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

Report on activities in Jordan 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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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 Jordanian 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.

In the past, the Jordanian government had to massively subsidize energy prices in the kingdom in order to protect households from price volatility of fossil fuels. Since Jordan imports all fossil energy carriers, this presented a major strain on the economy as a whole, giving energy efficiency (EE) and renewable energy sources (RES) political traction. This resulted in policies such as the renewable energy and efficiency law enacted in 2012 and the National Energy Efficiency Action Plans. Also, funding for EE and RES was made available by international institutions and through national programs like the Jordan Renewable Energy & Energy Efficiency Fund.

After the project analysed this background (see chapter 2), it conducted an extensive dialogue with the most relevant stakeholder groups in the Jordanian 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 the higher upfront investment and a lack of incentives (chapter 3.1 and 3.2).

In parallel, two pilot projects in Zarqa and Aqaba 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. While the Aqaba projects is currently not being developed further, the Zarqa project is continuing to evaluate the implementation of suggested measures (chapter 3.3).

In a next step, potential policy measures to promote EE and RES in buildings in Jordan 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 political measures were evaluated using integrated modelling. In order to prioritize the implementations of policy recommendations in Jordan, 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

2.1 Key Macro-Economic Indicators

Population		**Energy and Climate**	
10.3 M	Inhabitants (2020)	96 %	Energy Imports (Percentage of demand)
1.5%	Population growth (per annum, 2015)	6 %	Energy subsidies (share of GDP)
Economy		0.07 €/kWh	Residential power price (2015)
		1.8 MWh/a	Avg. Residential power consumption (2015)
10,9 k$	GDP per capita (2017)	0.6 $kgCO_2$/kWh	GHG emissions factor of electricity (2015)
2.3%	Avg. Inflation rate (2013-2015 per annum)	2.9 tCO_2	GHG emissions per capita (2015)
3.75%	Household interest rate (per annum)		

Figure 1. Key macro-economic indicators of Jordan

Jordan has a population of 9.5 million people with a moderate growth rate of 1.5% p.a. The average GDP per capita is USD (PPP) 10,900 which makes Jordan a middle-income economy. A low inflation rate of just over 2% on average over the past three years, combined with a low consumer interest rate of 3.75% results in comparatively low cost of capital and hence short amortization time for EE investments.

Jordan has no fossil fuel resources. More than 96% of energy demand is covered by imported fossil fuels, putting a substantial strain on Jordan's GDP. Energy subsidies in Jordan are high with approximately 6% of GDP spent on them in 2015 which was twice as much as in 2010. Particularly high subsidies are in place for diesel, kerosene and LPG, with more than half of the price of the latter being subsidised. Local partners see a considerable political willingness to reduce subsidies. Average electricity prices are at JOD 0.1 (~EUR 0,13) per kWh, with differentiated pricing for large and medium industries, hotels and agriculture. Characteristic for electricity pricing in Jordan are the high tariffs for commercial customers both compared regionally and with other costumer groups. Security of electricity supply in Jordan is good in regional comparison, with only about 91 hours of electricity shortages in 2015 (~1%).

The emission factor with 635g/CO_2 per kWh electricity is at an average among the countries in the group studied within this project. Jordan strives for a 14% reduction in GHG emissions by 2030 compared to a baseline scenario as part of its INDC. Currently, the per capita emissions of 2.9 tCO_2eq are still low. The EE of the overall economy of Jordan can be assessed through the evolution of its primary and final energy intensities. Primary energy intensity has decreased from 0.942 toe/1000 JD in 2005 to 0.728 toe/1000 JD in 2011, which represents a reduction of about -4.2%. The final energy intensity has decreased with higher rate - 4.9% in the same period. However, since 2011, both intensities have slightly increased with annual rate of 1.8% and 2.3% respectively, showing a degradation of the energy performance of the economy. On the overall period 2005-2015, the primary and final energy intensity has decreased with an annual rate of -1.8% and -2.1%, respectively.

2.2 Starting Situation in the Building Stock

Housing Indicators		Housing Economics	
0.8 M	Number of residential buildings (2015)	2.6%	New construction rate (2015)
2.2 M	Number of households (2020)	607 JD/m²	Average cost of new construction (urban multifamily houses)
84%	Share of population living in urban areas (2015)	26%	Share of rented buildings (% of privately owned res. buildings)
55%	Share of multifamily homes (% of total m² of residential buildings)	22%	Share of household expenditure on housing (2010, incl. water, power, housing fuels)

Figure 2. Key statistics on Jordan's building stock

There are 2.2 million households in Jordan with an average occupancy of 4.7 persons per household (latest data for 2020). Urbanization is high with 84% of population living in urban areas, most notably in the Amman metropolitan area that accounts for approx. 40% of Jordan's total population. In terms of real estate floor area, multifamily homes are slightly more common (55%) than single-family homes.

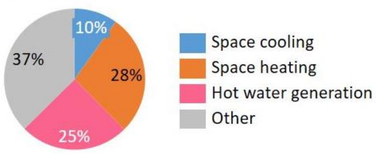
Jordan has a new construction rate of 2.6% with multifamily homes being built slightly above the average rate (2.7%) and single-family homes slightly below that (2.4%). Construction costs for urban multifamily homes vary from JD 222 per m^2 (low-class project) to JD 1,100 per m^2 (high-class project) with average costs amounting to JD 607 per m^2. Labour costs for craftsmen are usually estimated at JD 1.55 per hour and informality in the building sector was judged low by local partners. 26% of privately-owned residential buildings are rented out, on the other hand 71% of households own the property that they live in. There are no state-owned residential buildings being rented.

2.3 Current State in Cooling and Heating Technologies

Energy consumption

21.9 % — Share of residential final energy consumption (% of total final energy consumption)

Use of residential final energy consumption (2016)



Air conditioning

45-55% — Share of households with AC (2015)

1.4k — Cooling degree days (Reference: 18°C)

Figure 3. Key metrics of heating and cooling in residential buildings in Jordan

About 29% of energy in Jordan is consumed in the building sector, most of it (22%-pts.) is spent in residential buildings. Accordingly, 26% of GHG emissions occur in the residential sector. Space heating and hot water generation each account for about 25% of residential energy consumption while space cooling is responsible for about 10%. This is likely to change with rising living standards and a larger diffusion of space cooling equipment. Energy performance contracting in Jordan is so far only available for commercial and not for residential buildings.

Useful heating demand in residential building averages at 55 kWh/m^2*a and useful cooling demand averages at 40 kWh/m^2*a.

About 45-55% of households have air-conditioning facilities. For cooling, people usually use air conditioners split units and fans, both running on electricity. The common technologies for heating in Jordan are boilers (gas, diesel), reversible air conditioner split units, electric heaters, portable heating units (kerosene) and fireplaces (wood). There is an increase in selling LPG boilers within the last 3 years due to increased awareness of consumers and developers and the fact that LPG boilers require less floor area. Solar water heater penetration rate in Jordan is around 15%, with much unused potential.

2.4 Existing Policy Framework for Building Efficiency

Legal Situation

- Renewable energy and **energy efficiency law** was enacted in 2012
- Mandatory **Building Codes** regulate insulation, energy efficiency, solar energy etc.
- **Energy subsidies** are set to be reduced

Programs & Financing

- Funding is available through the **Jordan Renewable Energy and Energy Efficiency Fund** (JREEEF)
- **Awareness campaigns** were launched with moderate effect
- **Tax incentives** are granted for solar water heaters, efficient air conditioning etc.

Figure 4. Existing Policy Framework in Jordan

Legal Situation

Jordan has enacted a renewable energy and efficiency law in 2012 which was translated into several by-laws, regulations and instructions to control and monitor the different actions related to RES and EE. Through the National Building Council, the Jordanian government has issued building codes (e.g. on insulation, EE and solar energy) as well as a Green Building Manual. These codes are mandatory and must be complied during the construction process, yet in practice are not implemented (see 4.1.1.1 and 4.1.2.2). The Jordanian government also recently adopted and issued licencing instructions and procedures for ESCOs. In parallel, there is also a voluntary accreditation system which has been developed by a coalition of energy service providers through funding and support from USAID.

The national energy strategy of 2015 targets a reduction of 20% in primary energy consumption and a share of 10% of renewable by 2020. By reducing energy consumption and increasing the share of RES, the burden of energy subsidies on the Jordanian government should be reduced. In 2018, the second National Energy Efficiency Action Plan (NEEAP) has set a target of 17.5% reduction in energy consumption by 2020. The second NEEAP comprised several EE actions with estimated total investment costs of around 696 million JD (994 million USD) and will generate annual savings for users of about 230 million JD (329 million USD) per year by 2020. In this case the average payback period of all the measures applied in the NEEAP from the users' perspective will be around 2.5 years if all measures are fully implemented.

Other important steps to create favourable conditions for EE have been taken. A subsidy removal plan and EE action plan as well as standards for household appliances are encouraging signs in this regard. Especially energy prices for industrial and commercial sectors are set to increase further, which may likely increase demand for EE in this segment. Strengthening the implementation capacity of Jordanian institutions is now necessary to reap the benefits of these frameworks. The relatively scattered institutional responsibilities and the lack of coordination between EE stakeholder groups represent an additional challenge.

Programs and Financing

Jordan has adopted a Green Building Manual that includes requirements for appliances and material but no general energy performance standards for new buildings. According to the Green Building Manual, the Ministry of Public Works and Housing can issue energy performance certificates. Authorities have launched some awareness campaigns for EE, yet local partners evaluate public consciousness for the issue as only moderate and see a particular need for specific campaigns on EE in buildings.

While no specific funding tool for EE in buildings exists, the sector can benefit from available funding for windows within the Jordan Renewable Energy & Energy Efficiency Fund (JREEEF). Also, while the installation of solar water heaters in new buildings is now mandatory in Jordan but it is not well enforced in all municipalities, tax incentives are available for these investments as well as other highly energy efficient products such as efficient lighting and efficient air conditioning (mainly split units).

Furthermore, large-scale projects such as a EUR 90 M EU program on support for renewables and EE at the technical and policy level are being implemented. JREEEF and the National Energy and Research Centre are carrying out a program to improve EE in governmental schools across Jordan, starting with about 60 pilot projects.

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 Jordanian buildings sector

3.1.1 Public sector

3.1.1.1 Ministries and Government Agencies

The Jordanian Ministry of Energy and Mineral Resources (MEMR) is responsible for setting policies, strategies, and laws for the energy sector as well as raising awareness for these topics in the public. For instance, MEMR has prepared the National Energy Efficiency Action Plan (NEEAP) for the years until 2020. The Energy and Mineral Regulatory Commission (EMRC) is responsible for formulating by-laws and instructions to facilitate the enforcement of these laws. The Jordan Standards and Metrology Organization (JSMO) is responsible for issuing, approving, reviewing, amending and monitoring the implementation of standards and technical regulations regarding all goods, products and services including energy labelling and eco design for electric appliances. The Ministry of Public Works and Housing through the National Building Council (NBC), is responsible for preparing building codes including an EE code, a solar code, an insulation code and a green building manual. The National Energy Research Center (NERC) conducts research, development and training in the fields of new and renewable energy. Its purpose is to increase the standards of energy use in the different sectors. For example, NERC has cooperated with MEMR in designing and implementing an awareness campaign for all energy consuming sectors in Jordan with a focus on the residential sector.

3.1.1.2 Municipalities

There are 99 municipalities in Jordan with Greater Amman Municipality (GAM) representing 40% of the Jordanian population. This report covers in detail four municipalities across Jordan: from Irbid in the north to GAM and Sahab in the middle and to Karak in the south.

Municipalities in Jordan are responsible for granting permits for buildings. All four municipalities have a framework for EE. Sahab and Irbid municipalities have a sustainable energy action plan with a target to reduce 40% of CO_2 emission by 2030. These targets should be achieved by improving the

EE for the governmental buildings in the municipality such as administrative buildings, schools, mosques and churches and gardens. This includes installing PV systems on these buildings.

3.1.2 Private sector

3.1.2.1 Project developers

Out of the group of project developers interviewed, only three stated that they perform economic viability calculations for heating/cooling systems. For the ones who do, the Payback Period method is chosen because it can easily be shared with customers. They do not conduct Net Present Value calculations and argued that the profitability over the lifetime of the technology is not of interest for them, only for the future owners. According to their experience, customers expect a payback period of 2 to 3 years and gas condensing boilers are the go-to technology to achieve this payback compared to fuel oil conventional boilers.

In Jordan, the final decision to install an energy efficient heating or cooling unit is made by the owner of the dwelling, however, our field surveys show that the majority of project developers interviewed (>90%) recommend to the owner which heating and cooling technology should be installed. Two thirds of the developers do so at the design stage. Experience shows that recommendations given at this stage have a higher chance to be taken into account compared to recommendations during the construction phase.

3.1.2.2 Banks and Funds

Since 2016, the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) has been the motor driving the acceleration of EE and RES measures in the country through financing. The decision to establish the fund came in response to the national energy strategy of 2015. The JREEEF fund is an entity under the MEMR and is supported by the Central Bank of Jordan to distribute loans to individuals and small- to medium- sized enterprises (SME). The support is offered in the form of 0% interest loans only. Investment grants are not offered. The funding program supports households in the installation of solar water heaters with the financing of 50% of the capital costs and in the installation of PV systems with up to JD 2,250 for 3 kW_p systems. Furthermore, the bank will finance SMEs to install a solar PV system with upfront costs up to JD 350,000. Banks have had a positive experience offering loans to ESCOs as they are repaying their debt from the savings of their clients through benefit sharing model. Yet because of the non-conventionality of the cash flows of an energy efficient asset, no loans have been offered for efficiency heating and cooling equipment.

The largest commercial banks in Jordan include Ahli Bank, Ithad Bank, Jordan Trade Bank, Bloom Bank, Safwa Islamic Bank, Arab Bank, Amman Cairo Bank, Islamic International Arab Bank and Bank of Jordan. Our interviews showed that most commercial banks (>80%) are providing financial support for EE and RES projects and services. Most of these banks that support EE projects have started this support in 2016 as a result of the establishment of Jordan Renewable Energy & Energy Efficiency Fund (JREEEF). In deciding to lend money for EE or RES projects, banks consider the most bankable EE technology to be LED, followed by PV systems and last solar water heaters.

3.1.2.3 Suppliers

Jordanian suppliers and retailers are importing most of their technologies from China (90%) followed by Korea and EU countries. Sales of more EE technologies have increased in the last five years due to the enforcement of JSMO technical regulations concerning energy labelling and eco design for AC units.

The Jordanian heating and cooling supplier market is dominated by the product categories air conditioners and heat pumps (>80%). The local assemblers, suppliers and retailers interviewed typically import and sell single split type units with an average COP of 3.7. Packaged air conditioners, hot water boilers and electric resistance heaters each represent a share of 5% in the market.

3.1.2.4 Utilities

Jordan has a relatively simple single-buyer power market structure. After the privatization process was completed in 2011, four major private production companies (CEGCO, SEPCO, QEPCO, KOPSO), one public transmission company (NEPCO) and three main private distribution companies (JEPCO, IDECO and EDCO) emerged. The sale price from the production companies to NEPCO is established by bilateral contracts between NEPCO and the producers. These contracts specify that NEPCO is responsible for the purchase of the fuel necessary for the functioning of the power stations. The sale price from NEPCO to the distribution companies and the tariffs for consumers are established by the Energy and Mineral Regulatory Commission (EMRC). The distribution companies' profits are fixed at 12% of their assets value.

Currently, the Government of Jordan is facing a major financial crisis in the electricity sector. Due to the interruption of gas supply from Egypt and Syria in 2011, the cost of producing electricity in Jordan has increased by several folds with the import of much more expensive Diesel fuel. NEPCO, which bears all the costs of increases in fuel prices, is currently running an accumulated loss of more than JD 4.6 bn. This weighed on 64% of government spending and 11 % of GDP of Jordan in 2014. In addition to a yearly operational deficit, NEPCO estimates that to meet the expected growth rate of electricity demand of 7% in the next ten years, electricity capacity will need to double from 4 GW in 2014 to 8 GW in 2030. The investment required is estimated at JD 6.9 million on generation and JD 296 million on transmission system. With such substantial expenses putting massive strain on the government budget, tariffs have been revised almost every year in order to restore NEPCO's financial viability.

3.2 Stakeholder group specific drivers and barriers

3.2.1 Methodology

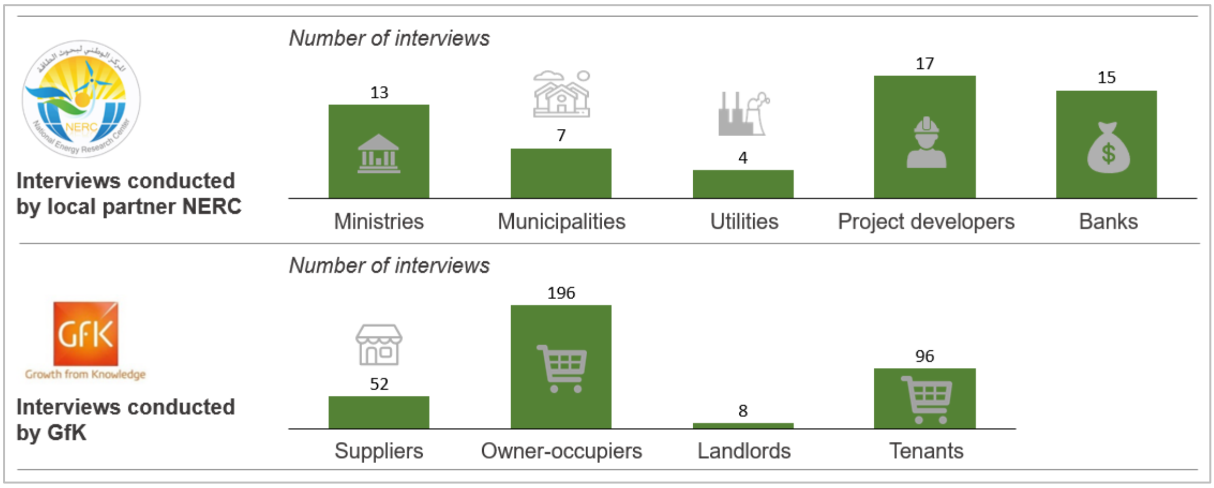


Figure 6. Sample sizes of interviews conducted in Jordan to obtain stakeholder's perspectives on energy efficiency in buildings

NERC and Navigant have conducted numerous interviews and organized stakeholder roundtables to assess drivers and barriers for efficient heating and cooling in residential buildings in Jordan. Within this process, NERC conducted 56 interviews with stakeholders in the building sector in Jordan in the summer 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 home-owners 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. , 1,300 survey were completed, of which 300 residents and 50 suppliers in Jordan. Figure 7 illustrate the numbers of survey conducted in each country and the breakdown for Owner/Occupier and Owner/Landlord.

