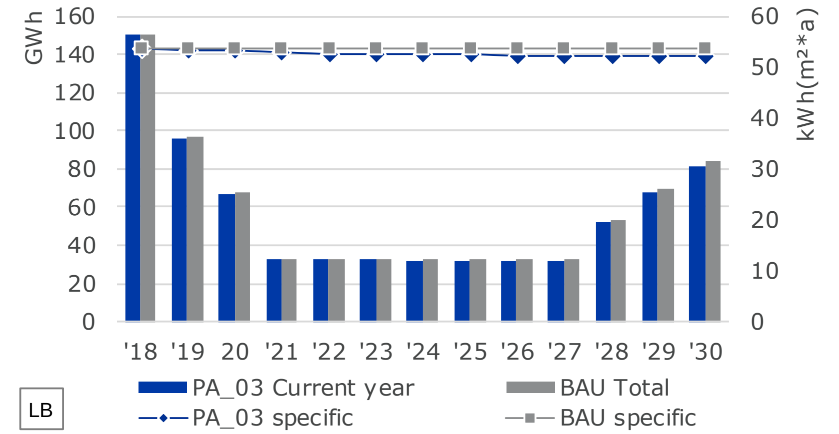
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

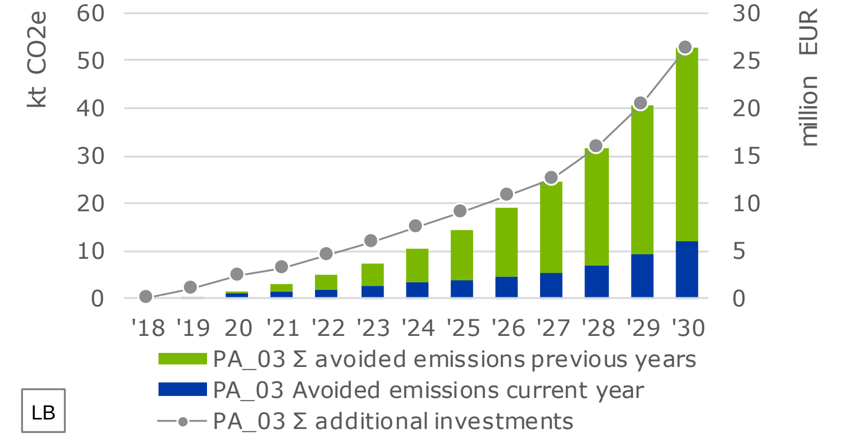
LEB_PA_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



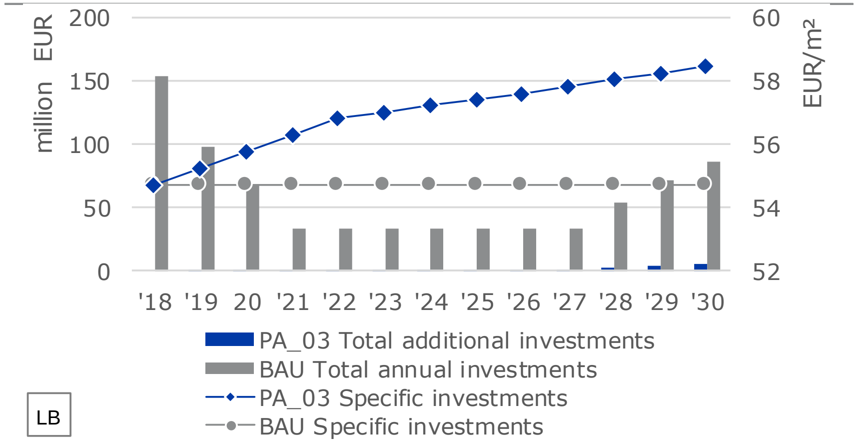
- **Energy demand of new constructions can be reduced by ~3% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



