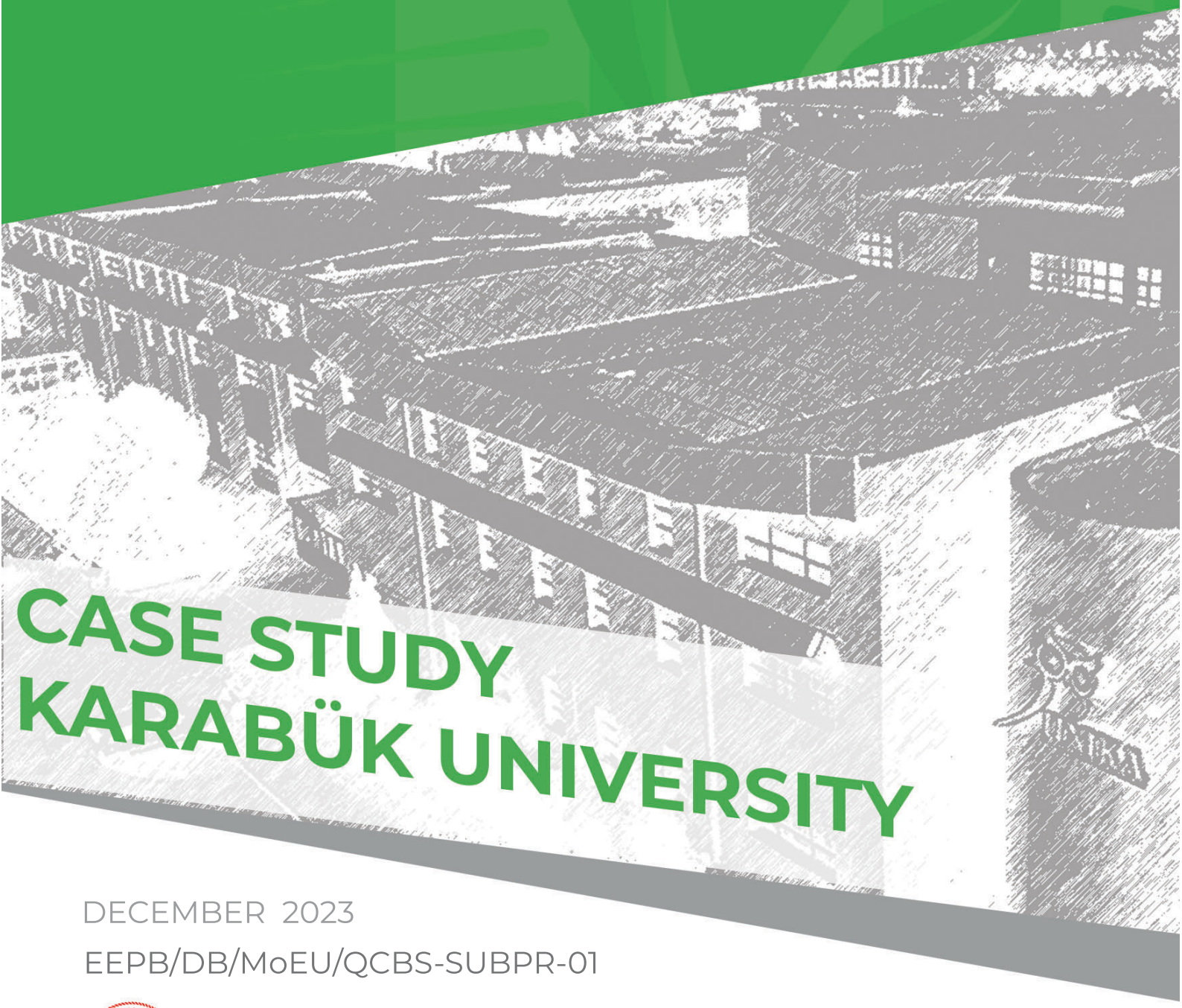
KABEV



CASE STUDY
KARABÜK UNIVERSITY

DECEMBER 2023

EEPB/DB/MoEU/QCBS-SUBPR-01

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

THE WORLD BANK
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KABEV
KAMU BİNALARINDA
ENERJİ VERİMLİLİĞİ PROJESİ
YAPI İŞLERİ GENEL MÜDÜRLÜĞÜ

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ABOUT THE PROJECT – KABEV

The Energy Efficiency in Public Buildings (EEPB / KABEV) project is implemented by the Ministry of Environment, Urbanization and Climate Change (MoEUCC), **General Directorate of Construction Affairs (GDCA)** with funding from the World Bank.