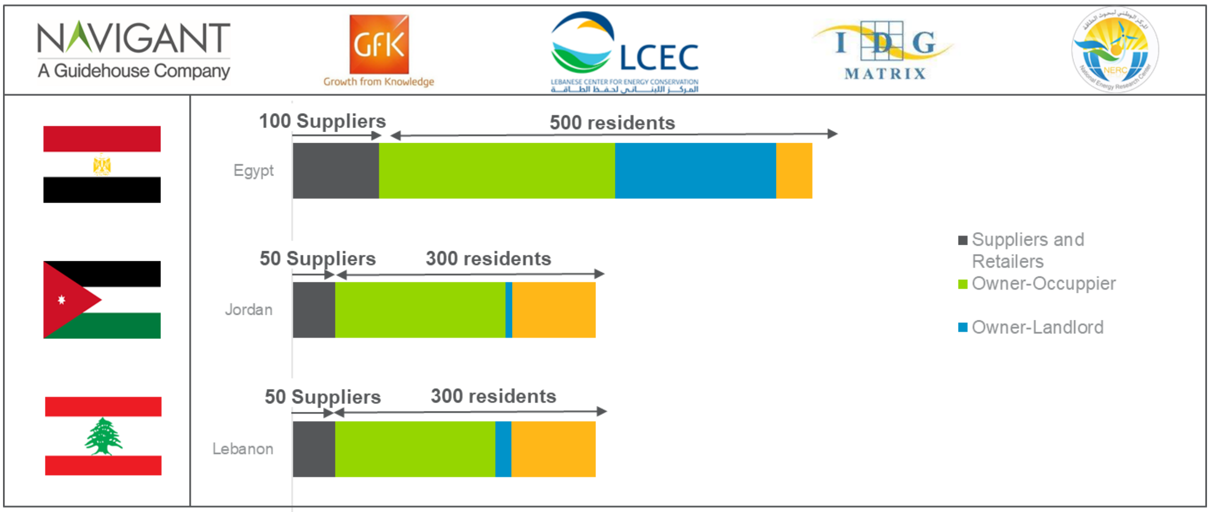


Figure 7. Breakdown of suppliers and residential surveys conducted by GfK across Egypt, Jordan and Lebanon

3.2.2 Drivers and barriers by stakeholder group

In the following figure, all concrete drivers and barriers for energy efficiency in Jordan, 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.

„What are concrete drivers and barriers for energy efficiency in cooling & heating in Jordan?"

Stakeholder Group	Drivers	Barriers
Public Authorities	High electricity prices and energy security Reduction of CO_2 emissions Improvement of health & building environment	Too high upfront investment Lack of financial support
Municipalities		Lack of qualified personnel for enforcement
Project Developers	Increased availability of technologies Customer desire to minimize total cost of ownership	Customer preference for minimizing upfront investment Lack of financial incentives to push for efficiency Unproven effectiveness, risk of construction delays
Banks and Funds	„Greening" corporate image Availability of funding through JREEEF and int'l donors	Lending money for EE not part of portfolio No government regulation or incentive for EE No impact of EE on value of building
Utilities	National laws and by-laws for EE Reduction of subsidies for securing peak load Legal obligation to promote EE in buildings (NEPCO only)	No incentive for households to invest in EE (low power tariffs) Lack of obligations for utilities to reduce demand of consumers
Technology Suppliers	Shift in customers' mindset to reduce total cost of ownership First mover advantage for companies to import new products	Lack of demand due to high purchasing costs Governmental restrictions National political and economic situation
Consumers	Recommendation from vendor or project developer	Lack of consciousness Personal financial reasons

Figure 8. Drivers and barriers for energy efficiency as learned in stakeholder interviews

3.2.2.1 Public Authorities

Drivers for public authorities can be categorised in four levels:

- First level: Electricity prices. Interviewees with public authorities have shown that high electricity prices are the most important driver to increase EE in buildings and reduce the energy bill on the final consumer.
- Second level: Providing a better health and building environment for occupiers and reducing CO2 emissions from the building sector
- Third level: Reducing imports, improving energy security and attracting international donors' money
- Fourth level: Improving NEPCO financial state and reaching government energy efficiency targets.

Figure 9 illustrates the detail breakdown between those levels.

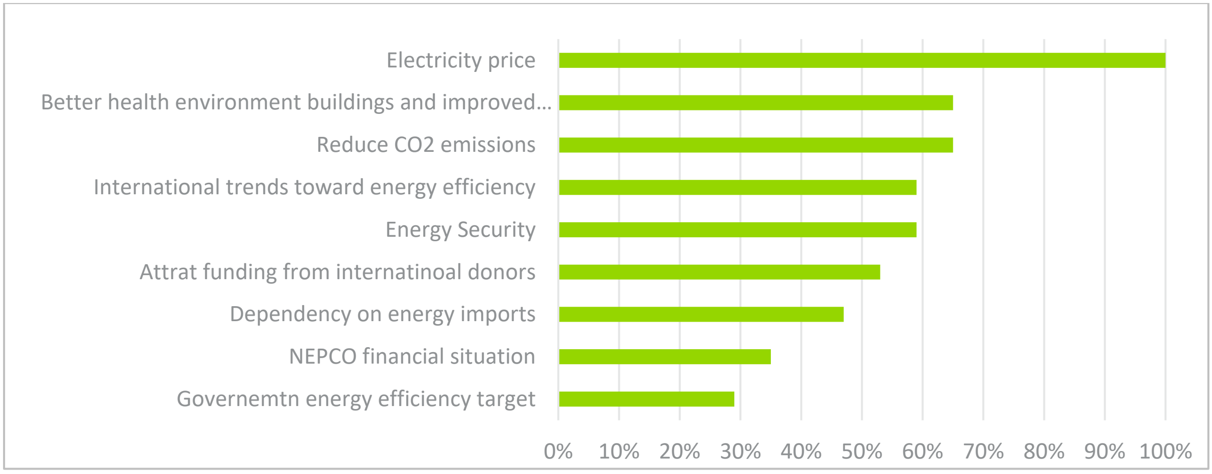


Figure 9. Drivers for energy efficiency from the perspective of public authorities

Barriers for public authorities can also be categorised in four levels:

- First level: Upfront cost and lack of financial support/subsidies. The upfront cost of energy efficiency measures influences the decision making of building occupiers. With low purchasing power and absence of financial support, the priorities of average Jordanian citizens are not on energy efficiency.
- Second level: Lack of enforcement from the side of public sector and lack of awareness from the side of private sector, including technical and financial sector (engineers/architects/investors)
- Third level: Lack of standards and labels
- Fourth level: Weak regulatory framework and low energy prices

Figure 10 illustrate the detailed breakdown of those levels.

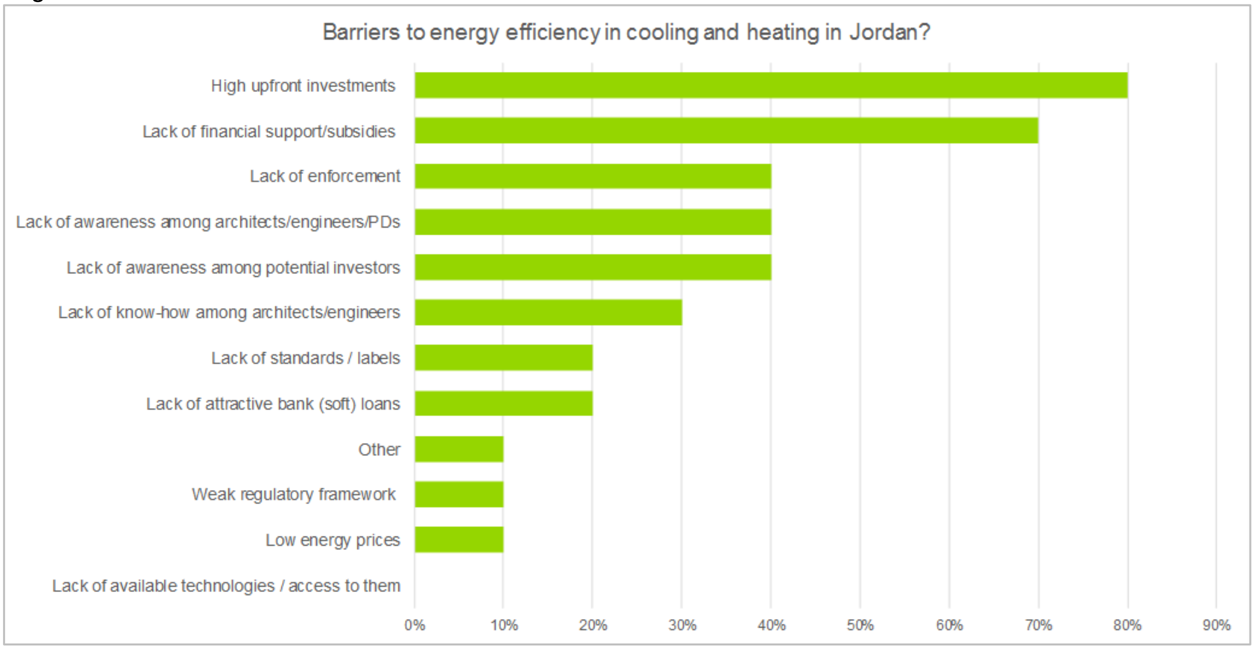


Figure 10. Barriers for energy efficiency from the perspective of public authorities

3.2.2.2 Municipalities

The Greater Amman Municipality (GAM) is the only municipality that currently has an incentive system to promote EE in residential buildings. This is a special regulation for this municipality since it is an independent authority. Other municipalities do not have any incentive system because there is no law to cover it. The incentives offered by GAM are faster permitting processes (by prioritizing the applications related to EE in buildings), larger floor spaces for building area permits and exemptions from optical/design standards for buildings. There are no financial incentives provided by any of the interviewed municipalities because there are no regulations or laws to cover such incentives.

Interviewees from Irbid and Karak municipalities answered that they are generally satisfied with the current building regulations that are enforced in their cities. The main challenges are the regulations and the lack of qualified personnel. GAM, Irbid and Karak municipalities think that they can force the regulation with their staff, but they need awareness and training to perform this. In addition, only GAM think they have enough budget to enforce building standards in its municipality. Based on the interviewee's answers, the average number of the required people to carry out the enforcement is 17-20 people.

3.2.2.3 Project Developers

Our interviews showed that EE measures in the building sector in Jordan are moving forward but have not yet passed the business as usual approach.

Half of the interviewees answered that the efficiency of heating and cooling technologies plays a role in their residential projects. There is a correlation between the income class of customers and the decision of project developers to consider energy efficient heating and cooling technologies. Project developers with a major share of high-income clients were considering EE whereas other project developers with major share of low-income clients were not considering energy efficient measures. In general, project developers listed several reasons driving them to increasingly install or recommend energy efficient heating and cooling technologies to their customers:

- The increased availability and market-readiness of EE heating and cooling technologies driven by an increasing customer demand;
- The wish of customers to minimize the total cost of ownership of their assets, have a faster payback period and higher comfort within their apartments;
- Growing environmental concerns in Jordan;
- Marketing a green image is attracting more customers and increasing value of the company in the market;
- Corporate sustainability strategy.

The other half of project developers interviewed answered that efficiency of heating and cooling technologies does not play a role in their residential projects. The main reason given is that the final decision on heating and cooling appliances is taken by the owners, who would benefit from lower operating cost whereas project developers do not have any advantage in promoting more efficient equipment. A quarter of the interviewed project developers even stated that it is not their job to take care of this aspect of the building. Other barriers can be categorised in two groups of barriers: technical and financial barriers.

Several project developers considered that technical barriers prohibit them from opting for efficient heating and cooling technologies. They stated that there are not enough pilot projects to prove the effectiveness of EE systems, deplored a lack of standards for residential units to guide them through their calculations and a shortage of qualified technical personnel in the company to install the systems.

A comparable number of developers considered the business case for energy efficient heating/cooling technologies to be weak for three reasons:

1. Customer demand is focused on minimizing upfront investment cost;
2. There are no financial incentives existing to push for their adoption;
3. Installing such technologies leads to longer commissioning times and delays potentially increasing project developer cost.

3.2.2.4 Banks and Funds

Although the vast majority of interviewees in the banking sector confirmed they were offering loans for EE and RES projects in Jordan, only a small portion of the interviewed banks see heating/cooling systems of buildings as a relevant aspect for them in the lending decision. They perceive lending money for investments in energy efficient heating and cooling technologies positively because it greens their image attracting more customers and funding is available through JREEF and international donors. However, loan officers lack understanding of technologies and trust in the quality of products. Banks are more comfortable lending money to solar PV projects. There exists no obligation by law to lend money for EE projects.

Most interviewees stated that the heating/cooling systems in buildings are not a relevant aspect for them in lending. The reasons they provided were as follows:

- 50% of the bankers:
  - have no interest in lending money for efficient heating and cooling systems because it is not considered a part of their portfolio;

  - state they do not see a need because there is no government regulation or incentive to stimulate demand from customers to apply for an EE loan;
  - have no interest in lending money for efficient heating and cooling systems because it does not impact the value of the building.
- 25% of the bankers explained that it is not easy for them to quantify the financial benefits and risks of energy efficient heating and cooling technologies as energy savings are not a conventional asset to which they can lend money to.

3.2.2.5 Utilities

Regarding drivers to accelerate EE in residential buildings, interviewees stated several reasons:

- Laws and governmental targets such as the national energy strategy of 2015 (which targets a reduction of 20% in primary energy consumption), Law No. 13 of 2012 (Energy Efficiency Law) and By-Law No. 10 of 2013 granting tax exemption for EE products;
- Energy efficient heating and cooling technologies reducing electrical peak load, which from a distribution utility perspective is the highest cost for investment and operation of the grid. Any reduction in such cost is a reduction of government subsidies;
- Obligation by law for NEPCO to promote EE in buildings;
- JEPCO voluntary program to deploy energy efficient CFL lighting to its residential customers.

There were also several drivers mentioned to accelerate RES in residential buildings:

- The national energy strategy of 2015 which targets a share of 10% of RES in the energy mix by 2020 and a share of 30% of households equipped by solar water heater by 2020;
- Renewable Energy Law No. 13 of 2012, granting net-metering rights to residential consumers opting to in-vest for a solar PV installation on their roof top. This has encouraged consumers from all sectors with high tariff to generate their own electricity to meet 100% of their demand;
- Renewable Energy By-Law No.10 of 2012, granting tax exemptions on RE products.

On the other hand, utility representatives mentioned the following barriers to accelerate EE and RES in residential buildings:

- With 90% of households in Jordan receiving an electricity tariff below cost of production and the government subsidizing such cost for the utility, there is no incentive to invest in efficiency in residential households in Jordan at the moment;
- Lack of clear regulation on obligations set to utilities to reduce demand of consumers;
- Long term Power Purchasing Agreement contract with fossil fuel generation companies introduce inflexibility in the Jordanian power system, hindering the acceleration of residential solar PV;
- The current net metering policy benefits commercial institutions that end up paying less for their energy bill as they move from the high-to-low consumer group and benefit from low subsidized electricity prices;

- Lack of experience in implementing EE programs: For example, JEPCO struggled to implement a residential lighting program as the CFL lighting that was imported was of poor quality. The process was time-intensive and costly.

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 (73%) is a shift in customers' mind-set to reduce total cost of an asset over its lifetime rather than reducing the upfront investment cost. Demanding comfort appears not to be the priority. The second driver mentioned the most (28%) was called first-mover advantage. In other words, 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. This however appears to be a contradictory barrier because it was also considered as a driver. In the process of surveys, a certain margin of contradictory responses is always present and factored in because of the nature of the survey itself (i.e. the subjectivity of the feedback), which always plays a role even when limiting the number of open-end questions.

3.2.2.7 Consumers

Respondents in the consumer survey suggested that the drive to apply EE technologies through the vendor's or the project developer's recommendation. In contrast, individual motivation (i.e. for one's comfort) or friends' recommendations appear to be less relevant drivers.

As main barriers preventing consumers from installing EE heating and cooling appliances the lack of consciousness in the choice of this type of appliances was mentioned the most (55%), followed by personal financial reasons (42%).

3.3 Main Results and Learnings from Pilot Projects

Project	Boundary Conditions		Proposed Technical Measures
 Ea´tedal Complex Zarqa	95-120	Expected inhabitants	Energy Efficient Windows
	3,870 m²	Conditioned floor area	Window Fraction
	1,186 K*d	Heating Degree Days	Shading
	1,113 K*d	Cooling Degree Days	Air tightness
	2,049 kWh/m²	Solar Irradiation p.a.	Increased efficiency of cooling
			LED lighting
	0.13 JOD/kWh	Electricity Price	Adjust set temperature for cooling/ heating
	0.05 JOD/kWh	Diesel Price	
 North Project Aqaba	4 (per villa)	Expected inhabitants	Orientation, outside color, window fraction
	200	Conditioned floor area	Shading structures
	1,197 K*d	Heating Degree Days	Thermal insulation
	1,150 K*d	Cooling Degree Days	Green roof
	2,448 kWh/m²	Solar Irradiation p.a.	Solar thermal collectors and PV panels
			Inreased efficiency of cooling
			LED/CFL lighting

Potential Impact (Ea´tedal Complex Zarqa)	Before measures	After measures
Energy demand	51 kWh/(m²*a)	17 kWh/(m²*a)
Investment cost	9 €/m²	31 €/m²
GHG emissions	34 $kgCO_2$/(m²*a)	8 $kgCO_2$/(m²*a)

Potential Impact (North Project Aqaba)	Effect through measures (for 1 villa)
Energy demand	– 20,000 kWh/a
Investment cost	25,000 €
GHG emissions	– 12,000 $kgCO_2$/a

Figure 11. Overview of pilot projects conducted in Jordan

3.3.1 Ea´tedal Complex, Zarqa

3.3.1.1 General Information

The Al-Urwa Al-Whathqa Charity Association was founded in 1965 and is working towards establishing several social projects and residential buildings for comfort and development of orphans and people in need. Zarqa is Jordan's third-largest city after Amman and Irbid with approximately 1.36 million citizens in 2015 and a total area of 4,761 km2. Zarqa is considered a residential and industrial city. It is located 15 miles (24 km) northeast of Amman. The project was planned to be built from 2017 to 2019. It contains residential properties and a mosque; the residential part consists of 24 apartments for an expected 95-120 inhabitants. The floor area is 3,870 m2 with a clear room height of 3.2 m, resulting in a conditioned volume of 11,500 m3.

Figure 12: Picture of Ea´tedal Complex, Zarqa

The climate in Amman is moderate. The annual average temperature is 18°C and only a few hours per year undercut the freezing point. Similar heating and cooling degree days of around 1,150 kd indicate a balanced and moderate need for heating and cooling. High horizontal irradiation of more than 2,000 kWh/(m²*a) and more than 1,100 kWh/(m²*a) for east, south, and west orientations create opportunities for solar-based energy generation.

In Jordan, natural gas is used only for power generation plants, and liquefied petroleum gas (LPG), diesel fuel, and electricity are used in space heating. The mean energy prices are JOD 0.13 per kWh (EUR 0.16 per kWh) for electricity and JOD 0.05 per kWh (EUR 0.06 per kWh) for diesel.

Table 1: Main information overview

Criteria	Input
Latitude	32.068 °N
Longitude	36.087 °E
Elevation	688 m
Number of expected inhabitants	95-120
Utilisation	Residential/mosque
Year of construction	2017-2019
Number of floors	Five plus parking
Number of apartments	24
Conditioned floor area	3,870 m²
Clear room height	3.2 m
Conditioned volume	11,500 m³

3.3.1.2 Current Situation (BaU)

The building envelope is in line with current building code (BaU – Building as Usual); however, no special attention has been given to use of renewable energy sources: heat and cold supply are reversible split unit with a COP of 2.5, and hot water is supplied by an electric instantaneous appliance. The set temperature is 24°C and 21°C for heating and cooling, respectively.

In this scenario, cooling energy represents the largest portion of energy demand with a total share of 32%. Domestic hot water demand reaches 27% of total demand, and heating and lighting have the smallest shares with 21% and 20%, respectively. The current situation reaches an energy demand of 51.4 kWh/(m²*a) and an environmental impact of 33.9 kg CO2e/(m²*a). For a unit of 90 m², the energy cost will reach about EUR 59.63 or JOD 50.11 per month. This represents the standard building package.

21% and 20% are heating and lighting. In its combination the current situation reaches an energy demand of 51.4 kWh/(m²*a) and an environmental impact of 33.9 kg CO2e/(m²*a). For a unit of 90 m² the energy cost will reach about €59.63 per month or 50.11 JOD. This represents the standard building package.