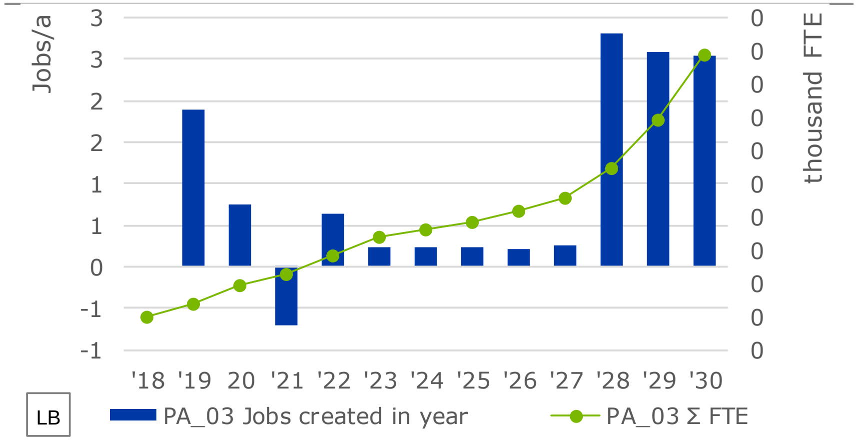
- **~10 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~2 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~12 jobs can be created until 2030**

ANNEX_LEB_PA_03: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	40%	0%	33%	0%	30%	0%
	Gas boilers - condensing	10%		10%		10%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	40%		35%		30%	
	Heat Pumps (any source) - COP 4	5%		15%		20%	
	Heat Pumps (any source) - COP 5	5%		7%		10%	
	Solar water heaters	0%		0%		0%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	10%	70%	0%	80%	0%	90%
	Fossil - efficient	10%		10%		5%	
	Electric	10%		10%		5%	
	Solar water heaters	70%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	100%	0%	100%	0%	100%	0%
	Mechanical ventilation w heat recovery 50%	0%		0%		0%	
	Mechanical ventilation w heat recovery 90%	0%		0%		0%	
Space cooling technologies	AC or Chillers COP > 4	o	0%	o	0%	o	0%
Windows		o		o		o	
Infiltration rate		o		o		o	
Insulation Thickness	Facade	o	0%	o	0%	o	0%
	Rooftop	o		o		o	
	Ground	o		o		o	
Shadowing measures (window shading)		o	0%	o	0%	o	0%

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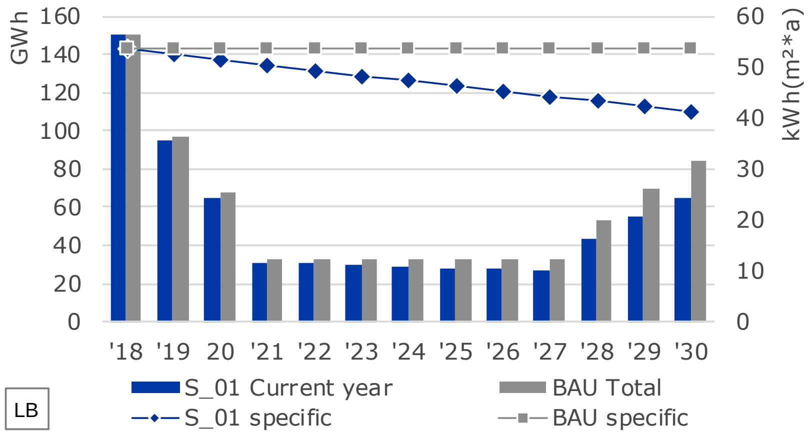
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

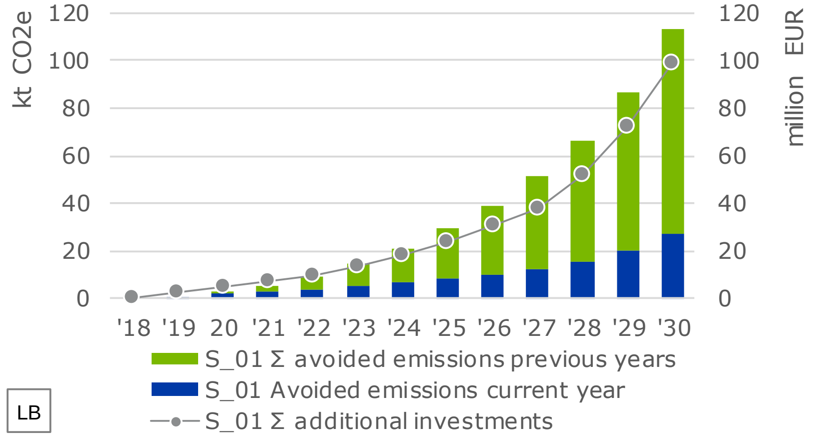
LEB_S_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