Through the project, MoEUCC supports the renovation of central government and central-government affiliated buildings (i.e., schools, universities, court houses, administrative buildings and schools). It is expected that such subprojects will generate at least 20% energy cost savings and CO2 emissions reductions in addition to social co-benefits such as improving the comfort level within the buildings, which would form the basis for developing a national-level program for energy efficiency (EE) in public buildings.
Project investments primarily focus on public buildings with high energy consumption and shorter payback periods.

With the project, which aims to renew 500 public buildings in an energy efficient way, it is aimed to combat climate change by providing at least 20% energy and CO_2 savings, demonstrating deep renovations and nearly zero energy buildings (NZEB), energy performance contracts (EPCs), increasing comfort.

OVERVIEW

KARABÜK ÜNİVERSİTESİ

Karabük, Türkiye

Public University

Educational Blocks

83.277 m²

University Blocks

Energy Efficiency Renovation

Picture 1. Karabük University (Before vs After)

Karabük University is a university with four educational blocks (Rectorate building, Engineering Faculty, Faculty of Administrative Sciences, Foreign Languages Instutite) and an energy centre block. The buildings are about 14 years old. They had major technical and comfort problems such as insufficient heating due to often poor operation of heating water circulation loop, no control over HVAC system due to lack of a HVAC automation system, old and inefficient lighting system and high energy bills.

Building administration was enthusiastic to join KABEV program to resolve the technical and comfort problems orginating from insufficient heating, frequently malfunctioning boilers, lighting bulbs. They also would like to avoid unplanned repair services due to malfunctioning boilers. What's more, building administration wanted to decrease the high energy bills of the buildings.
The implementation of energy efficiency works were done by an energy efficiency renovation contractor via conventional renovation construction contract.

Building Envelope

Foreing Languages Institute building was not insulated, had double pane windows in main building with old aluminum frames and therefore was cold in the winter. By installing 6 cm rock wool insulation on the façade of the building, it is now able to maintain a better indoor temperature as the heat losses are reduced. At the same time, the façade insulation and improved exterior image of the building, and it now appears as a new building from the outside.

Picture 2. Building Envelope (Before)

Picture 3. Building Envelope (Implementation)

Heating System and Mechnical Installation Retrofit

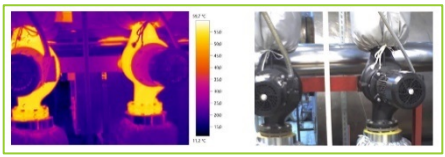
Heating system comprised of 5 pcs of floor mounted natural gas heating boilers (2 pcs of 2.000.000 kCal/h and 3 pcs of 2.500.000 kCal/h) in the energy center. Constant speed low efficiency heating water circulation pumps. Heating water circulation loop defects including use of wrong pipe diameters, pressure losses, pumps with bigger capacity than needed, wrong use of 3-way valves, etc.) causing too much interruption in heating system. Heating water circulation loop (piping, valves, heat exchangers, etc.) have been

replaced with brand new and optimized capacity components. Various types of heat pump options were also considered but, their payback period came out to be longer than KABEV project requirements. (Annual operation hour of the building for heating was around 600 hours which lead to respectively longer payback period of a heat pump investment.)

Now, the boilers with capacity modulation and hot water supply temperature reset capability provide as much heating energy as demanded by the buildings leading to much less heating energy consumption.

Mechanical installation and plumbing instruments including piping, valves, etc. had no insulation. The piping and instrumentation in the boiler room have been replaced with new systems having proper insulation based on local plumbing insulation standard.