3.3.1.3 Variants

All measures are grouped according to their payback time. All measures with a payback time of less than 2 years are implemented with the low-cost variant (bronze). For the moderate variant (silver), all measures with a payback time of less than 5 years are implemented. Therefore, all measures from the bronze package are included. With the highly energy efficient variant (gold), all proposed measures are implemented, with a payback time greater than 5 years and smaller than 15 years.

3.3.1.4 Technical Description – Variant 1 - Bronze package

The bronze package offers the best cost efficiency in terms of energy savings and paybacks due to lower energy costs. The package consists of three main measures: adjusting set temperatures (20°C for heating, 26°C for cooling), LEDs for lighting, and an increased COP of 3.0 for cooling and heating.

Table 2: Measures of current situation and Variant 1

Measure	Current Situation	Variant 1 (Bronze)*
Roof insulation	0.55 W/m²K	0.55 W/m²K
Wall insulation	0.57 W/m²K	0.57 W/m²K
Floor insulation	0.8 W/m²K	0.8 W/m²K
Windows	5.7 W/m²K, G = 0.85	5.7 W/m²K, G = 0.85
Window fraction	Ø 11%	Ø 11%
Shading	No	No
Air tightness	0.25 1/h	0.25 1/h
Heating system	Reversible split unit - COP 2.5	**Reversible split unit - COP 3.0**
Cooling system	Reversible split unit - COP 2.5	**Reversible split unit - COP 3.0**
Hot water	Electric instantaneous	Electric instantaneous
Ventilation system	Natural	Natural
Lighting system	CFL	**LED**
Renewable energy	No	No
Temperature setpoint: heating	21°C	**20°C**
Temperature setpoint: cooling	24°C	**26°C**

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

3.3.1.5 Technical Description – Variant 2 - Silver package

The moderate silver package consists of bronze variant and additional implemented measures: increased COP of 5.0 for cooling and heating, rooftop PV and solar thermal appliances, and low E glazing (U-value 1.2 W/m²K) as well as overhangs for south-orientated windows. These measures offer high energy savings and moderate paybacks, with a payback time of less than 5 years. Unlike the standard and bronze approaches, the silver approach also achieves reductions for domestic hot water and additional savings using PV.

3.3.1.6 Technical Description – Variant 3 - Gold package

The highly energy efficient gold package consists of the following additional measures: triple glazed windows (U-value 0.8 W/m²K), automatic shading, and an air infiltration rate of 0.05/h. These measures offer high energy savings but are bound to high investments costs, which leads to payback times of 15 years.

Table 3: Measures of Variant 2 and Variant 3

Measure	Variant 2 (Silver)	Variant 3 (Bronze)
Roof insulation	0.55 W/m²K	0.4 W/m²K
Wall insulation	0.57 W/m²K	0.55 W/m²K
Floor insulation	0.8 W/m²K	0.8 W/m²K
Windows	1.2 W/m²K, G = 0.65	**0.8 W/m²K, G = 0.50**
Window fraction	Ø 11%	Ø 11%
Shading	Overhang south	**Automatic; not towards north**
Air tightness	0.25 1/h	**0.05 1/h**
Heating system	**Reversible split unit - COP 5.0**	**Reversible split unit - COP 5.0**
Cooling system	**Reversible split unit - COP 5.0**	**Reversible split unit - COP 5.0**
Hot water	**Electricity/solar thermal 45%**	**Electricity/solar thermal 45%**
Ventilation system	Natural	Natural
Lighting system	LED	**LED**
Renewable energy	**PV**	**PV**
Temperature setpoint: heating	20°C	20°C
Temperature setpoint: cooling	26°C	26°C

Note: Bolded entries indicate those that differ from variant 1.

3.3.1.7 Results

Variant 1, the bronze package reaches an energy demand of 36 kWh/(m²*a) and an environmental impact of 24 kg CO2e/(m²*a). For an apartment of 90 m², the energy cost reaches approximately a monthly rate of EUR 42 or JOD 35. In comparison with the investment costs of the current situation / building as usual (BaU), the total is increased by 24%. However, the energy costs are reduced by 29%. The reductions take place in heating, cooling, and lighting.

Variant 2, the silver package will reach an energy demand of 17 kWh/(m²*a) and an environmental impact of 8 kgCO2e/(m²*a). For a residential unit of 90 m², the energy cost will reach approximately a monthly rate of EUR 15 or JOD 13. In comparison to the investment costs of the standard package, the grand total related to energy efficiency is increased by 291%, however the energy costs are reduced by 75% which makes up for the incremental investments over time. Unlike the standard and bronze approaches, the silver approach also achieves reductions for domestic hot water and additional savings using PV.

Variant 3, the gold package consumes 15 kWh/(m²*a) of final energy and 8 kg CO2e/(m²*a) are released. The investment costs related to energy efficiency are about 440% higher than the standard approach, and the energy cost reduction reaches 78%. For a unit of 90m², this results in a monthly energy rate of EUR 13 or JOD 11.

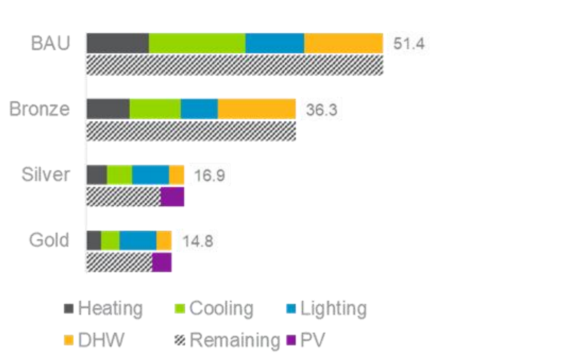


Figure 13. Specific final energy demand [kWh/(m²*a)]

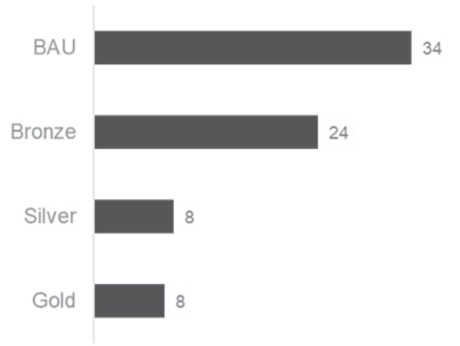


Figure 14. Specific emissions [kg CO2e/(m²*a)]

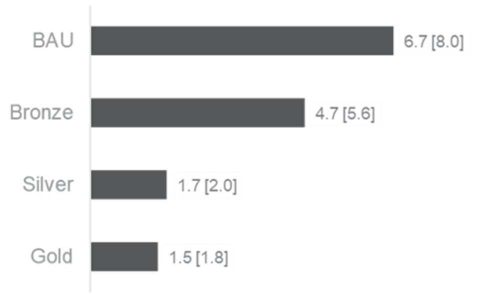


Figure 15. Specific energy costs LBP/(m²*a) [EUR/(m²*a)]

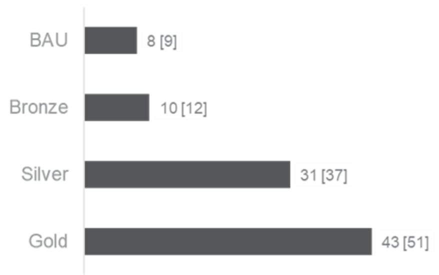


Figure 16. Specific investment costs LBP/(m²*a [EUR/(m²*a)]]

3.3.1.8 Recommendation

As the silver package combines high energy and CO2 savings with reasonable investment efforts, it was recommended. To achieve the calculated results, the following approach should be followed. To reduce energy demand, educate inhabitants (e.g., through flyers and training) about adjusting the set temperature for cooling and heating, achieve improved thermal insulation by investing in low energy windows (U-values 1.2 W/m²K), and investigate overhangs towards the south—in this course, the shading of the surrounded buildings on the southern façade should be rechecked. To utilise solar energy on the roof, unshaded space towards the south should be reserved for the installation of PV/solar collectors (e.g., when installing water tanks, satellite dishes). Also, the cost benefits of PV and solar thermal should be verified by obtaining offers from local suppliers. Furthermore, energy efficient appliances and lighting should be used. Specifically, reversible split units with a COP of at least 5.0 for cooling and heating. Also, LED technology should be used for lighting.

3.3.2 North Project, Aqaba

3.3.2.1 General Information

The Villa options offered by the North Project in Aqaba range from modest Premier Villas on small plots to Executive Villas on spacious parcels. The measures and potentials discussed are designed and quantified for the Premier Villa. The project is designed to contain Premier Villas for 796 inhabitants. Aqaba has a population of approximately 150,000 and is of special importance to Jordan because it is the country's only coastal city. For the same reason, commercial and industrial activities are important for the local economy, with a growing tourism sector. The North Project currently has two arrival points from the north and east with future connections to the south and west. The site is accessed from both the Dead Sea Highway and the Desert Highway and is approximately 10 km from Downtown Aqaba by car. In the future, the site will directly connect to the Mourjan project to the west and with future development to the south. Nearby facilities such as the University of Jordan, public and private schools, mosques, and health service are all accessible via car with a maximum travel time of 10-15 minutes. The King Hussein International Airport is a 10-minute (7 km) drive.

Figure 17: Illustration of North Project, Aqaba

Aqaba's average mean temperature ranges from an average low of 18.3°C to an average high of 30.9°C. During the summer months, the average maximum temperature reaches 38°C-40°C between June and August. This temperature leads to a cooling demand of 1,150 cooling degree days; at the same time, the solar irradiation of 2,448 kWh creates high potential for harvesting solar energy. The low amount of annual rainfall of approximately 24.6 mm creates water scarcity challenges that require low water-consumption landscape and architectural strategies. Also, there are significant impacts from flash floods; currently, several dams are under construction to address insufficient storm water capacity. Without further investment from local authorities, a flood might threaten the North Project.

3.3.2.2 Concept

As the project was in an immature phase (master planning) and the project developer intended to sell lots rather than build, the BUILD_ME team emphasized increasing awareness and provided single measure calculations to give architects/homeowners freedom to apply measures as best fit. The outcome is intended as a flyer/brochure, clearly illustrating the best energy efficiency and renewable measures for this specific master plan area.

The overarching BUILD_ME team message conveys the Trias Energetica methodology, which is a concept developed by the Delft University of Technology to act as a guideline for energy sustainability in the building sector. It follows the principle: The most sustainable energy is saved energy. Therefore, the first measures should always limit the energy demand through energy savings (such as insulation, shading, etc.). The remaining energy demand should be met by renewable resources (e.g., solar energy). Only then should fossil fuels be used to meet the remaining demand as efficiently and cleanly as possible (e.g., efficient cooling devices, efficient lighting).

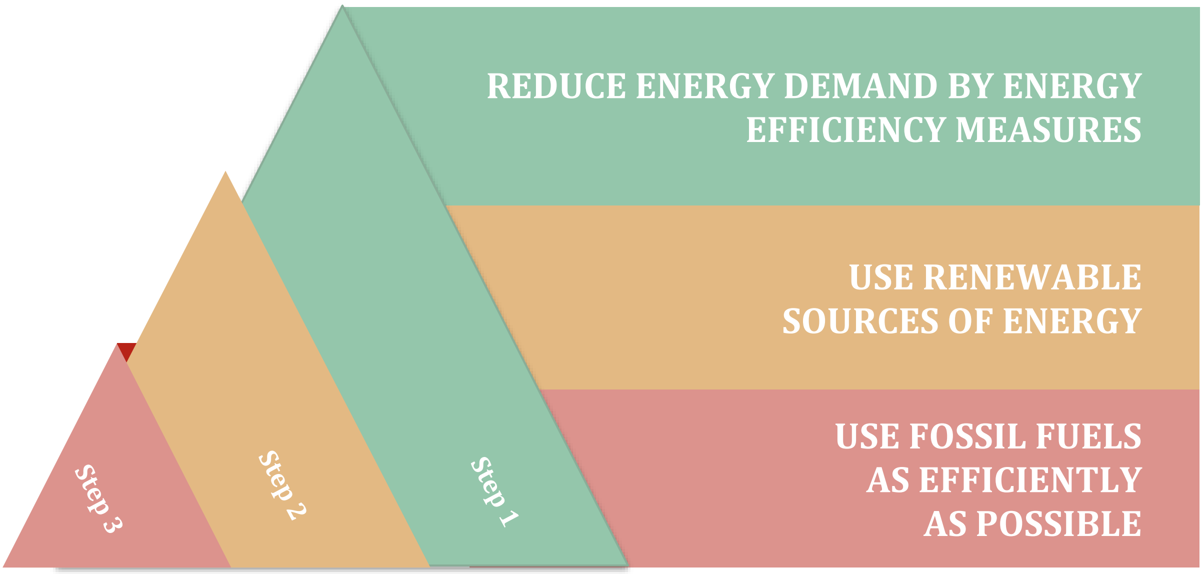


Figure 18: Steps of measures

3.3.2.3 Possible Measures

Table 4: Cost savings, reduced energy and GHG emissions of measures

Measure	Cost savings [EUR/y]	Reduced Energy Demand [kWh/y]	Reduced CO_2-Emissions [kg/y]
Shading structures	400	2,500	1,500
Thermal insulation and windows	1,000	7,800	4,200
Green roofs	370	2,500	1,500
Solar thermal collectors	300	2,000	1,200
PV-panels	900	6,000	3,600
Cooling Devices	1,400	9,000	6,200
Efficient Lighting	150	1,000	600

Recommendations for this master plan area based on the Trias Energetica methodology include:

- **Energy efficient design:** Optimised orientation of a building reduces solar heat gains and the related cooling load, leading to lower operational costs. On the north and south façades, solar radiation is normally lower than on the east and west façades. Therefore, the building should be orientated along the east-west axis, with the largest surfaces facing north and south. Additionally, a bright envelope colour for roof and external walls is an effective measure to reduce solar heat gains. Finally, reducing the window fraction for façades facing the south, east, and west is recommended to minimise solar heat gains and decrease the cooling energy demand. The reduced window fraction should be less than 20 %, based on the Window-Wall-Ratio. These measures have a short payback period of less than two years.

- **Shading structures:** Shading structures in front of windows are important for the climate conditions inside the building, especially in the east, south, and west directions. External shading devices for windows are much more efficient than internal window coverings. They reduce heat gains by 70%-85%, whereas internal coverings can reduce heat gains by as little as 15%. These measures also have a short payback period (less than two years).

- **Thermal insulation:** Improved wall and roof insulation reduces heat loss or gain and lowers the energy demand for heating and cooling. Common insulation materials used to reduce heat loss include (by decreasing efficiency): polyurethane foam, mineral wool, stone wool, polystyrene, cellulose, and vermiculite. However, transmission losses from windows are approximately four times the losses of massive building elements. Thus, windows should achieve an insulation level of at least 1.50 W/m²K. These measures have a long payback period (higher than 15 years).

- **Green roof:** Rooftop vegetation moderates extreme temperatures and UV radiation, which extends the lifespan of the roof by around 20 years. Additionally, the vegetation collects storm water, filters particulates and pollutants, and serves as a cooling layer on the roof. The evaporation process helps to cool air temperatures and reduces the heat island effect, which benefits the whole area. The cooling effect also has a positive impact on the efficiency of PV modules on the roof. This measure has a long payback period (higher than 15 years).

- **Solar thermal collectors:** A typical option for single-family houses is a combination of small-scale collectors with integrated hot water storage. They are sufficient to cover low or medium hot water demands and have economic advantages compared to big systems. This measure pays back in the medium term (around 5 years).

- **PV panels:** PV competes against solar thermal collectors in terms of space on the roof. Thermal collectors have proven to be more economical, although the cooling effect of green roofs in combination with PV may influence this estimation. Therefore, solar thermal collectors should be used to cover the domestic hot water demand and, if there is still roof space, PV panels could be installed. This measure pays back in the medium term (around 5 years).

- **Cooling efficiency:** Using cooling systems with a Seasonal Energy Efficiency Ratio (SEER) of greater than 4.5 is recommended. Air intake on the roof should be at 2 meters to ensure cooler air temperatures. Also, the implementation of highly efficient fans should be considered. These measures pay off in the short term (less than 2 years).

- **Lighting efficiency:** Energy efficient light bulbs include CFLs and LEDs. These types consume between 25% and 80% less energy than conventional light bulbs and can last 3 to 25 times longer. Also, these light bulbs are available in a variety of colours and light levels and may be used as architectural design elements. This measure is easy to apply and has a short payback period (less than 2 years).

3.3.2.4 Results

Investing in efficiency measures is strongly recommended for economic and ecological reasons. For the Premier Villa, payback times for single measures range from less than 1 year to 15 years. If all presented measures are considered, a payback time of around 8 years with annual savings of around EUR 2,900 in energy costs are possible, this translates to 20,000 kWh yearly energy savings and yearly CO2 savings of 12,000 kg CO2.

First, the building should be planned using energy efficient design guidelines, including (passive) natural cooling, following the Trias Energetica concept. These efficient design measures offer huge benefits for no or low additional costs and should be discussed with the responsible architect during the planning process.

The effects of single measures are greater than in combination with other efficiency measures because most measures target similar goals (e.g., room temperature). However, savings will rise as more measures are taken. A combination of all measures leads to the biggest long-term savings and will benefit the neighbourhood by decreasing the heat island effect.

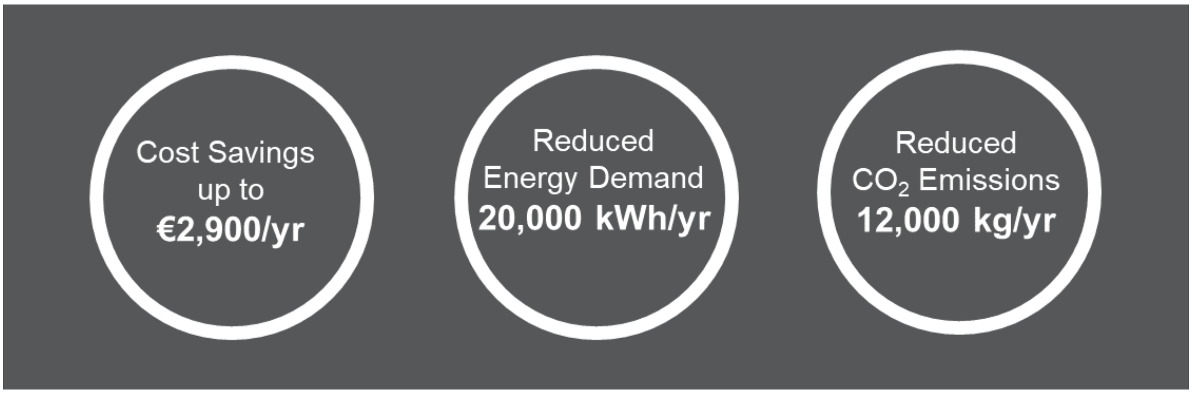


Figure 19: Savings of the combination of all measures

Although Trias Energetica should be respected, the best options regarding cost-optimality and lifetime are:

1. Efficient building design
2. Shading structures
3. Cooling efficiency
4. PV panels
5. Efficient lighting
6. Insulation
7. Solar thermal modules
8. Green roofs

Costs:	**Additional invest costs: ~€25,000**
Return:	**About €2,900/yr**
Payback Period:	**Medium (8-9 yrs)**

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 Jordan towards zero emissions.