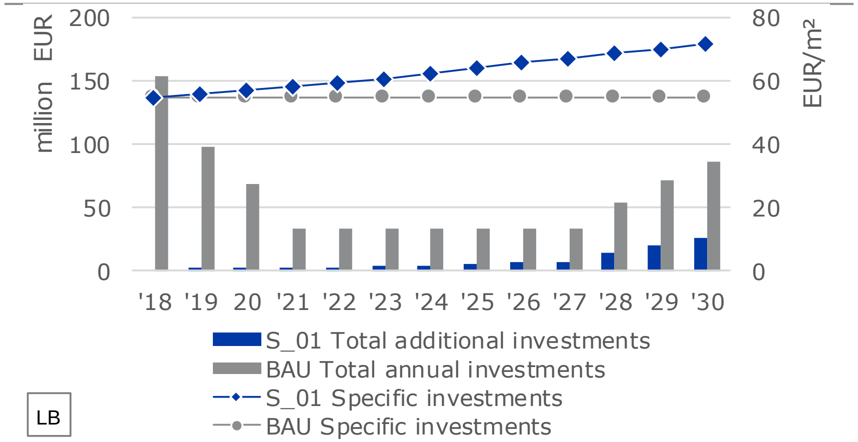
- Energy demand of new constructions can be reduced by ~23% until 2030

Accumulated avoided emissions (left) and additional accumulated investments (right)



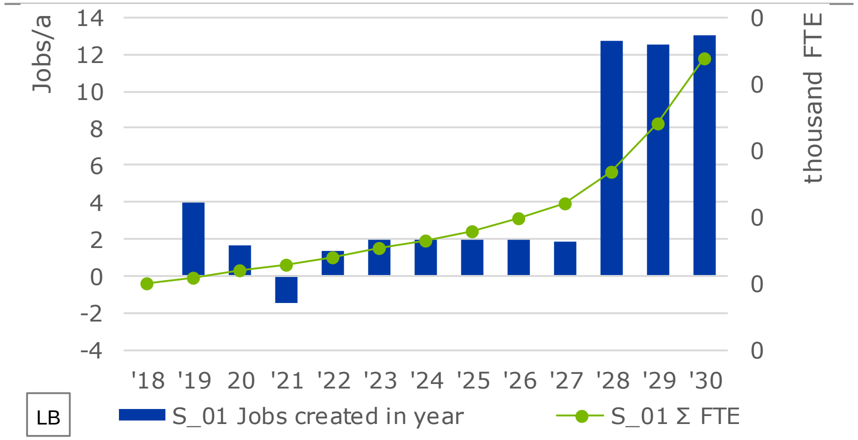
- ~20 ktCO2e can be mitigated by 2030

Total (left) and specific (right) investments per year



- Average additional investment costs between 2019-2030 are ~9 EUR/m² new building floor space

Newly created jobs per year (left) and accumulated FTE (right)



- ~53 jobs can be created until 2030

LEB_S_01: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	50%	0%	75%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	0%	0%	0%	0%	0%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	0%	50%	0%	40%	0%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	20%	++	30%	++	40%
Windows		o	0%	o	0%	o	0%
Infiltration rate		o	0%	o	0%	o	0%
Insulation Thickness	Facade	o	0%	o	0%	o	0%
	Rooftop	++	0%	++	0%	++	0%
	Ground	o	0%	o	0%	o	0%
Shadowing measures (window shading)		o	0%	o	0%	o	0%