Picture 4. Mechanical Installation and Pumps (Before vs After)



Picture 5. Mechanical Installation Insulation – Before vs After

Variable Speed Circulation Pumps

Constant speed heating water circulation pumps operate all the time and leading to excess energy consumption and low thermal comfort. Old and constant speed heating water circulation pumps have been replaced with brand new variable speed circulation pumps. Now, all the heating energy is distributed by more efficient circulation pumps avoiding overheating and excess heating energy consumption. Circulation pumps now adjust their speed and operate only as much as the heating demand leading to savings both in heating and pump energy.

Picture 6. Circulation Pumps Replacement (Before vs After)

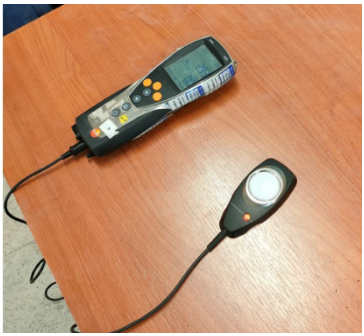
Lighting System Retrofit

There were lighting fixtures of various types and powers within the university campus buildings. Luminaires generally used were surface mounted T8 fluorescents with magnetic ballast for interior lighting. All inefficient luminaires have been replaced with more efficient LEDs.

In order to make an overall evaluation of lighting system, lighting fixtures inventory was prepared first. Types of lighting fixtures, their power, location, daily and annual operation hours were identified. Energy saving calculations were done based on these parameters. As a result, over 5.500 pieces pieces of lighting bulbs have been replaced with LED type bulbs.

Picture 7. Old Flourescent T8 bulbs vs LED lighting

Illuminances and lighting levels were measured during energy audit and after the renovation works were implemented. Site survey interviews with building staff and visual inspection of a lighting expert aduring measurement and verification process confirmed that there was no issue in lighting levels with the new lighting fixtures. Luminous flux of the proposed LED luminaires have been better than the existing T8 luminaires. Hence, better lighting quality has been experienced after lighting retrofit works.



Picture 8. Illuminance level measurement

Renewable Energy

There was no renewable energy system within the educational facility before. After reducing the energy demand and consumption to the minimum level, on-site renewable energy measure has been adopted in order to further reduce carbon footprint of the facility. Solar photovoltaic system with a 100 kW_e rated power has been applied at rooftops based on the effective roof area and transformer capacity of the facility.

Picture 9. Rooftop solar photovoltaics (PV)

Building Automation and Energy Monitoring System

There was no automation system in the building and there was no energy monitoring system. Heating demand from building spaces were not controlled. There was a potential in building automation system which can contribute to the overall energy efficiency. Within the scope of this energy efficiency renovation works, it has been proposed to integrate a simple building automation system for HVAC and auxiliary systems in addition to an energy monitoring system. It has been expected that energy would be saved as systems could be controlled automatically at an optimum operation scenario. Moreover, the energy savings within this project and possible future energy efficiency projects will be monitored and verified in compliance with the international performance measurement and verificaiton protocol (IPMVP) by means of this newly established established energy monitoring system.

On the other hand, considering the competencies and skills of operation and maintenance personnel in public buildings, such systems have been proposed to provide a basic level of control and monitoring in order to avoid difficulties in terms of user friendliness, operation complexity and an increase in the costs of maintenance. Thus, a basic system has been installed that can be easily used by building staff who do not have a high level of competence in building automation systems. As a result, a system that can control and monitor the main HVAC equipments at the basic level, while monitoring energy consumption at the building level has been established.