Public Authorities

Review and simplify the **building and EE codes**

Raise **municipalities' awareness** of existing incentives and introduce policies that enable municipalities to offer incentives for EE

Review technical workforce **capability of municipalities**

Set clear **obligations for utilities** to reduce energy demand of consumers

Restructure **electricity tariffs** to incentivize EE measures in residential sector

Re-think design of **solar PV tariffs** to allow solar PV to contribute to reducing government subsidies

Capacity training of utilities to deploy and implement EE measures in the residential sector

Project developers

Mandatory examination of all architects and civil engineers on EE building codes

Turn building rating system to **mandatory rating systems** for all new buildings

Digitalize **permitting process** to ensure code compliance at design stage

Build technical capability of **municipalities' workforce** to inspect buildings and enforce penalties

Banks and Funds

Raise **awareness among bankers** and loan applicants on the benefits of EE in the building sector and the JREEEF application process

Offer **training to support credit officers** in understanding the impact of low interest loans on business opportunities in EE

Technology Suppliers

Provide financial incentives to importers and manufacturers of **thermal insulation** and double glazed windows

Introduce **solar air collectors** for space heating and encourage suppliers to import them

Incentivize suppliers to import **reflective film** for windows to reduce the cooling load

Figure 20. Policy measures proposed by stakeholders in interviews

4.1.1 Public Authorities

4.1.1.1 JOR_PA_01: Review and simplify the building codes and EE codes

- **Rationale:** There are more than 30 building codes in Jordan. Project developers consider the codes too complicated and long. Many ask for a simplified code in the form of a checklist.

- **Implementation:** The MPWH is responsible for issuing new guidelines for codes through establishing a technical committee to prepare detailed guidelines. The Ministry is also responsible for organizing workshops for contractors and local building experts from the private and public sectors to introduce/explain the code guidelines. Best practice from countries with similar climatic conditions should be considered in the revision of guidelines and potential revision of codes.

4.1.1.2 JOR_PA_02: Raise municipalities' awareness on existing EE incentives in the Jordan Green Building Guide and introduce policies that enable municipalities to offer incentives for EE in buildings beyond the floor to area ratio

- **Rationale:** Except for Greater Amman Municipality (GAM), which is not under the jurisdiction of the Ministry of Public Works and Housing, other municipalities in Jordan do not have the knowledge and currently lack interest in offering incentives to EE measures in buildings following the Jordan Green Building Guide.

- **Implementation:** GAM prepares bylaws to offer incentives for EE measures in buildings based on its own experience. The by-laws must be approved by the parliament. These incentives include lower registration fees for energy efficient buildings, privileged treatment for applicants opting for EE measures by prioritizing their applications and faster treatment than typical applications.

4.1.1.3 JOR_PA_03: Review the technical workforce capability of municipalities to ensure the compliance of rooftop solar water heaters (SWH) and solar PV to the Jordanian Solar Code

- **Rationale:** Although instructions were issued in 2014 to install SWH on new buildings, flats and offices with surface areas larger than 250 m2, 150 m2 and 100 m2 respectively, the lack of inspection regarding the quality of the design and absence of penalties resulted in lack of control on the design and proper installation of SWH in Jordan due to lack of qualified inspectors.

- **Implementation:** Conducting training courses by the Royal Scientific Society / National Energy Research Center on solar water heater installation and system sizing to municipalities and to clarify requirements for proper installation according to the solar code.

4.1.1.4 JOR_PA_04: Set clear obligations for utilities to reduce energy demand of consumers

- **Rationale:** Lack of clear regulation on obligations for utilities to reduce demand of their consumers. In addition, utilities lack experience to roll out EE programs (see chapter 2.2.2.5).

- **Implementation:** Conducting an awareness campaign in cooperation with utilities in implementing energy efficient measures in the residential sector mainly on replacement of old lamps with LED. International consultant support can be requested on demand to support utilities in ensuring quality testing of LEDs. Recently in Jordan, the planned and ongoing replacement of incandescent lamps with LED for residential sector was mentioned in second NEEAP (2017 – 2020). About 1 million LED for 250,000 consumers will be targeted in Jordan. Similar programs could be rolled out for other measures.

4.1.1.5 JOR_PA_05: Restructure electricity tariffs to incentivize energy efficient measures in residential sector

- This measure was proposed by interviewed utilities. Currently, subsidised electricity tariffs lower the financial value of energy savings, hence making energy efficiency measures less

4.1.1.6 JOR_PA_06: Re-think the design of solar PV tariffs to allow solar PV to contribute to reducing government subsidies and not increasing them

- This measure was proposed by interviewed utilities. With the appropriate policy design, solar PV can decrease pressure on the conventional-based power supply, alleviating some of the need for the government to subsidize generation capacities.

4.1.1.7 JOR_PA_07: Capacity training of utilities to deploy and implement energy efficient measures in the residential sector

- This measure was proposed by interviewed utilities. Utilities have direct access to energy end consumers. This can be leveraged to implement energy efficiency measures in the residential sector.

4.1.2 Project Developers

4.1.2.1 JOR_PD_01: Mandatory examination of the knowledge of all mechanical, architects and civil engineers regarding the Jordanian EE building codes and introduction of the Junior Engineer Program

- **Rationale:** Engineering offices are often not putting in practice the EE-related provisions of building codes because of a lack of knowledge and training. In Jordan, there are several different codes that are focusing on EE in buildings and for RES. Some project developers admitted that they lack knowledge in, for example, conducting a load analysis for the heating and cooling demand of the building and thus, just follow business as usual approaches and their experience to select technologies.

- **Implementation:** The Jordan Engineers Association (JEA) has the responsibility and mandate to design, organize and complete the examination. JEA will be responsible to offer trainings to engineers. The test shall be designed in different sections targeting different sectors in the design, construction and inspection of new residential buildings. Civil, electrical and mechanical engineers who work in contracting companies shall apply for a test tailored to the design phase of EE measures, whereas engineers who work in municipalities shall apply for a test tailored to the inspection of EE measures during construction phase. As a next step, we propose to implement a new program at the JEA to continue bridging the gap between the theoretical building codes and their application in practice. This program will be called the "Junior Engineer program" and will be a key step on the road to becoming a professional engineer. Fresh university graduate will work as junior engineers under the immediate supervision and direction of an experienced engineer for a training period that can last up to 36 months. By the end of their training, junior engineers will have to successfully pass a professional examination and will be expected to take full professional responsibility, manage technical risk and solve problems using best professional practices.

4.1.2.2 JOR_PD_02: Digitalize the permitting process to ensure code compliance at the design stage

- **Rationale:** There is a considerable lack of capacity among municipalities' inspectors to inspect the conformity of 4000 to 7000 new buildings per year with respect to the Jordanian EE codes. To frame the picture in a concrete example, 100 engineers are currently employed at the Order of engineers to inspect conformity with 45 building codes whereas 200 engineers are employed at the Civil Defence Department to inspect the conformity with respect to 5 civil defence codes. In addition, bureaucratic procedures slow down the building permitting process and increase cost on the side of project developers. Digitalizing the process of checking compliance with the EE building code, the process of assessment for compliance with this code and enforcement needs to be as transparent and clear as possible. Thus, the need to digitalize the process to facilitate adequate enforcement.

- **Implementation:** Computerize the building design review and permitting process by implementing new software with online applications and machine verification processes at JEA in coordination with municipalities.

4.1.2.3 JOR_PD_03: Empower municipalities through a technical workforce capable to inspect buildings in the construction phase and enforce penalties for non-compliance to the EE building code

- **Rationale:** Missing compliance with building code provisions. Municipalities' inspectors lack the engineering knowledge and tools to inspect the compliance of innovative EE solutions with the building code.

- **Implementation:** Training courses should be offered to municipalities, following the example of GAM. Municipalities should use their authority to set penalties for non-compliance with training requirements on the one hand and with code provisions on the other hand. A second Jordanian NEEAP (2017 – 2020) was launched in April 2018 by MEMR to implement EE measures such as the enforcement of using thermal insulation for new households. The proposed measures would hence be in line with the requirements of the NEEAP.

4.1.2.4 JOR_PD_05: Progressively turn the currently used national building rating system for energy savings from being a guideline to national mandatory rating systems for all new buildings

- **Rationale:** Because of the lack of a transparent national database on the building energy performance, there exists currently no agreed baseline across stakeholders on a business-as-usual-scenario for heating and cooling technologies. Because of this lack of baseline, some stakeholders prefer to keep the Jordan Green Building Guide rating system as a guideline rather to implement it as a mandatory requirement.

- **Implementation:** Develop a buildings baseline and train government officials to update the baseline to benchmark the building energy performance for different geographies and type of buildings. An Energy Use Index should be developed to determine the minimum acceptable energy performance of each building type in the different climate zones in Jordan. Enforcement of the law could start with the new buildings in the public sector and then private sector. Energy Performance Certificates of public buildings should be displayed at the entrance of the building to raise awareness on the economic, social and environmental benefits to citizens. To lower cost of implementation on the side of the government and on the side of the project developer of this policy, it is advised to develop a uniform standard and simple engineering tool that calculates the energy performance of the building and can evaluate the impact of implementing different energy measures on the performance of the building is advised. An example of such tool can be Excel based following standard EN13790.

4.1.3 Banks

4.1.3.1 JOR_B_01: Raise awareness of the end user (and hence loan applicant) on the social, economic and environmental benefits of EE and RES solutions in the building sector and the JREEEF application process

- **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 will translate in improved public services. Lack of awareness on the impacts of climate change in Jordan for future generations.

- **Implementation:** To be most effective in changing traditional conceptions of appropriate heating and cooling technologies, a campaign should target schools and introduce curriculum on impacts of climate change and mitigation measures. The message should clearly highlight the role of citizens in mitigating climate change by investing today in energy efficient and renewable solutions for residential buildings. The government should lead a nation-wide campaign to increase market demand for JREEEF support to loan applicants. Energy performance certificates could further increase awareness about EE in new and existing buildings.

4.1.3.2 JOR_B_03: Offer training and capacity-building to support loan officers in understanding the impact of low interest loans on business opportunities in EE, with a focus on efficient heating and cooling technologies

- **Rationale:** Because of the non-conventionality of the cash flows of an energy efficient asset, loan officers sometimes feel unsure about how to value energy efficient solutions and consider their applications similar to normal consumable goods, instead of depreciable assets.

- **Implementation:** Training bankers in understanding the impact of bank loans on the value of EE measures and how to categorize these from least to highest impact with respect to financial indicators. An analysis tool can be distributed for bankers for this purpose to allow them to tailor financial products to energy efficient products.

4.1.4 Suppliers

4.1.4.1 JOR_S_01: Provide financial incentives to the importers and manufacturers of thermal insulation and double glaze windows

- **Rationale:** Double glazed windows are more expensive than single glazed windows. However, the initial cost should be offset against savings made by reduced energy required to heat and cool buildings and the subsequent carbon emissions reduction.

- **Implementation:** The government should provide tax reductions or exemptions for double glaze windows and insulation materials to encourage suppliers to sell this efficient equipment with adequate prices for the customers. This requires an impact assessment study to be performed by a qualified consultant to figure out the value of tax reduction that would lead to encourage the using of above measures while decreasing the energy bill burden.

4.1.4.2 JOR_S_02: Introduce solar air collector for space heating and encourage suppliers to import it

- **Rationale:** This technology is well known in Europe and has successfully proved its economic feasibility. While in Jordan this technology is still not utilized due to lack of awareness about its importance.

- **Implementation:** Awareness campaigns in cooperation with chambers of trade, universities, energy companies and users about of the importance of utilizing this technology in how it can provide energy and cost savings.

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.

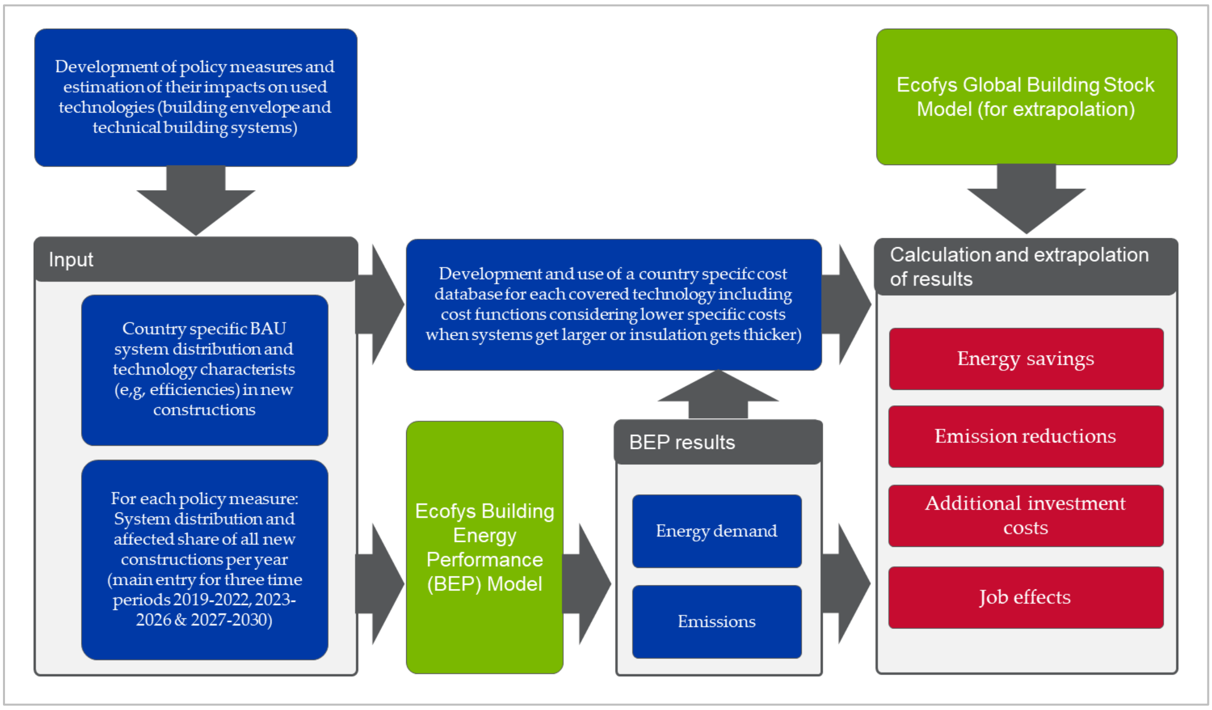


Figure 21: Definition of BAU path

The BAU path has been defined as a „Frozen Technology Reference Level ", meaning that the energetic quality of today‘s 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.

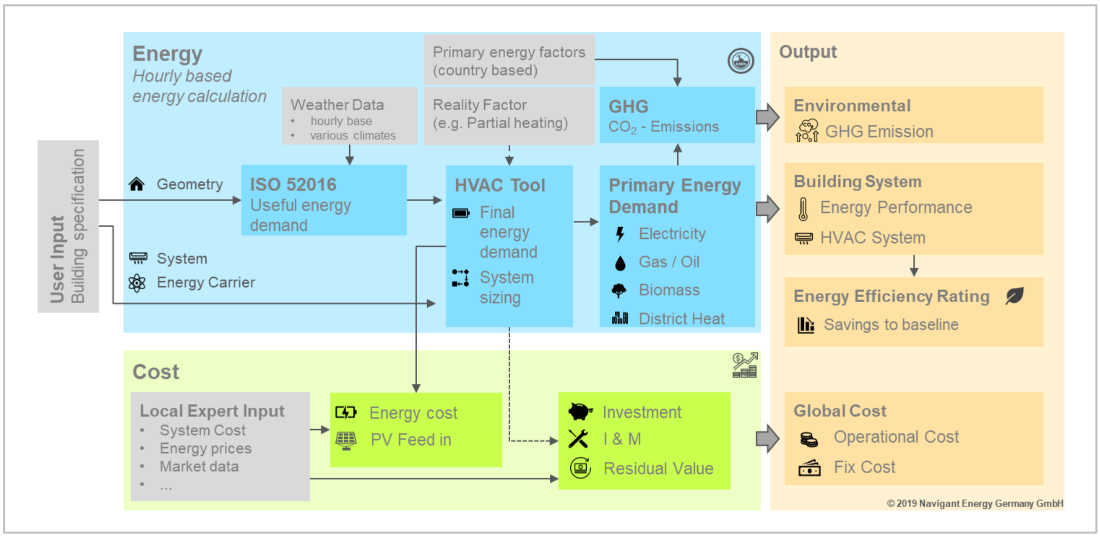


Figure 22 Navigant Building Energy Performance (BEP) Model

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.

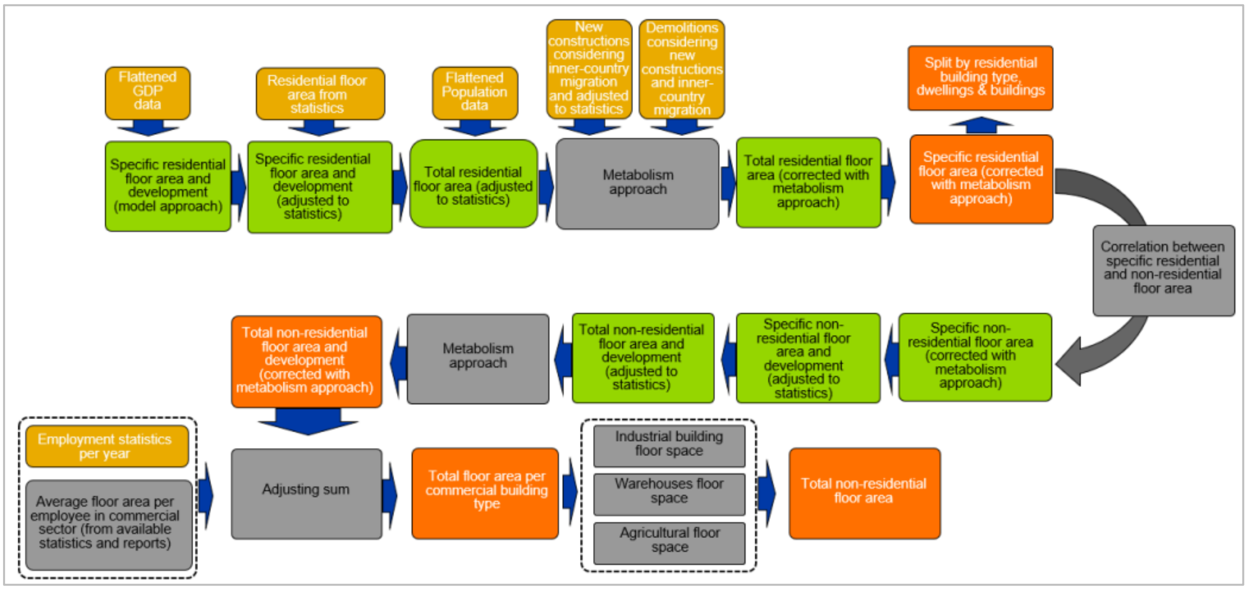


Figure 23: Illustration of the overall approach of Navigant’s Global Building Stock (GLOBUS) Model

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 5: 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 Amman comprises most of Jordan’s population, this municipality was chosen to serve as a reference climate for impact assessment modelling. Hence, an average temperature of about 18 °C was used with a minimum temperature of approx. -2 °C in January and a maximum temperature of approx. 38 °C in July. Heating demand amounts to 1,186 heating degree days while cooling is needed at 1,113 cooling degree days.

The building stock is set to grow at 1.6% per annum on average from 2018 to 2030. This leads to a residential building stock of 227 million m^2 in 2030, up from 169 million m^2 in 2015 and estimated 187 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 100 kWh/m^2. The results of the impact assessment show that some of the measures discussed in chapter 3.1 can significantly cut this to 42 kWh/m^2, if implemented on a stand-alone basis:

- Mandatory re-examination of the knowledge of all mechanical and civil engineers regarding the Jordanian energy efficiency building code, proposed by project developers
- Turn the currently used international building rating system from guideline to progressively, a national mandatory rating system to all new buildings, proposed by project developers
- Review of the building code and energy efficiency code, proposed by public authorities
- Digitization of the permitting process proposed by project developers

Accordingly, the first three of the 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 more than 3 Mt CO_2 in the period from 2018 to 2030.