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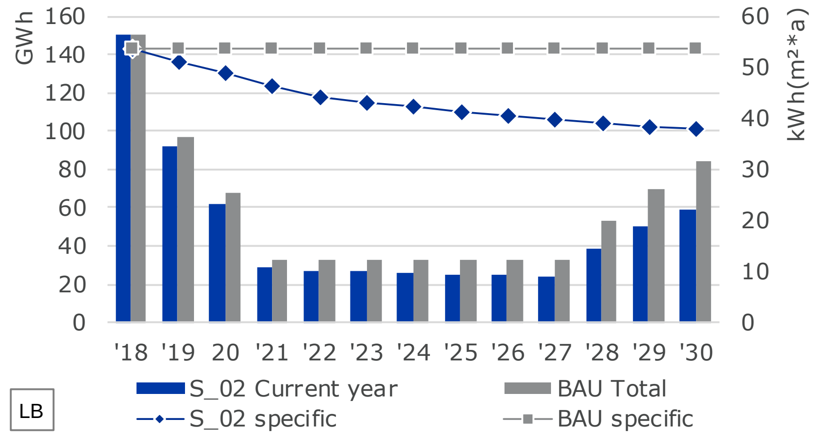
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

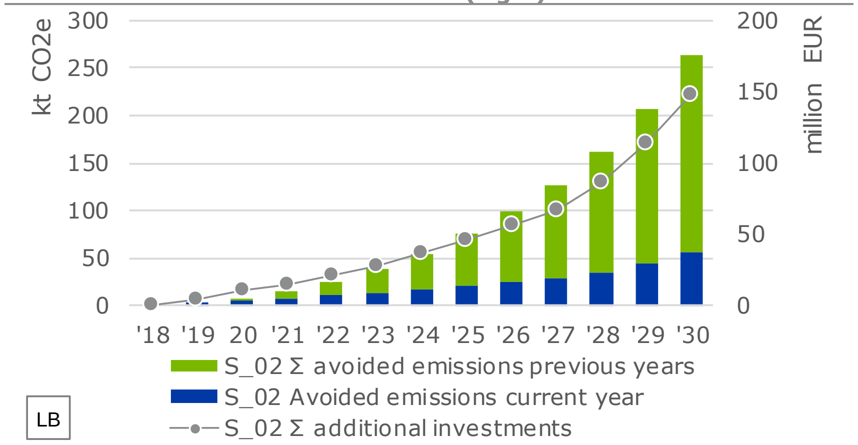
LEB_S_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



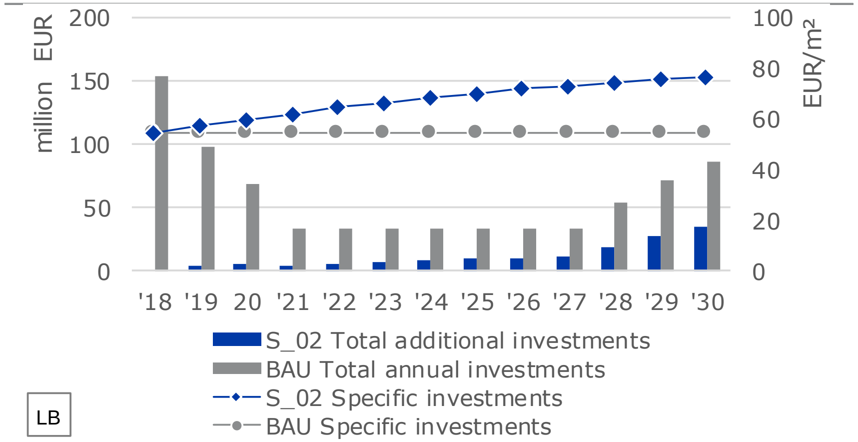
• **Energy demand of new constructions can be reduced by ~29% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