Building System	Before Implementation of EEMs	After Implementation of EEMs
Building Envelope	No insulation in Foreign Languages Institute.	Insulation (6 cm rock wool) beyond local building insulation standard requirement.
Heating System	2 x 2.000.000 kCal/h + 3 x 2.500.000 kCal/h floor mounted natural gas heating boilers and constant speed circulation pumps.	2 x 2.000.000 kCal/h + 3 x 2.500.000 kCal/h floor mounted natural gas heating boilers and circulation pumps integrated with variable speed drive.
Cooling System	VRF System	VRF System
Ventilation System	Heat recovery ventilation.	Heat recovery ventilation.
Domestic Hot Water System	Fed by main boilers via heat exchanger.	Fed by main boilers via heat exchanger.
Mechanical Installation/Plumbing	Old insulation in the piping system.	Insulated according to local plumbing insulation standard.
Interior Lighting System	Mostly T8 flourescent bulbs	LED lighting bulbs (over 5.500 pieces)
Exterior Lighting System	Sodium vapor bulbs	LED lighting bulbs
Electrical System	3 x 1.250 kVA main transformers	3 x 1.250 kVA main transformers
Compensation System	Operational compensation system.	Operational compensation system.
Renewable Energy System	None.	Installed 100 kWe rooftop photovoltaic solar power system.
Energy Monitoring System	None.	Energy monitoring system that allows building level monitoring for heating and electricity consumption.
Distributed Energy Source: Cogeneration/Trigeneration	None.	None.

Table 1. Building Systems Comparison (Before vs After EEMs)

ENERGY EFFICIENCY MEASURES AND EXPECTED SAVINGS

No	Energy Efficiency Measure	Energy Type	Energy Savings		Energy Cost Savings	Investment Cost	Payback Period
			kWh/y	%	TRY/y	TRY	Year
1	Building Thermal Insulation of Foreign Languages High School	N. Gas	400.448	4,8%	101.939	1.724.463	16,9
2	Rehabilitation of Heating System Circulation Loop	N.Gas	1.432.762	17,3%	407.869	546.776	1,3
		Electricity	40.038	0,5%			
3	Replacement of Existing Circulation Pumps in Main Heating Center with New Self-inverter Circulation Pumps	Electricity	24.876	0,3%	26.806	213.556	8,0
4	Replacing Current Lighting Fixtures with new LED Lighting Fixtures providing lighting levels specified in standards.	Electricity	378.283	4,6%	407.628	3.486.894	8,6
5	Building Automation and Energy Monitoring System Implementation	N. Gas	212.410	2,6%	54.071	453.558	8,4
6	Solar Photovoltaic Panel Installation	Electricity	88.718	1,1%	95.601	1.384.119	14,5
TOTAL SAVINGS		N. Gas (kWh)	2.045.621	24,8%	**1.093.914**	**7.809.367**	**7,1**
		Electricity (kWh)	531.915	6,4%			
		TOTAL	**2.577.535**	**31,2%**			

Table 2. List of Energy Efficiency Measures

Baseline Energy Use
Natural Gas adjusted final energy use was 6.075.704 kWh/year and electricity final energy use was 2.186.275 kWh/year corresponding to 8.261.979 kWh/year overall adjusted baseline final energy use based on IPMVP.

Saving Targets
2.045.621 kWh/year ± 130.736 kWh/year Natural Gas energy was targeted to be saved corresponding to 24,8% ± 1,6% saving.

531.915 kWh/year ± 116.971 kWh/year electricity energy was targeted to be saved corresponding to 6,4% ± 1,4% saving with solar PV system.

2.577.535 kWh/year ± 247.707 kWh/year overall energy was targeted to be saved corresponding to 31,2% ± 3,0% saving with solar PV system.