Investment Costs and Job Effects

In the BAU scenario, investment cost for residential new construction is slightly declining from EUR 182 million in 2018 to EUR 141 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 four measures was introduced on a stand-alone basis, annual investment in 2030 would increase to EUR 318 million. On the other hand, each of the measures would also reduce annual energy cost by EUR 29 million by 2030, leading to a payback of incremental investment over time.

Increasing investment in the building stock also has an effect on employment in the sector. In the BAU scenario, employment is slightly decreasing in line with shrinking investment volumes by a total of 189 jobs lost by 2030. In contrast, the four measures discussed in this section would create 1,744 jobs from 2018 to 2030 on a stand-alone basis.

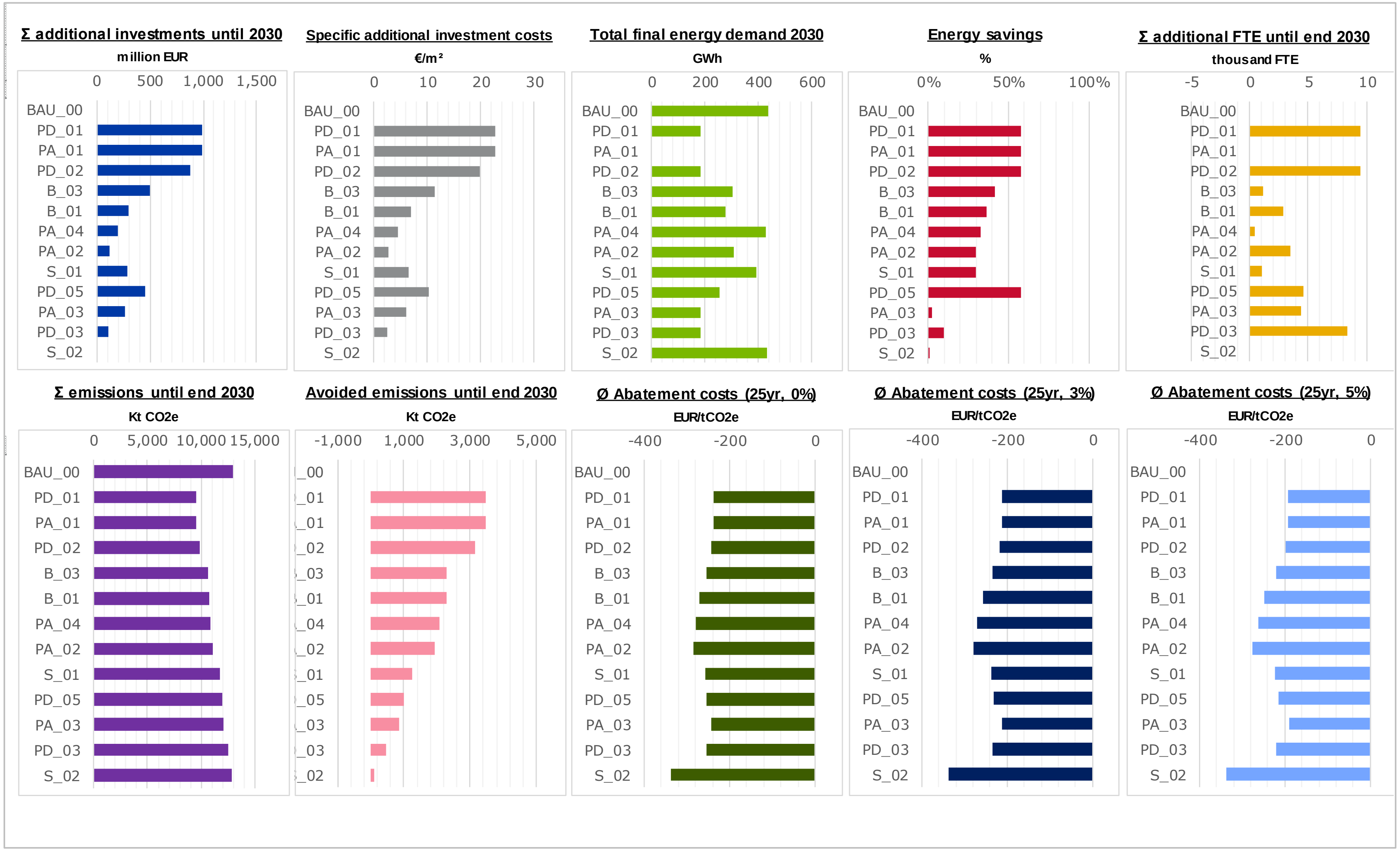


Figure 24: Summary of estimated impacts per policy module

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 Jordan. 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 Jordan with relevant stakeholders in 2017 and 2018 from the following groups:

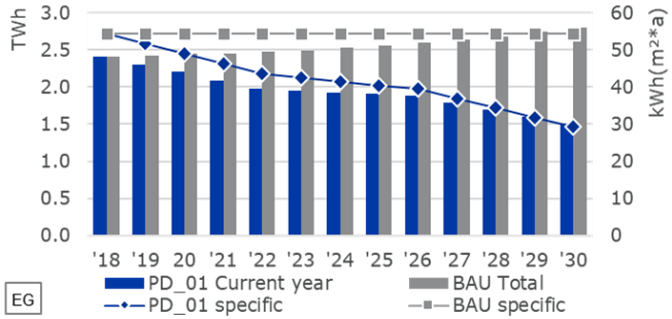
Table 6: Summary of key recommendations in stakeholder groups

Stakeholder groups	Key recommendations
Public Authorities	• Review and simplify the building codes and energy efficiency codes • Capacity building of municipalities with respect to the Jordan Green Building Guide • Capacity building of municipalities with respect to the Jordanian Solar Code • Mandate utilities to reduce energy demand • Restructure electricity tariffs to incentivize energy efficient measures in residential sector • Re-think the design of solar PV tariffs • Capacity training of utilities to deploy and implement energy efficient measures in the residential sector
Project Developers	• Mandatory examination of the knowledge of engineers and introduction of the Junior Engineer Program • Turn the Jordanian National Building rating system from guideline to mandatory • Digitalization of the permitting process • Capacity building at the municipality level for code enforcement
Suppliers	• Boost local manufacturing and assembling of energy efficiency products • Introduction of solar air collector for space heating
Banks	• Raise awareness on energy efficiency and JREEEF low interest loans • Capacity building of bank officers in Energy Efficiency Lending

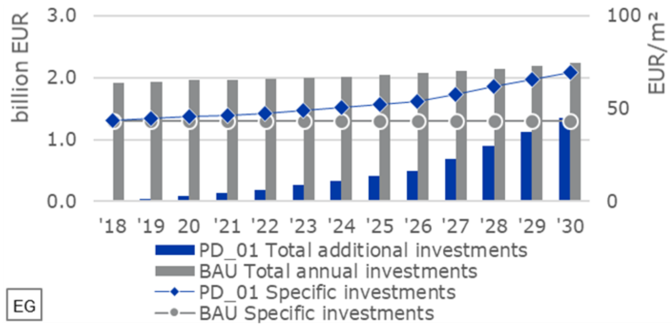
APPENDIX A. ASSESSED QUANTITATIVE IMPACTS OF POLICY MEASURES

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

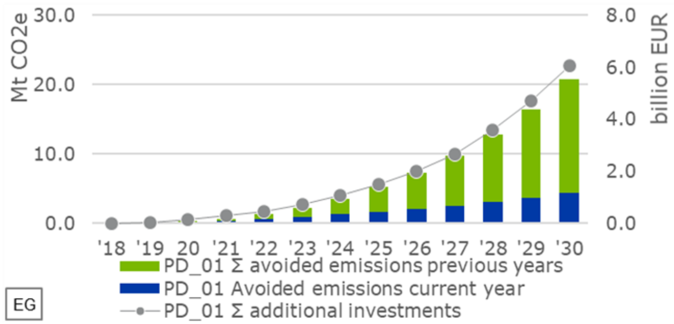
Specific Final Energy Demand



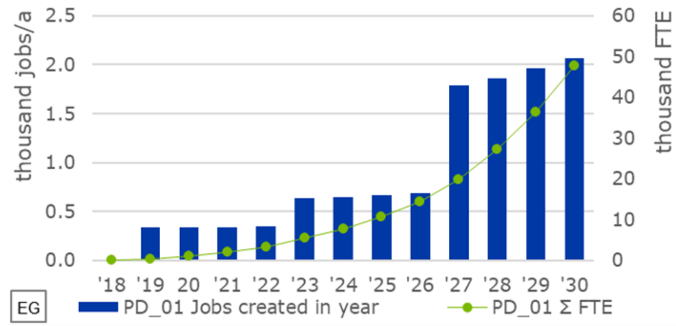
Investment Cost



GHG Emissions



Job Effects



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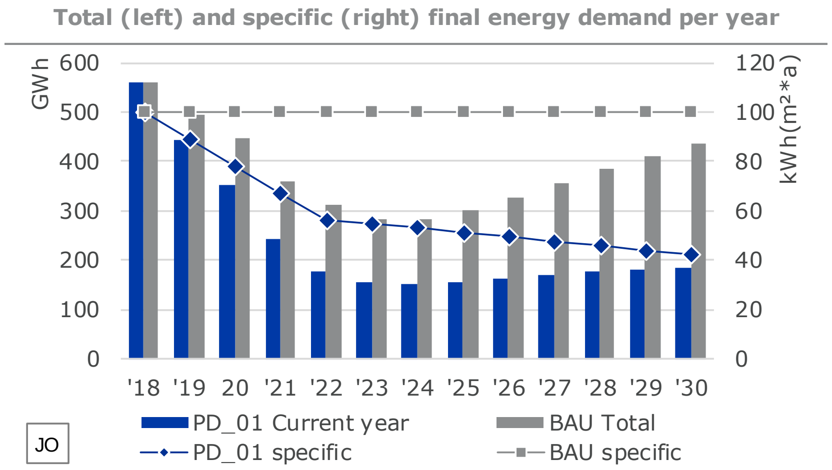
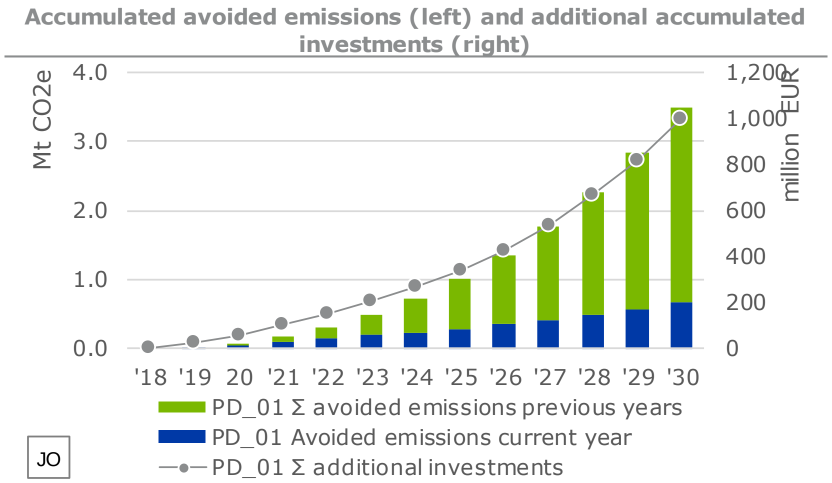
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

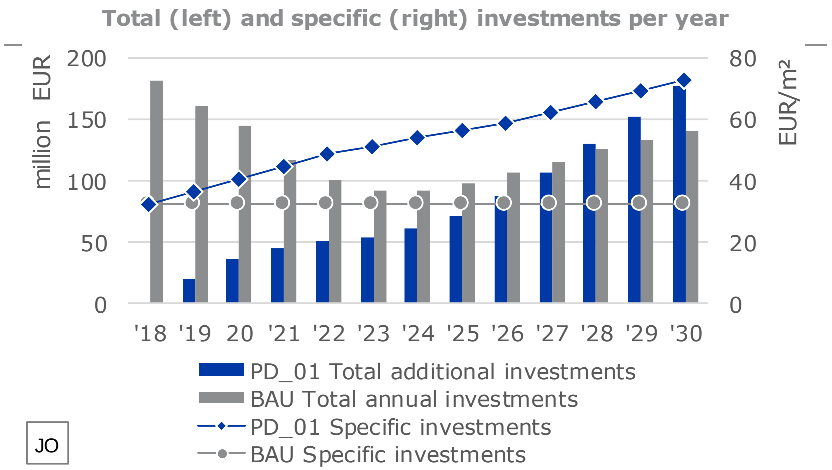
A.1 JOR_PD_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure



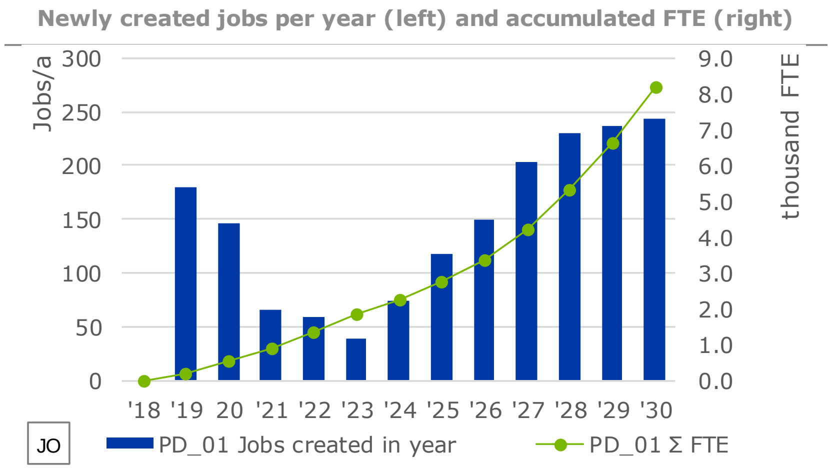
- **Energy demand of new constructions can be reduced by ~58% until 2030**



- **~660 ktCO2e can be mitigated by 2030**



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



- **~1,744 jobs can be created unitl 2030**

JOR_PD_01: Assumed future technology distribution and affected shares

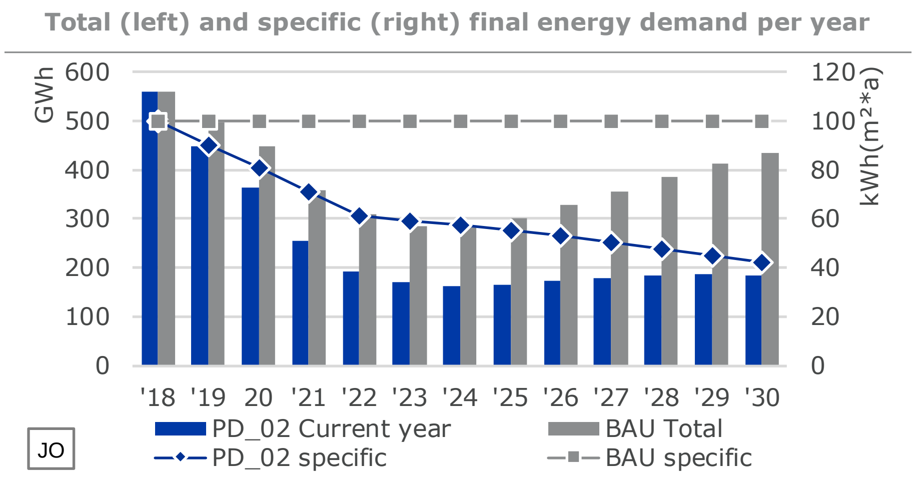
Technologies		2019-2022		2023-2026		2027-2030	
		Target distribution	Affected shares	Target distribution	Affected shares	Target distribution	Affected shares
Space heating technologies	Gas boilers - conventional	10%	22%	0%	27.5%	0%	34%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	55%	0%	55%	0%	55%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	20%	25%	30%	10%	40%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	25%	++	35%	++	45%
Windows		++	40%	++	60%	++	80%
Infiltration rate		o	10%	+	20%	++	30%
Insulation Thickness	Facade	+	40%	+	60%	+	80%
	Rooftop	+	20%	+	30%	+	40%
	Ground	+	20%	+	30%	+	40%
Shadowing measures (window shading)		+	5%	+	10%	+	15%

Supported by:

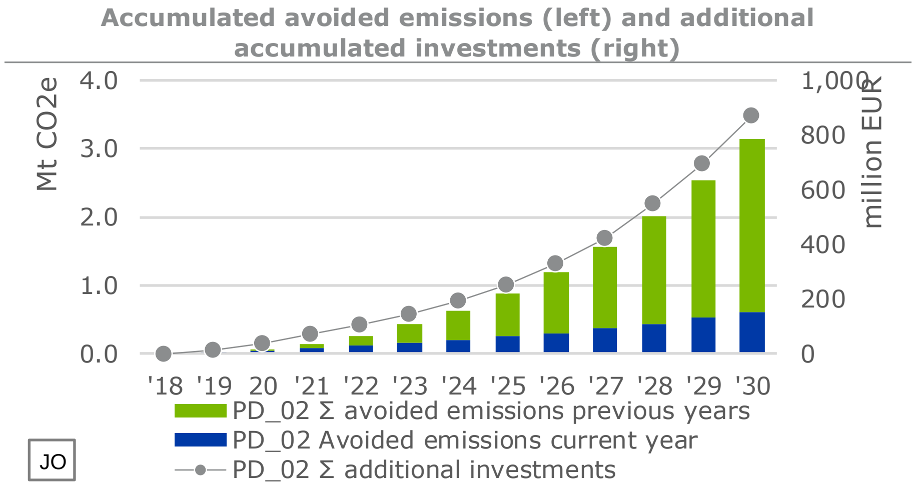
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

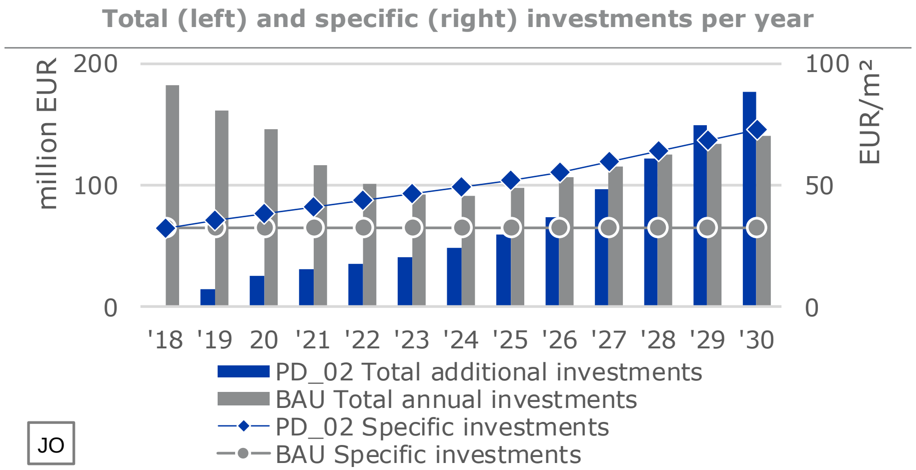
A.2 JOR_PD_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure



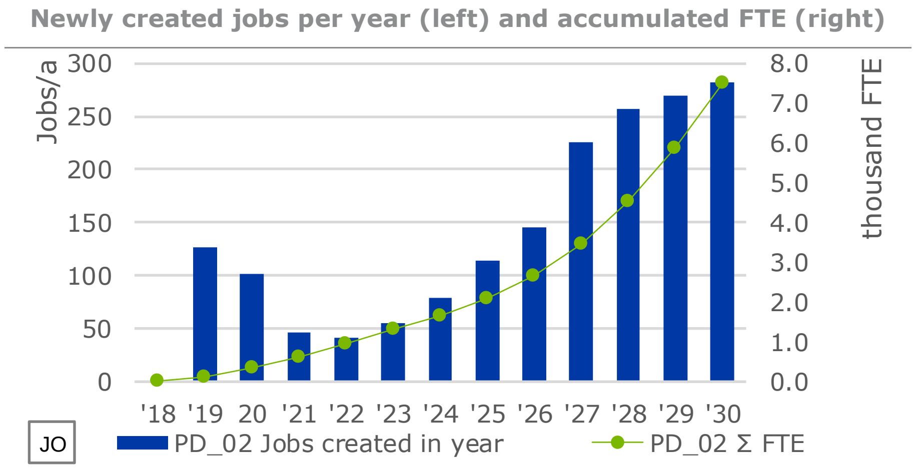
- Energy demand of new constructions can be reduced by ~58% until 2030