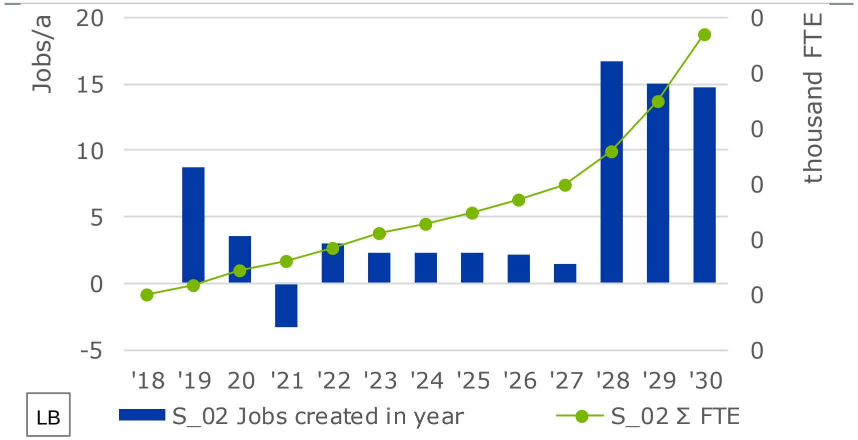
• **~50 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



• **Average additional investment costs between 2019-2030 are ~14 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



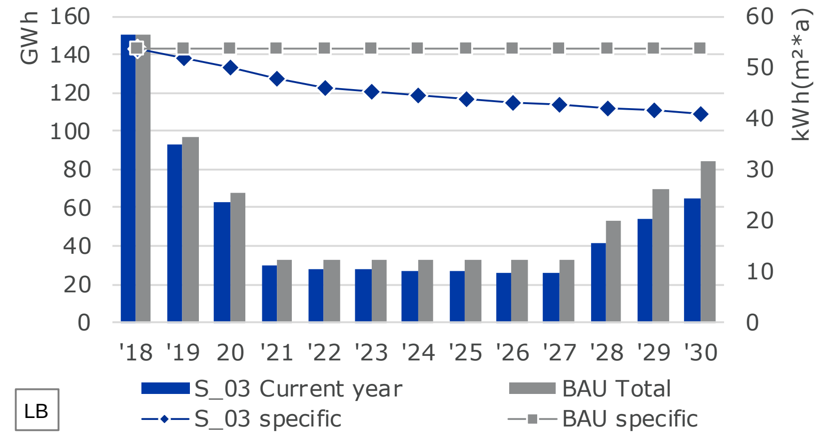
• **~69 jobs can be created until 2030**

LEB_S_02: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	90%	0%	95%	0%	100%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	40%	0%	65%	0%	90%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	0%	50%	0%	40%	0%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	50%	++	55%	++	60%
Windows		o	0%	o	0%	o	0%
Infiltration rate		o	0%	o	0%	o	0%
Insulation Thickness	Facade	o	0%	o	0%	o	0%
	Rooftop	o	0%	o	0%	o	0%
	Ground	o	0%	o	0%	o	0%
Shadowing measures (window shading)		o	0%	o	0%	o	0%

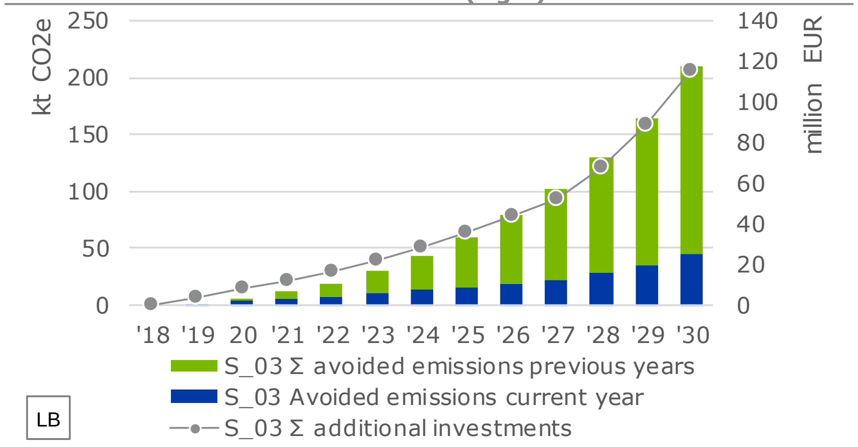
LEB_S_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