SUMMARY OF RESULTS

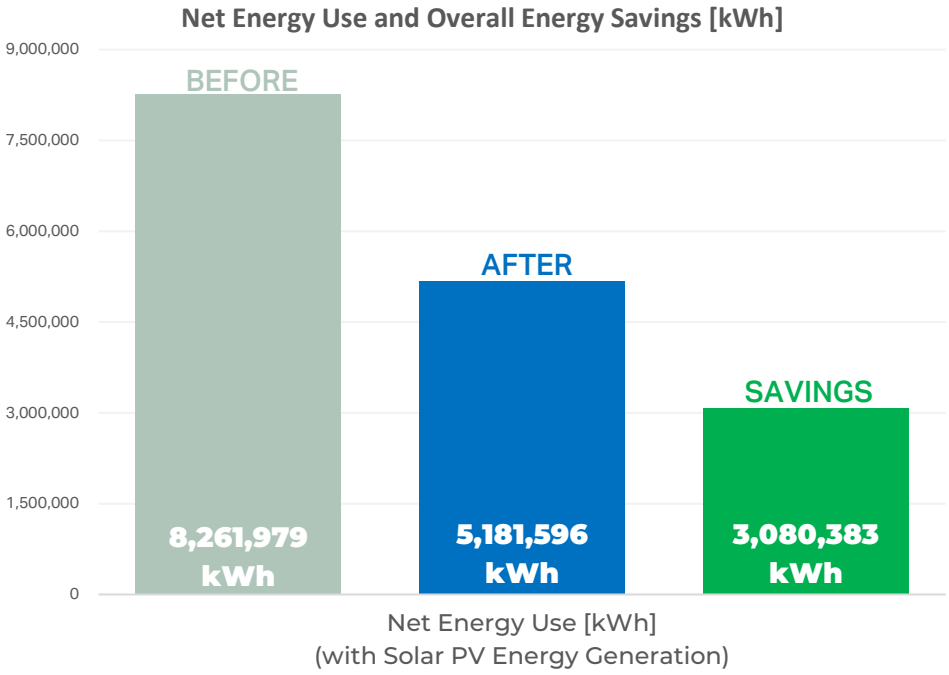
Energy Breakdown	Energy Before	Energy After	Energy Savings	Energy Saving %
Natural Gas Use [kWh]	6.075.704	3.642.231	2.433.473	40,1%
Electricity Use [kWh]	2.186.275	1.630.946	555.329	25,4%
Total Energy Use [kWh] (without Solar PV System)	8.261.979	5.273.177	2.988.802	36,2%
Renewable Energy Systems				
Solar PV Energy Generation [kWh]		-91.581	91.581	*1,1%*
Net Energy Use [kWh] (with Solar PV System)	**8.261.979**	**5.181.596**	**3.080.383**	**37,3%**
Annual Energy Cost [TRY]	**3.902.515**	**2.585.952**	**1.316.563**	**33,7%**
Green House Gas Emission [ton CO_{2e}]	**2.479,9**	**1.597,3**	**882,6**	**35,6%**
Corresponding No of Trees [pcs]			**40.541**	

Table 3. Summary of Energy and GHG Emission Results

Adjusted baseline overall energy use of the facility was 8.261.979 kWh/year. The energy use is reduced to 5.273.177 kWh/year corresponding to 36,2% savings without rooftop solar energy generation. When rooftop solar energy generation is included into the overall energy use calculations, overall energy use is reduced to 5.181.596 kWh/year corresponding to 3.080.383kWh/year energy savings (37,3% saving) compared to 2.577.535 kWh/year ± 247.707 kWh/year[1] expected energy savings (31,2% ± 3,0% saving).