- ~610 ktCO2e can be mitigated by 2030



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



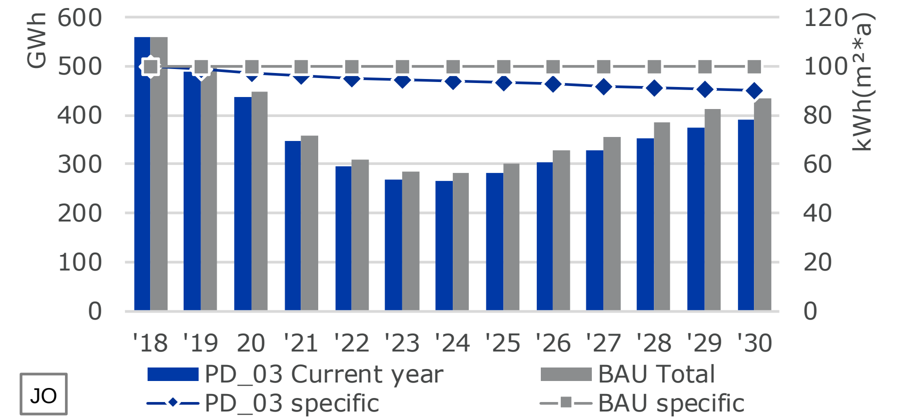
- ~1,744 jobs can be created unitl 2030

JOR_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%	0%	0%	2.75%	0%	34.375%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	0%	0%	5.5%	0%	55%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	0%	25%	3%	10%	40%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	0%	++	3.5%	++	45%
Windows		++	0%	++	6%	++	80%
Infiltration rate		o	10%	+	2%	++	30%
Insulation Thickness	Facade	+	0%	+	6%	+	80%
	Rooftop	+	0%	+	3%	+	40%
	Ground	+	0%	+	3%	+	40%
Shadowing measures (window shading)		+	0%	+	1%	+	15%

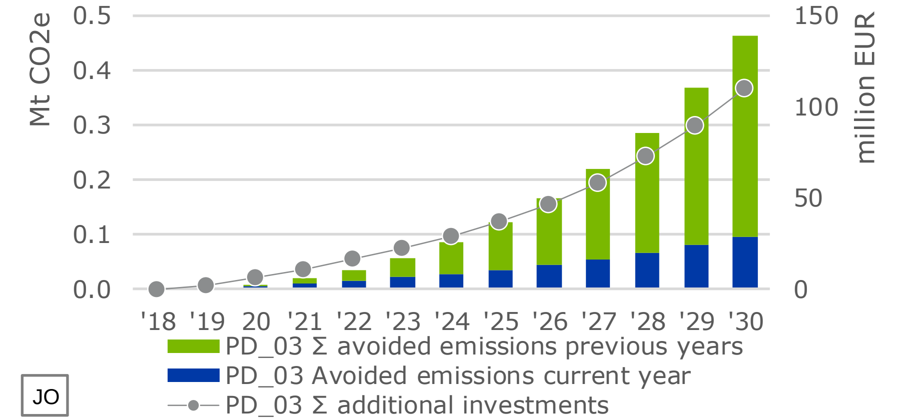
A.3 JOR_PD_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



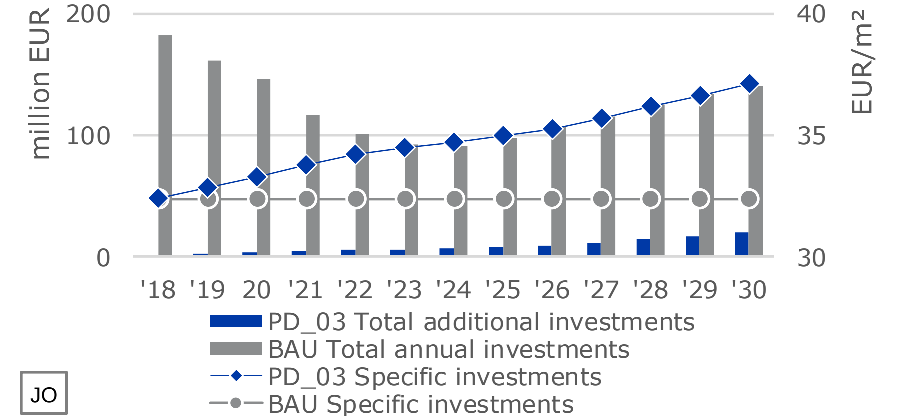
• **Energy demand of new constructions can be reduced by ~10% until 2030**

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



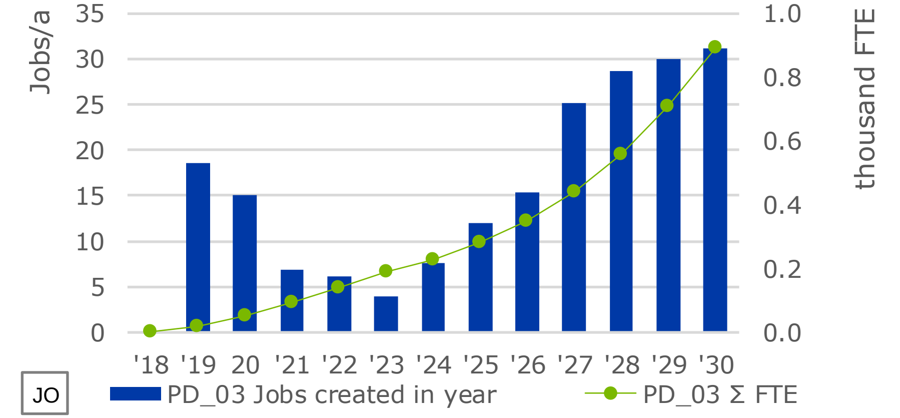
• **~90 ktCO2e can be mitigated by 2030**

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



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

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

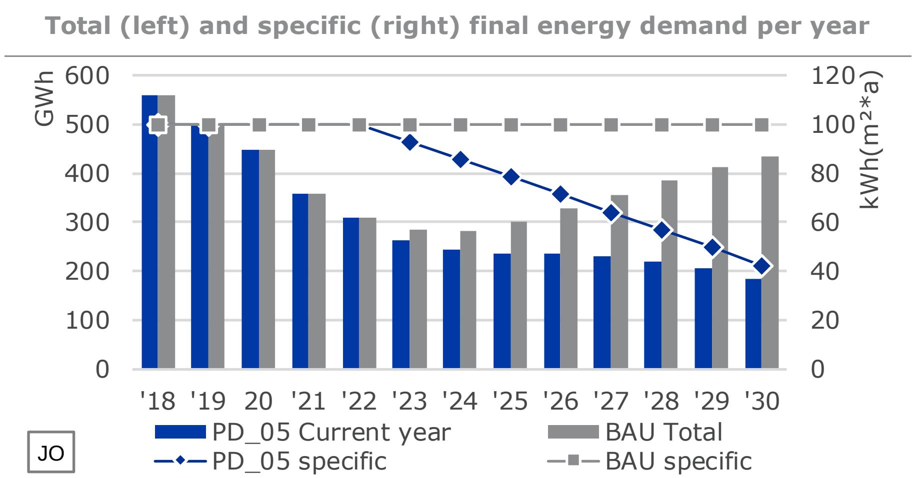


• **~200 jobs can be created unitl 2030**

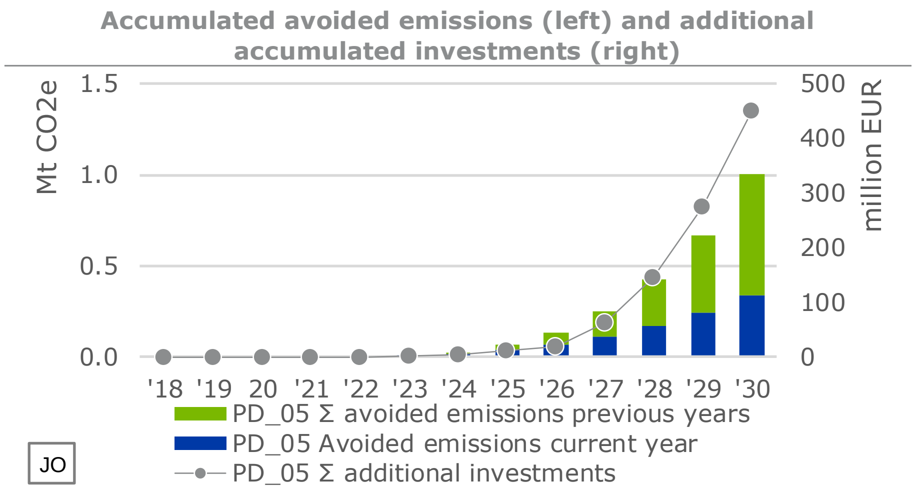
JOR_PD_03: Assumed future technology distribution and affected shares

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%	15.4%	0%	23%	0%	34%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	38.5%	0%	46.75%	0%	55%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	14%	25%	25.5%	10%	40%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	17.5%	++	29.7%5	++	45%
Windows		++	28%	++	51%	++	80%
Infiltration rate		o	10%	+	20%	++	30%
Insulation Thickness	Facade	+	28%	+	51%	+	80%
	Rooftop	+	14%	+	25.5%	+	40%
	Ground	+	14%	+	25.5%	+	40%
Shadowing measures (window shading)		+	3.5%	+	8.5%	+	15%

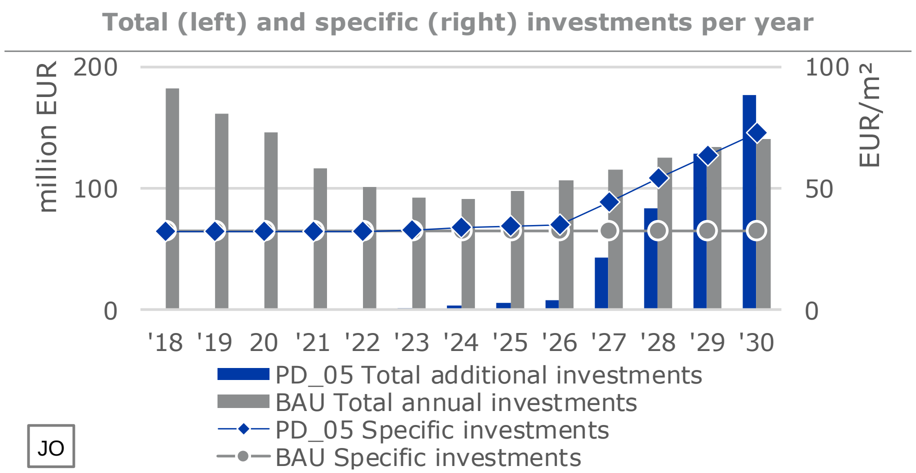
A.4 JOR_PD_05: Impacts on energy demand, avoided emissions, investments and jobs of policy measure



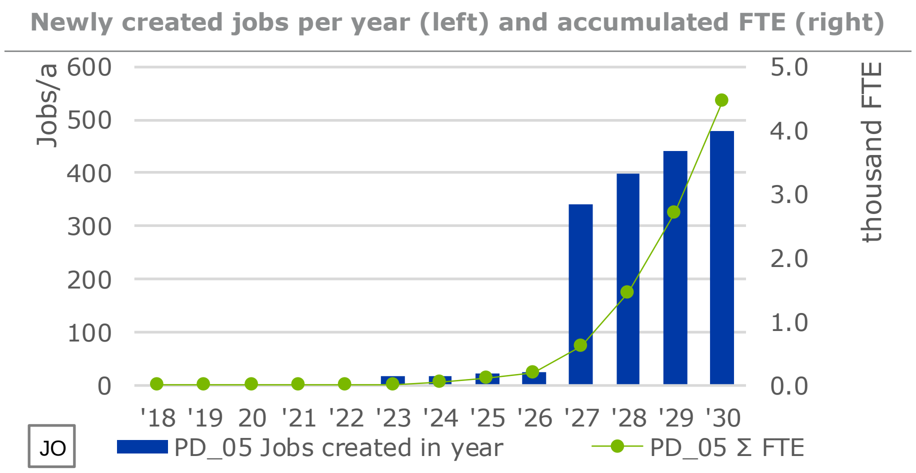
- **Energy demand of new constructions can be reduced by ~58% until 2030**



- **~330 ktCO2e can be mitigated by 2030**

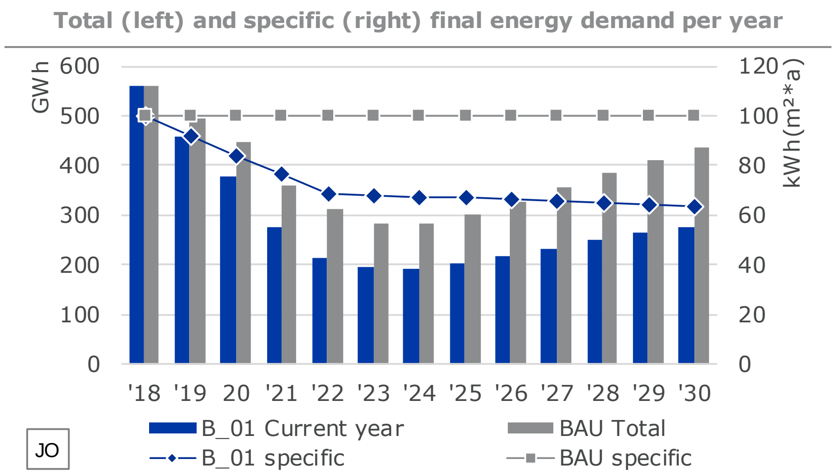


- **Average additional investment costs between 2019-2030 are ~9 EUR/m² new building floor space**

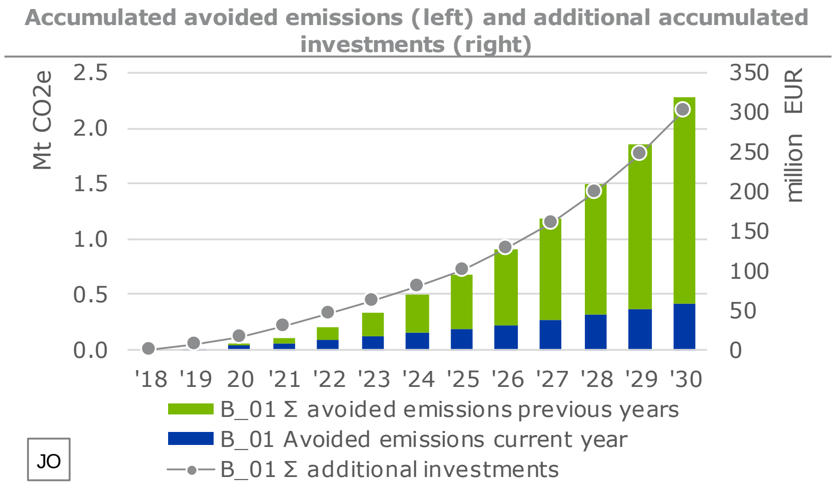


- **~1,744 jobs can be created unitl 2030**

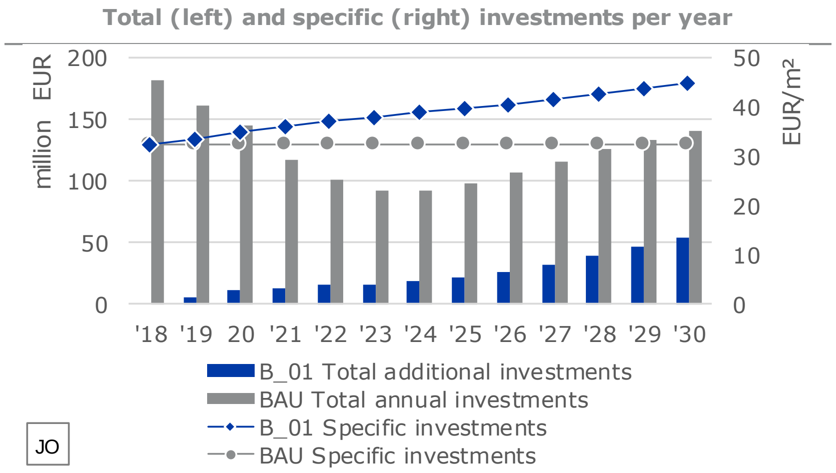
A.5 JOR_B_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure



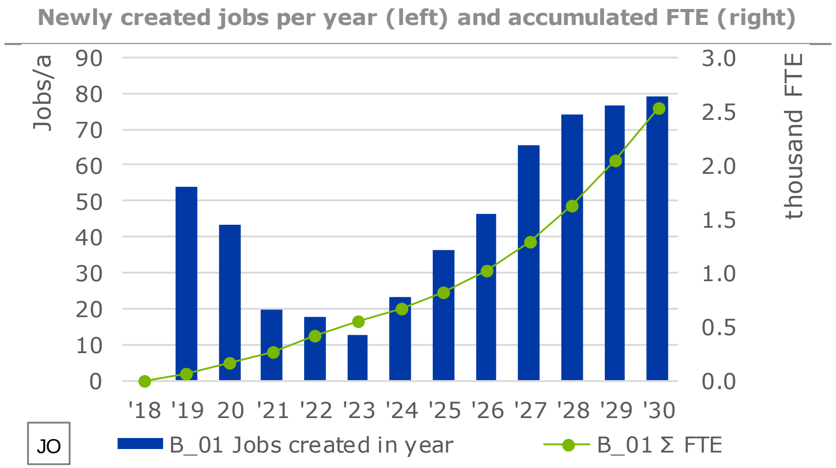
- **Energy demand of new constructions can be reduced by ~37% until 2030**



- **~420 ktCO2e can be mitigated by 2030**



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



- **~549 jobs can be created unitl 2030**

JOR_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%	6.6%	0%	8.25%	0%	10.3125%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	16.5%	0%	16.5%	0%	16.5%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	6%	25%	9%	10%	12%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	7.5%	++	10.5%	++	13.5%
Windows		++	12%	++	18%	++	24%
Infiltration rate		o	5%	+	10%	++	15%
Insulation Thickness	Facade	+	12%	+	18%	+	24%
	Rooftop	+	6%	+	9%	+	12%
	Ground	+	6%	+	9%	+	12%
Shadowing measures (window shading)		+	1.5%	+	3%	+	4.5%

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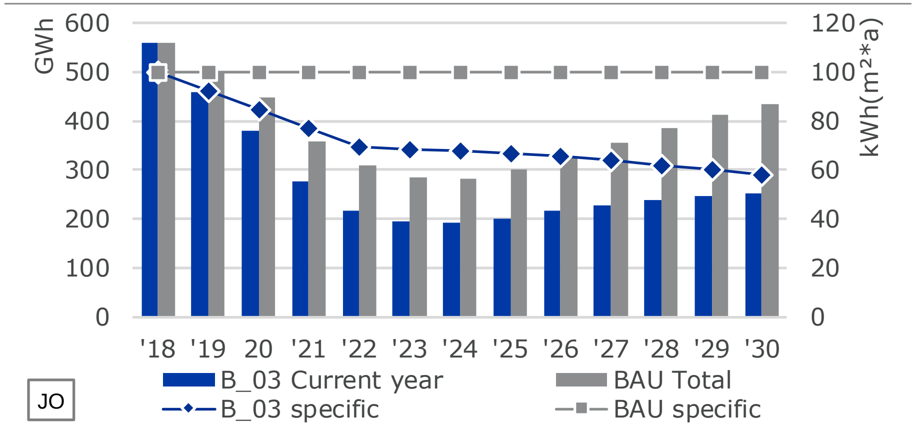
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