Total (left) and specific (right) final energy demand per year



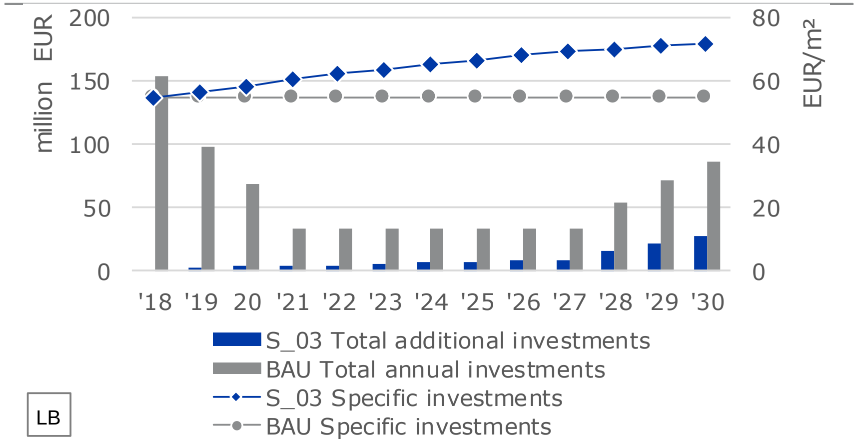
- **Energy demand of new constructions can be reduced by ~23% until 2030**

Accumulated avoided emissions (left) and additional accumulated investments (right)



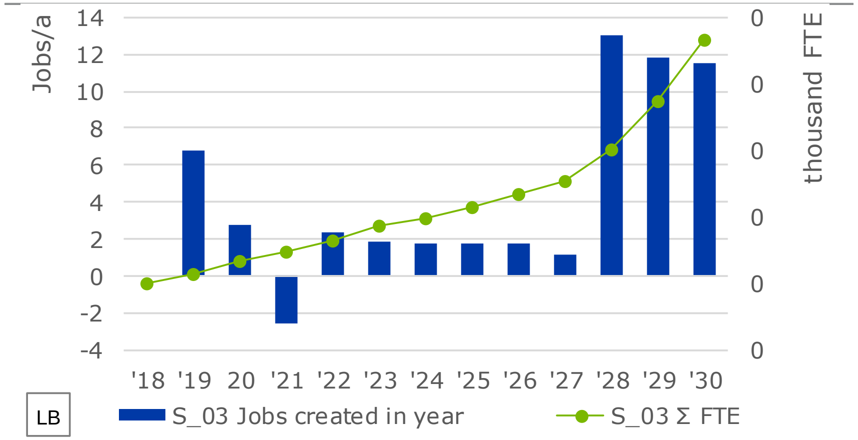
- **~40 ktCO2e can be mitigated by 2030**

Total (left) and specific (right) investments per year



- **Average additional investment costs between 2019-2030 are ~11 EUR/m² new building floor space**

Newly created jobs per year (left) and accumulated FTE (right)



- **~54 jobs can be created until 2030**

LEB_S_03: Assumed future technology distribution and affected shares

Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	72%	0%	76%	0%	80%
	Gas boilers - condensing	60%		55%		45%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	5%		0%		0%	
	Heat Pumps (any source) - COP 4	15%		20%		20%	
	Heat Pumps (any source) - COP 5	9%		23%		30%	
	Solar water heaters	1%		2%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	20%	32%	0%	52%	0%	72%
	Fossil - efficient	25%		20%		10%	
	Electric	5%		0%		0%	
	Solar water heaters	50%		80%		90%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	70%	0%	50%	0%	40%	0%
	Mechanical ventilation w heat recovery 50%	15%		20%		20%	
	Mechanical ventilation w heat recovery 90%	15%		30%		40%	
Space cooling technologies	AC or Chillers COP > 4	++	40%	++	44%	++	48%
Windows		o	0%	o	0%	o	0%
Infiltration rate		o	0%	o	0%	o	0%
Insulation Thickness	Facade	o	0%	o	0%	o	0%
	Rooftop	o	0%	o	0%	o	0%
	Ground	o	0%	o	0%	o	0%
Shadowing measures (window shading)		o	0%	o	0%	o	0%