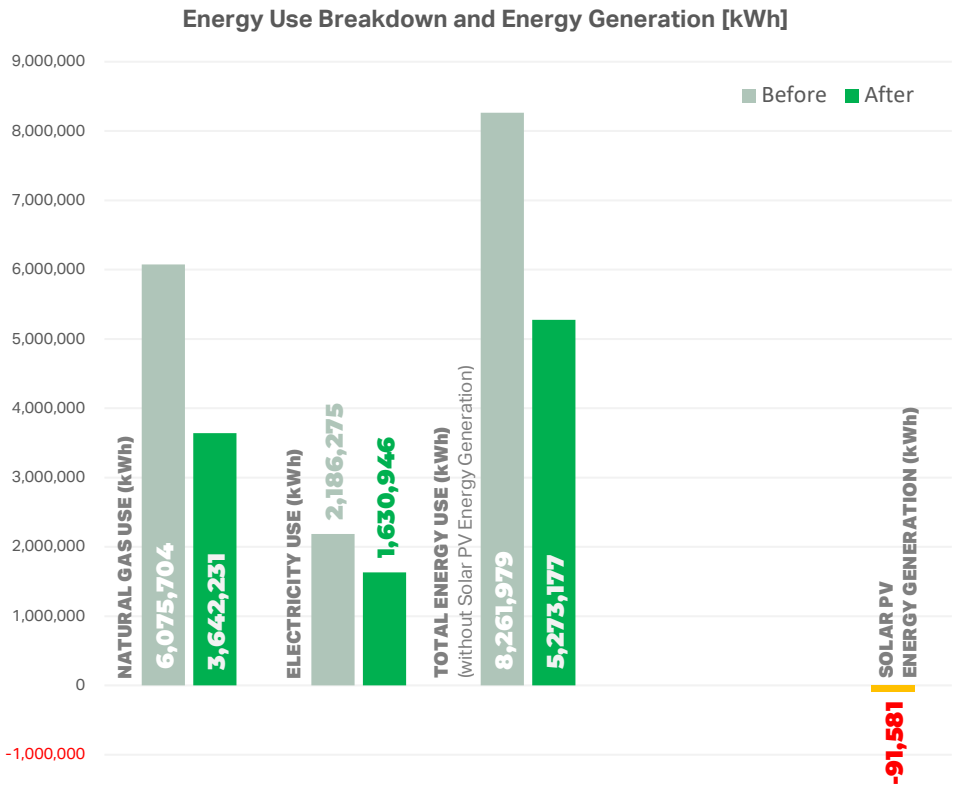
As a result, overall realized energy savings exceeded the expected savings by 502.848 kWh/year (19,5% higher than the expected savings).

[1] Based on baseline model uncertainty calculated at 90% confidence level as per IPMVP.



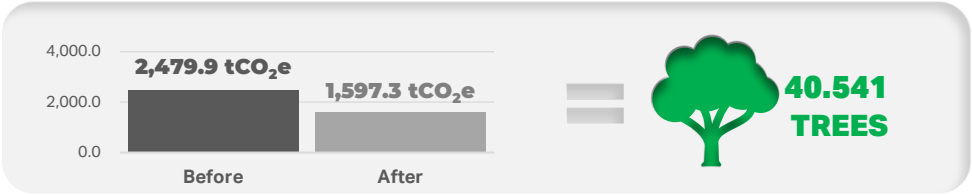
Graph 1. Net Energy Use (Before vs After) and Overall Energy Savings (with Solar PV Energy Generation)

Comparison of natural gas and electricity energy before and after EEMs are implemented are provided below along with onsite renewable energy.



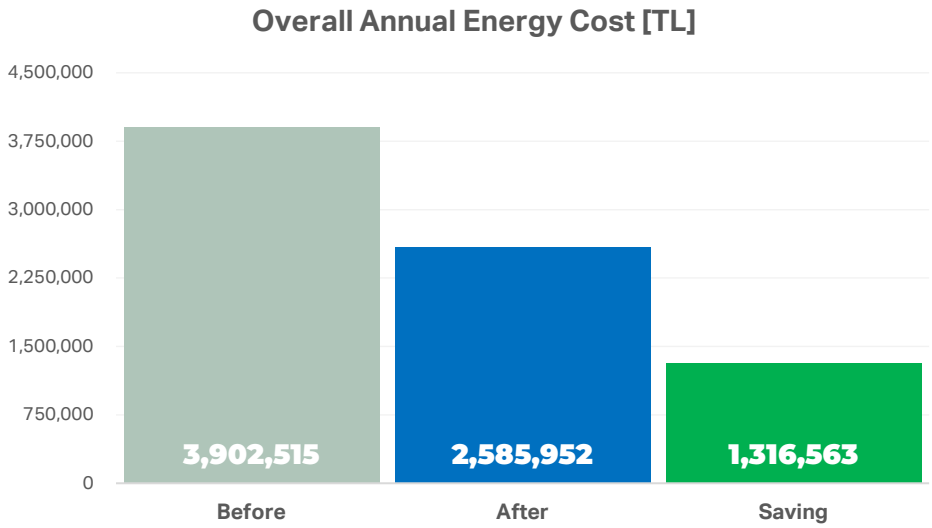
Graph 2. Energy Use Breakdown and Energy Generation Comparison (Before vs After)

Greenhouse gas emissions are calculated to be reduced from 2.479,9 tons of CO_{2e} to 1.597,3 tons of CO_{2e} corresponding to 882,6 tons of CO_{2e} reduction. Overall green house gas emissions are reduced by 35,6% which would be a good example for other educational facilities in terms of decarbonization of buildings in the future.