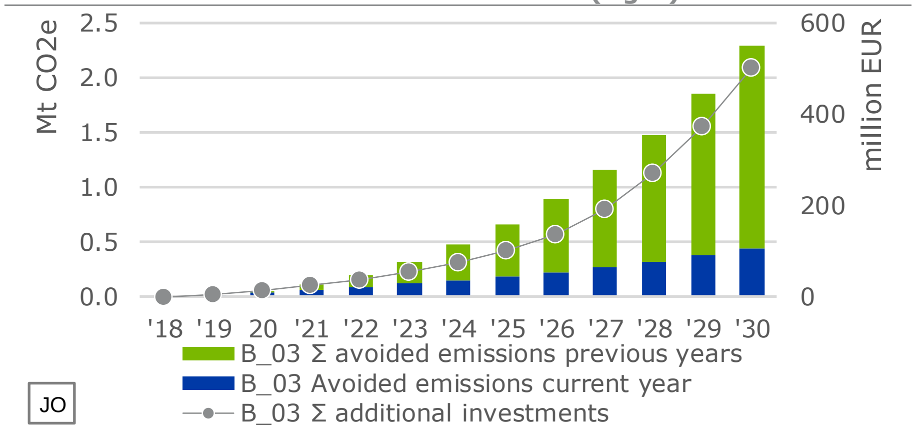
A.6 JOR_B_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



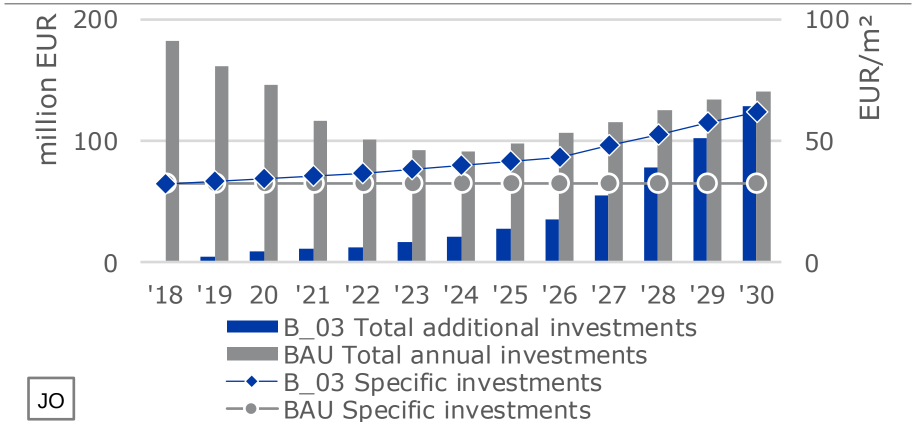
- **Energy demand of new constructions can be reduced by ~42% until 2030**

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



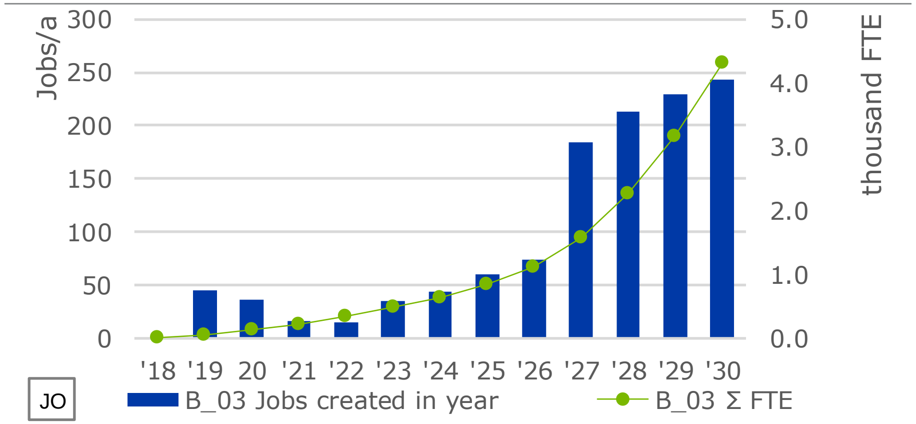
- **~440 ktCO2e can be mitigated by 2030**

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)



- **~1,197 jobs can be created unitl 2030**

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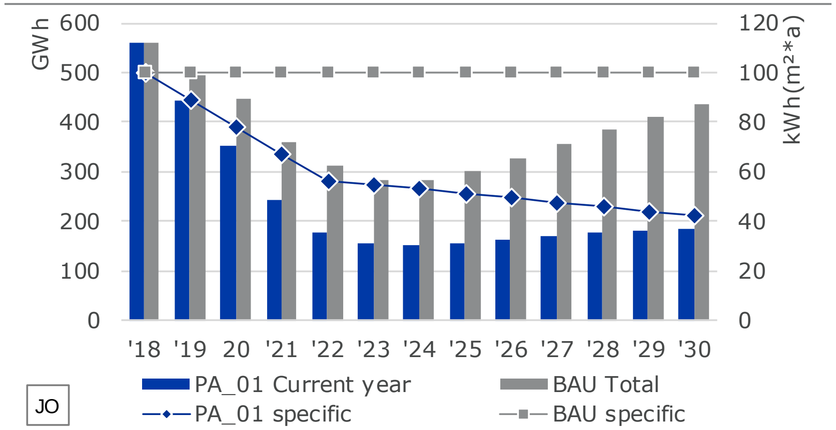
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

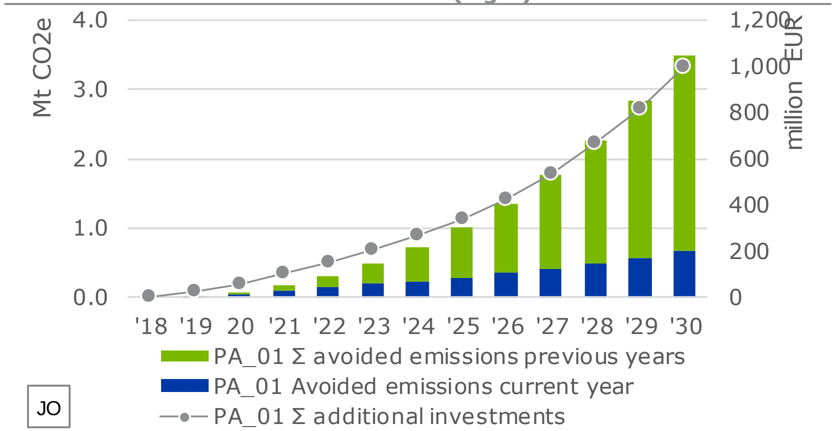
A.7 JOR_PA_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



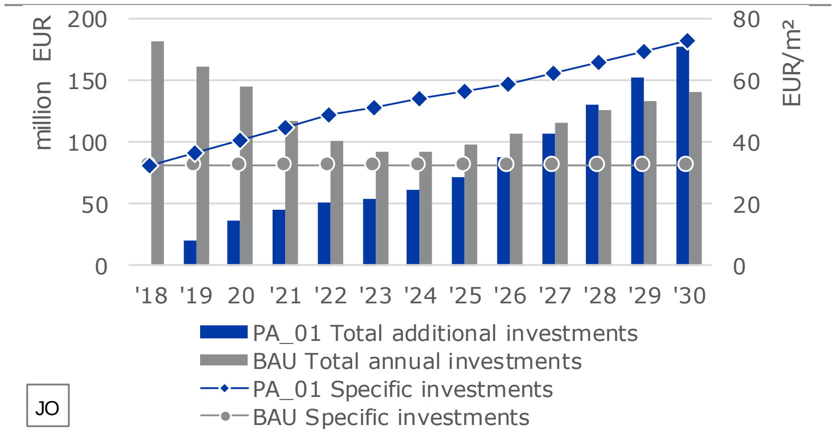
• **Energy demand of new constructions can be reduced by ~58% until 2030**

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



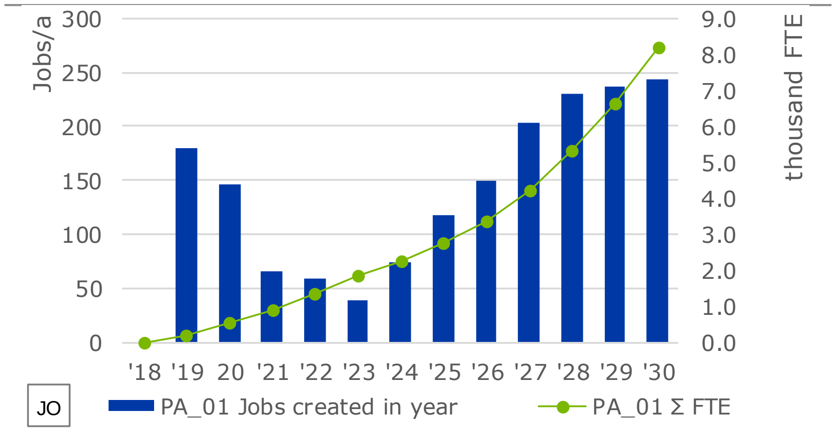
• **~660 ktCO2e can be mitigated by 2030**

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)



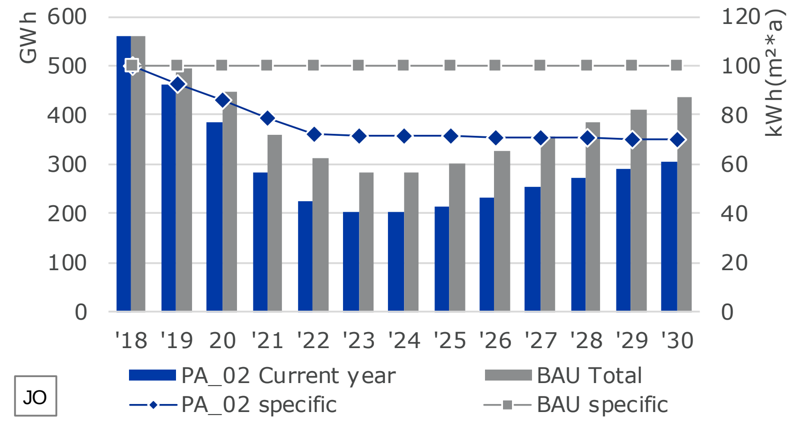
• **~1,744 jobs can be created unitl 2030**

JOR_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%	22%	0%	27.5%	0%	34.375%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	55%	0%	55%	0%	55%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	20%	25%	30%	10%	40%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	25%	++	35%	++	45%
Windows		++	40%	++	60%	++	80%
Infiltration rate		o	10%	+	20%	++	30%
Insulation Thickness	Facade	+	40%	+	60%	+	80%
	Rooftop	+	20%	+	30%	+	40%
	Ground	+	20%	+	30%	+	40%
Shadowing measures (window shading)		+	5%	+	10%	+	15%

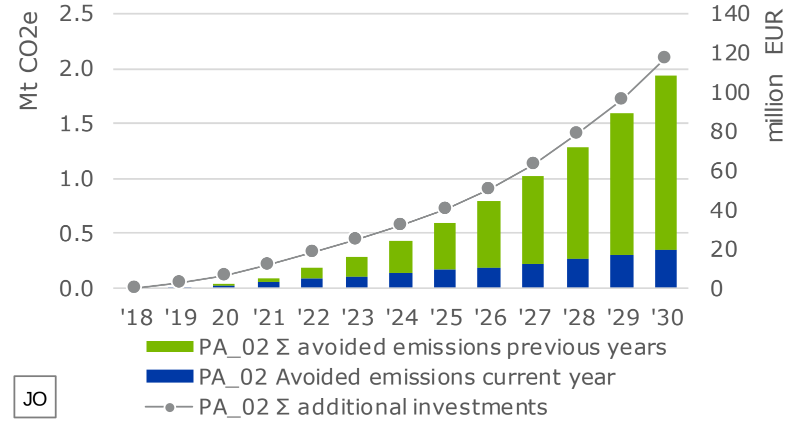
A.8 JOR_PA_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



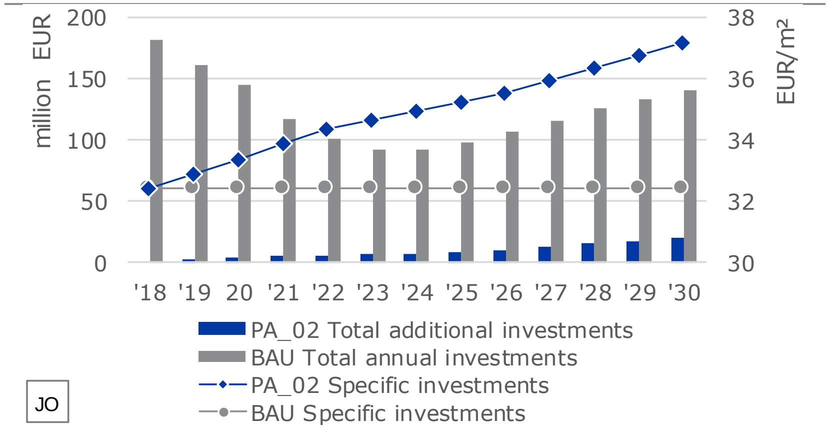
- **Energy demand of new constructions can be reduced by ~30% until 2030**

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



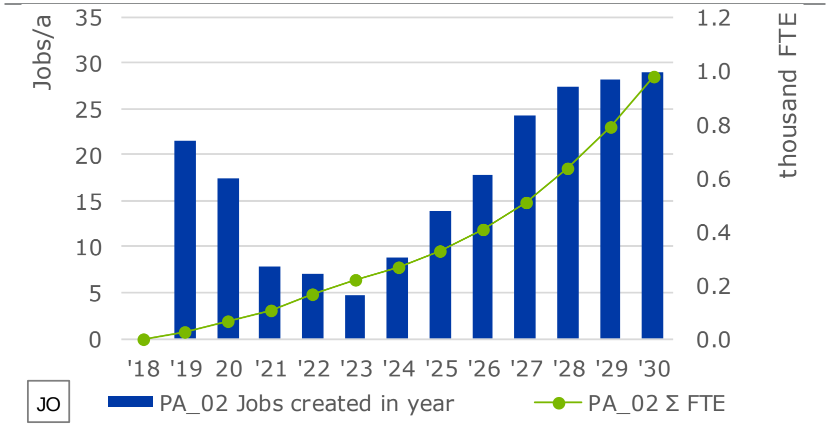
- **~340 ktCO2e can be mitigated by 2030**

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)



- **~208 jobs can be created unitl 2030**

JOR_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	10%	3%	0%	3%	0%	4%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	6.6%	0%	6.6%	0%	6.6%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	2.4%	25%	3.6%	10%	4.8%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	3%	++	4.2%	++	5.4%
Windows		++	4.8%	++	7.2%	++	9.6%
Infiltration rate		o	1.2%	+	2.4%	++	3.6%
Insulation Thickness	Facade	+	4.8%	+	7.2%	+	9.6%
	Rooftop	+	2.4%	+	3.6%	+	4.8%
	Ground	+	2.4%	+	3.6%	+	4.8%
Shadowing measures (window shading)		+	0.6%	+	1.2%	+	1.8%

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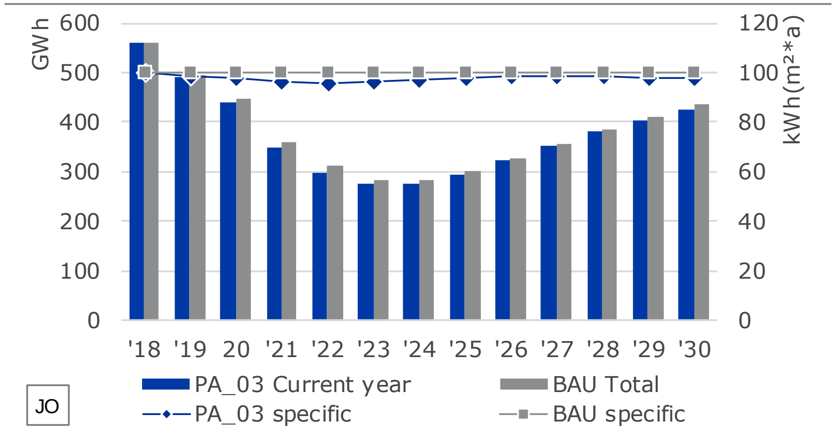
INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

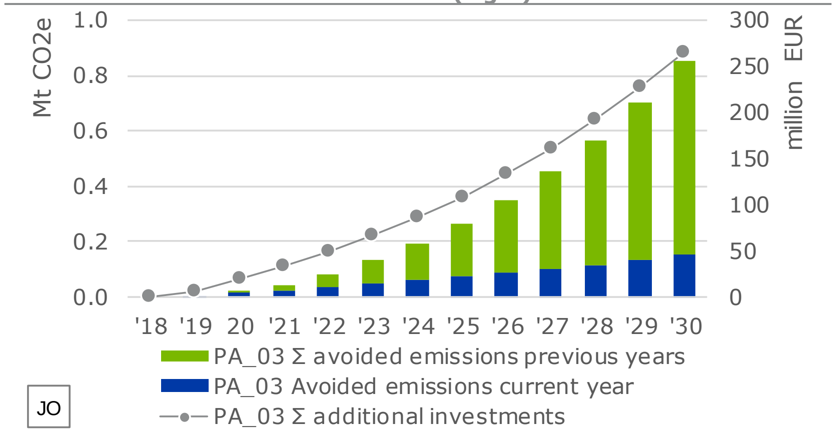
A.9 JOR_PA_03: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



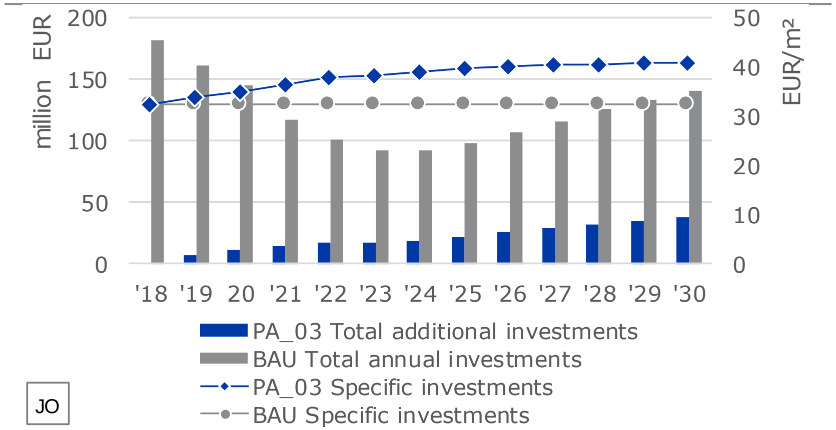
- **Energy demand of new constructions can be reduced by ~2% until 2030**

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



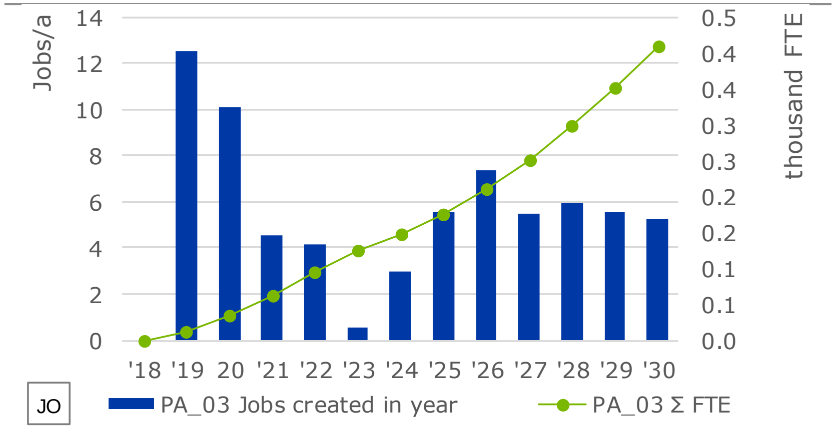
- **~150 ktCO2e can be mitigated by 2030**

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



- **Average additional investment costs between 2019-2030 are ~6 EUR/m² new building floor space**

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



- **~70 jobs can be created unitl 2030**

JOR_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	0%	10%	0%	15%	0%	20%
	Gas boilers - condensing	0%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	0%		20%		15%	
	Heat Pumps (any source) - COP 5	50%		50%		50%	
	Solar water heaters	50%		50%		50%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	100%	0%	100%	0%	100%
	Fossil - efficient	0%		0%		0%	
	Electric	0%		0%		0%	
	Solar water heaters	100%		100%		100%	
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	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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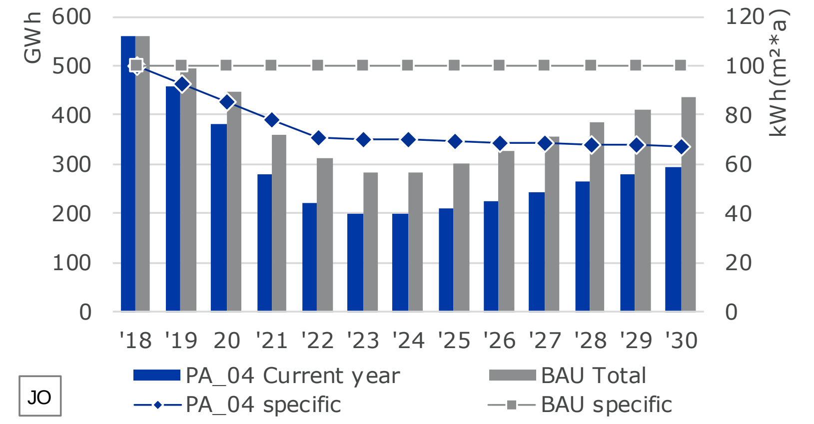
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONALE KLIMASCHUTZINITIATIVE (IKI)

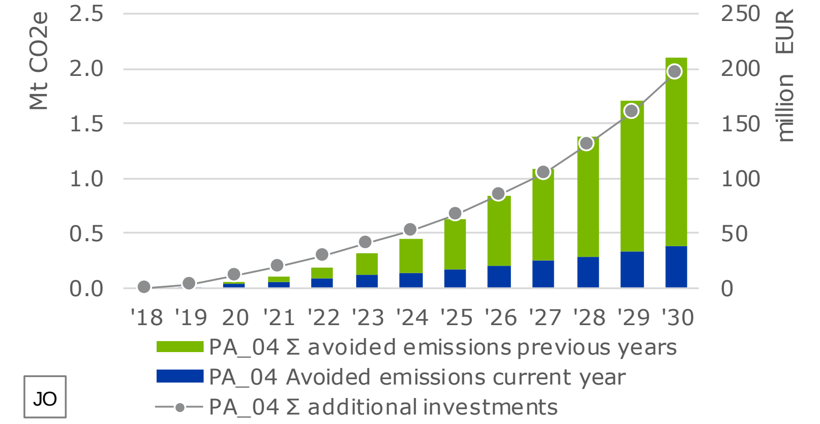
A.10 JOR_PA_04: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



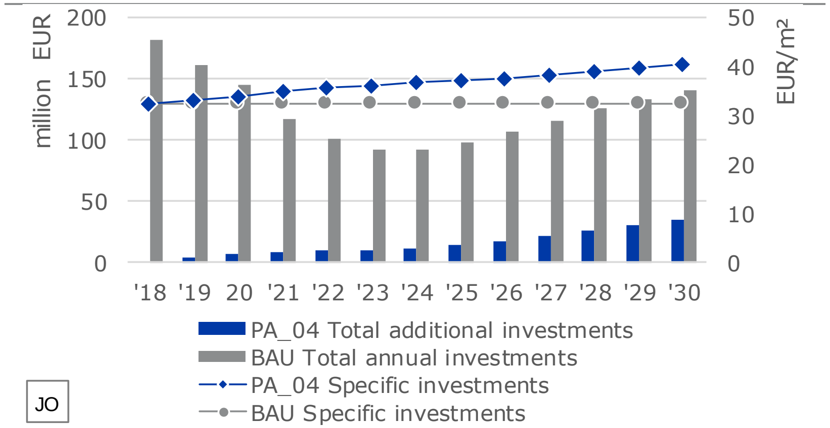
- **Energy demand of new constructions can be reduced by ~33% until 2030**

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



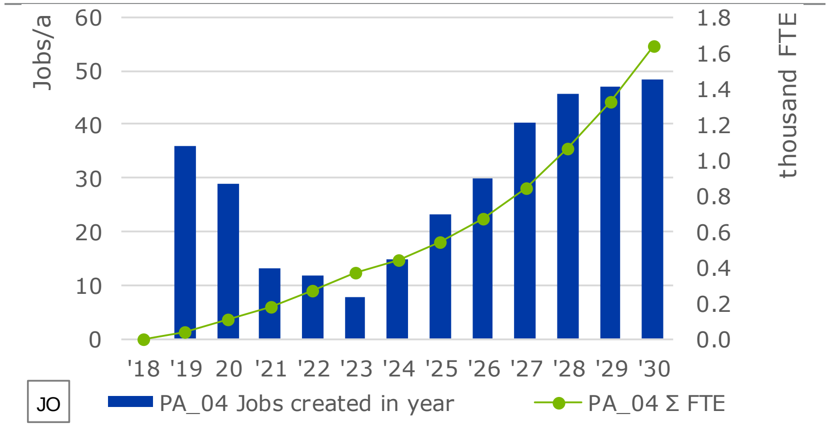
- **~380 ktCO2e can be mitigated by 2030**

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



- **Average additional investment costs between 2019-2030 are ~4 EUR/m² new building floor space**

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



- **~348 jobs can be created unitl 2030**

JOR_PA_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%	4.4%	0%	5.5%	0%	6.875%
	Gas boilers - condensing	30%		35%		30%	
	Direct electricity	0%		0%		0%	
	Heat Pumps (any source) - COP 3	0%		0%		0%	
	Heat Pumps (any source) - COP 4	25%		20%		15%	
	Heat Pumps (any source) - COP 5	35%		40%		50%	
	Solar water heaters	0%		5%		5%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	0%	11%	0%	11%	0%	11%
	Fossil - efficient	30%		25%		20%	
	Electric	0%		0%		0%	
	Solar water heaters	70%		75%		80%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	40%	4%	25%	6%	10%	8%
	Mechanical ventilation w heat recovery 50%	25%		20%		15%	
	Mechanical ventilation w heat recovery 90%	35%		55%		75%	
Space cooling technologies	AC or Chillers COP > 4	++	5%	++	7%	++	9%
Windows		++	8%	++	12%	++	16%
Infiltration rate		0%	2%	+	4%	++	6%
Insulation Thickness	Facade	+	8%	+	12%	+	16%
	Rooftop	+	4%	+	6%	+	8%
	Ground	+	4%	+	6%	+	8%
Shadowing measures (window shading)		+	1%	+	2%	+	3%

A.11 JOR_PA_05: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

No quantified impact assessment available

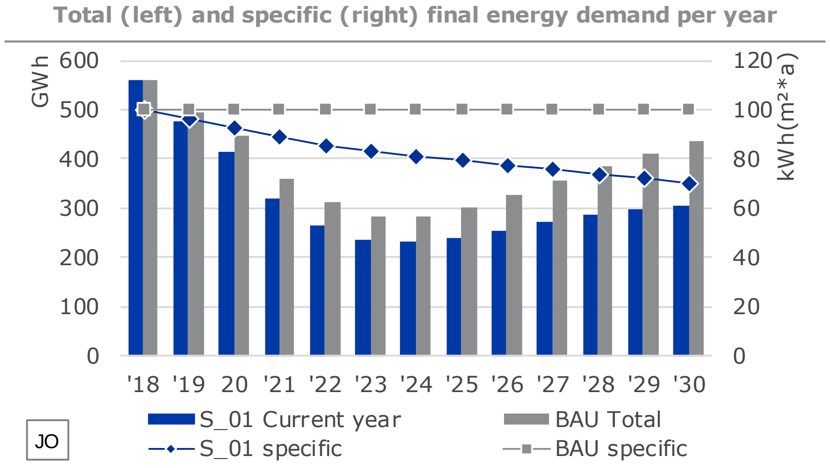
A.12 JOR_PA_06: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

No quantified impact assessment available

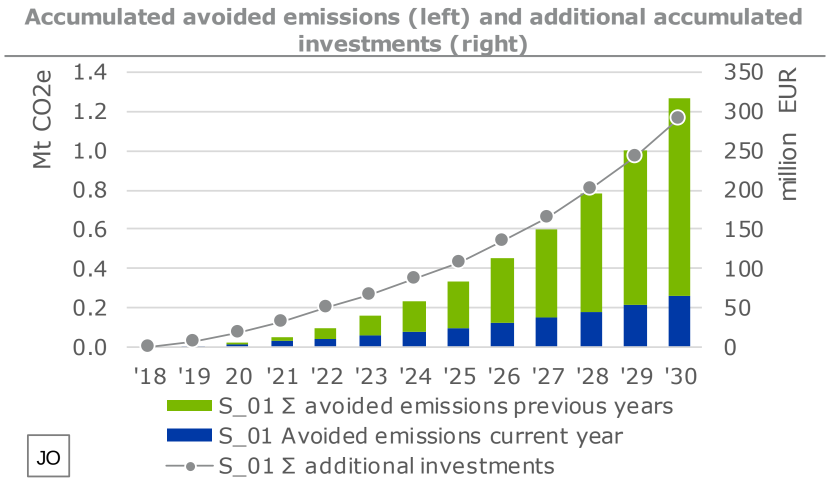
A.13 JOR_PA_07: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

No quantified impact assessment available

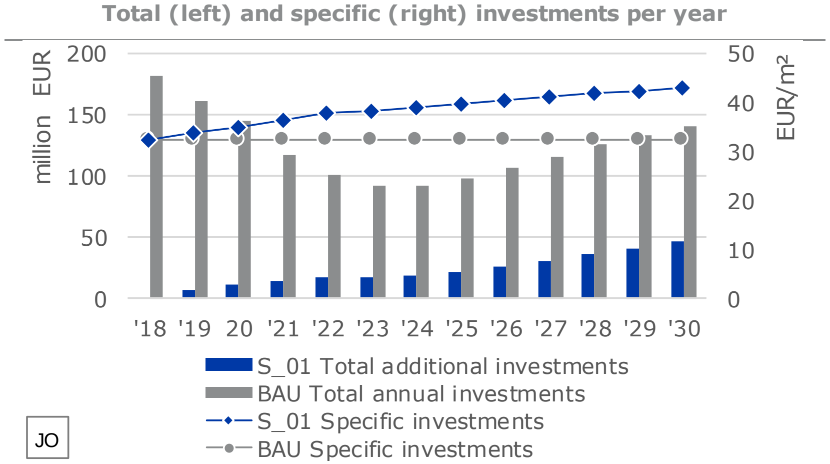
A.14 JOR_S_01: Impacts on energy demand, avoided emissions, investments and jobs of policy measure



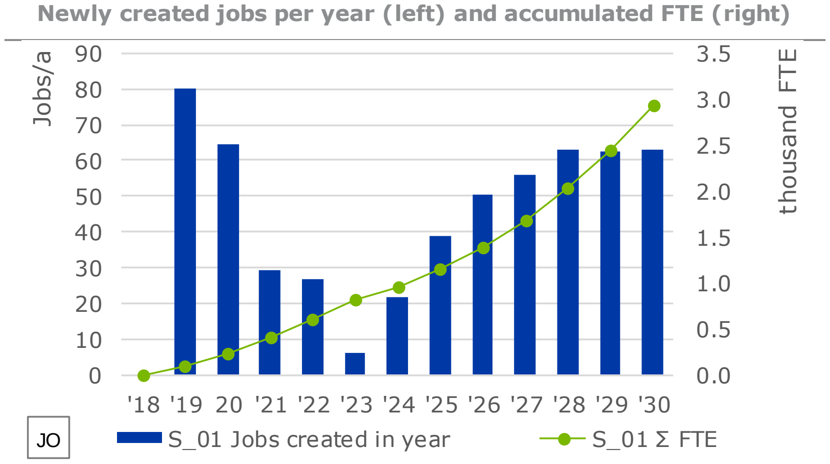
• Energy demand of new constructions can be reduced by ~30% until 2030



• ~260 ktCO2e can be mitigated by 2030



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



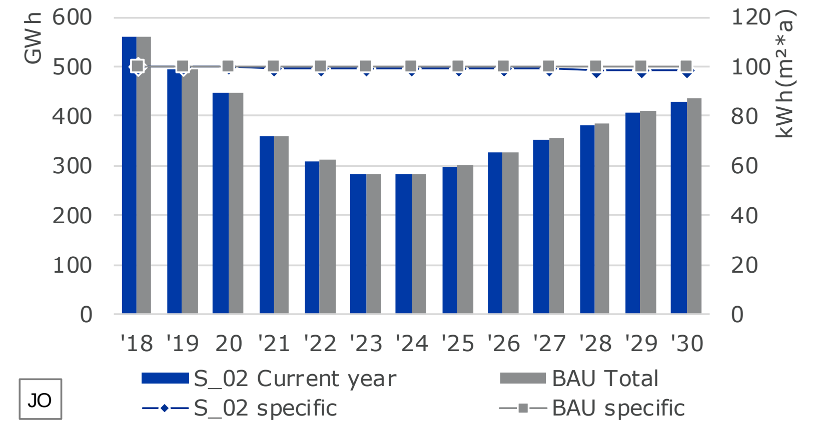
• ~562 jobs can be created unitl 2030

JOR_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	60%	0%	60%	0%	60%	0%
	Gas boilers - condensing	0%		0%		0%	
	Direct electricity	20%		20%		20%	
	Heat Pumps (any source) - COP 3	10%		10%		10%	
	Heat Pumps (any source) - COP 4	5%		5%		5%	
	Heat Pumps (any source) - COP 5	5%		5%		5%	
	Solar water heaters	0%		0%		0%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	50%	0%	50%	0%	50%	0%
	Fossil - efficient	20%		20%		20%	
	Electric	10%		10%		10%	
	Solar water heaters	20%		20%		20%	
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	0%	0%	0%	0%	0%	0%
Windows		++	40%	++	60%	++	80%
Infiltration rate		0%	0%	0%	0%	0%	0%
Insulation Thickness	Facade	++	40%	++	60%	++	80%
	Rooftop	++	20%	++	30%	++	40%
	Ground	++	20%	++	30%	++	40%
Shadowing measures (window shading)		0%	0%	0%	0%	0%	0%

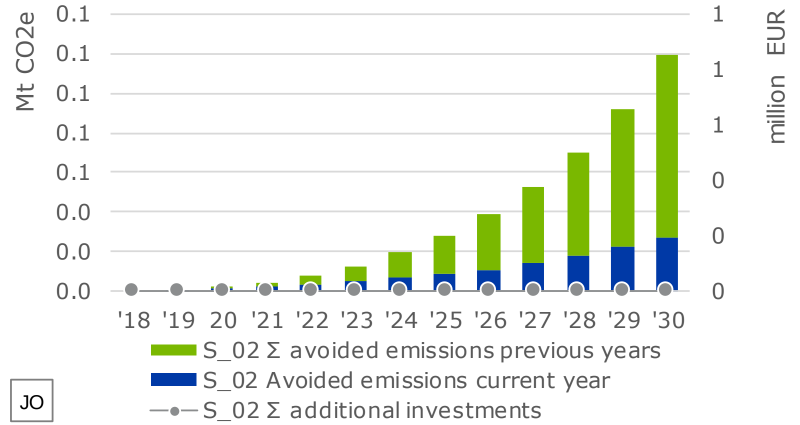
A.15 JOR_S_02: Impacts on energy demand, avoided emissions, investments and jobs of policy measure

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



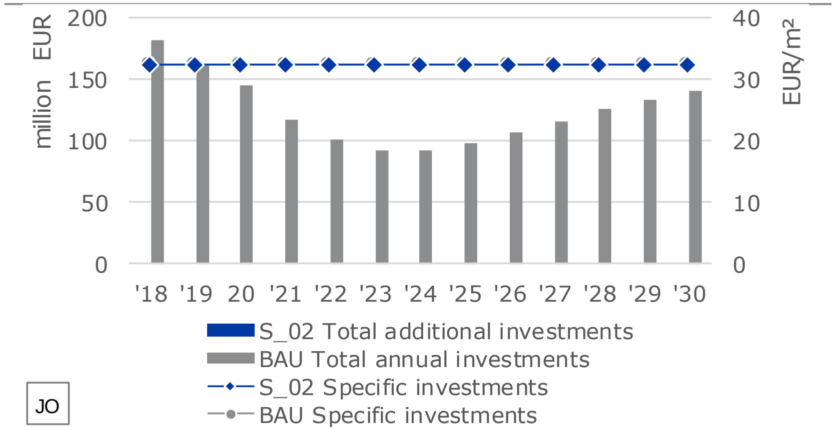
• **Energy demand of new constructions can be reduced by ~1% until 2030**

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



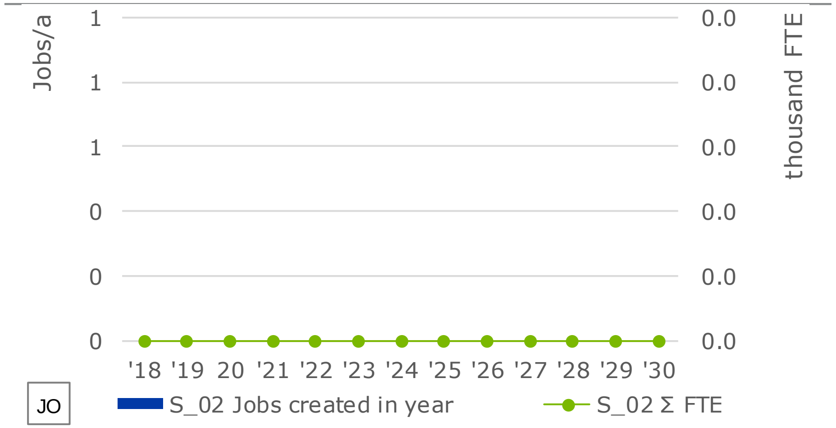
• **~20 ktCO2e can be mitigated by 2030**

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



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

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



• **~ jobs can be created unitl 2030**

JOR_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	50%		45%		40%	
	Gas boilers - condensing	0%		0%		0%	
	Direct electricity	20%		20%		20%	
	Heat Pumps (any source) - COP 3	10%		10%		10%	
	Heat Pumps (any source) - COP 4	5%	22%	5%	28%	5%	34%
	Heat Pumps (any source) - COP 5	5%		5%		5%	
	Solar water heaters	10%		15%		20%	
	Biomass boilers - conventional	0%		0%		0%	
	Biomass boilers - efficient	0%		0%		0%	
Water heating technologies	Fossil - conventional	50%		50%		50%	
	Fossil - efficient	20%	0%	20%	0%	20%	0%
	Electric	10%		10%		10%	
	Solar water heaters	20%		20%		20%	
Mechanical Ventilation	Natural ventilation (windows) or mechanical ventilation w/o heat recovery	100%		100%		100%	
	Mechanical ventilation w heat recovery 50%	0%	0%	0%	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	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%