Graph 3. Green House Gas Emissions Comparison and Corresponding No of Trees

Overall energy cost of educational facility before and after EEMs are implemented are represented in below graph. Energy cost is reduced from 3.902.515 TL to 2.585.952 TL corresponding to 1.316.563 TL annual energy cost savings. With an investment cost of 7.809.367 TL, it refers to 5,9 years of simple payback period.



Graph 4. Overall Annual Energy Cost (Before vs After)

PROJECT IMPLEMENTATION PROCESS

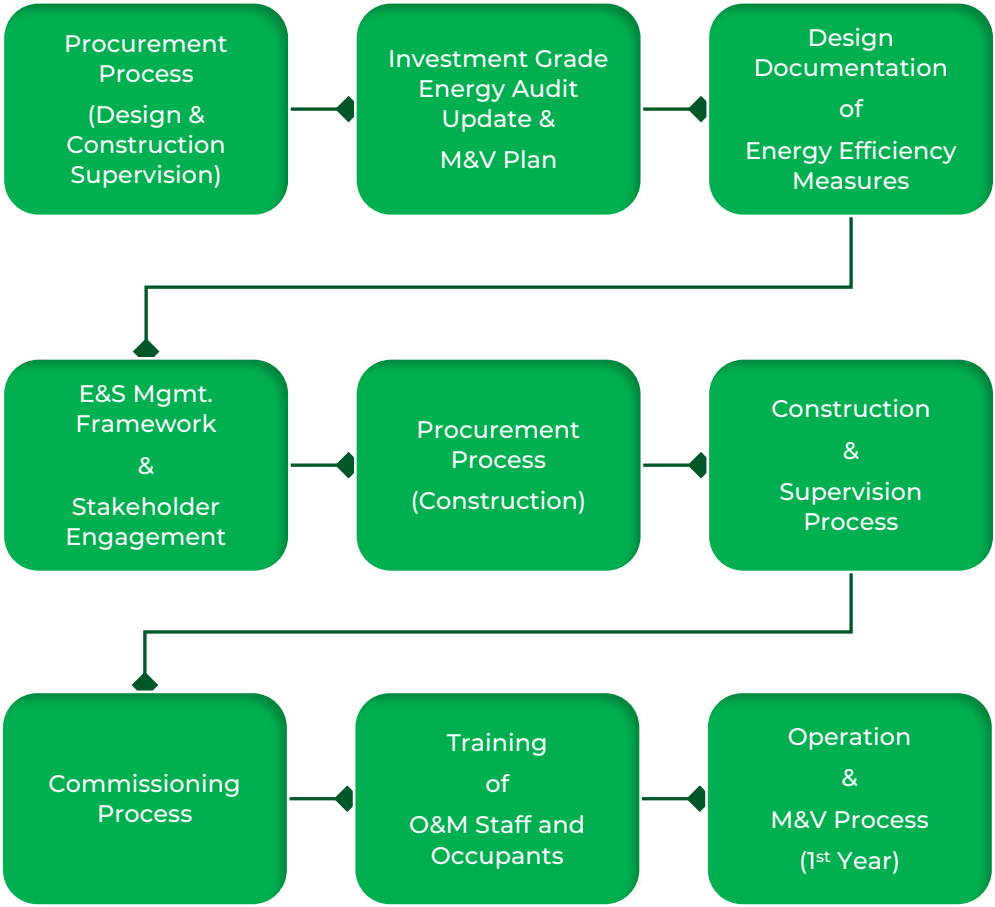


Figure 1. KABEV Project Implementation Process

Procurement Process (Design and Construction Supervision)

Karabük University had gone through an investment grade energy audit in 2019 in order to reveal the true energy efficiency potential and associated investment.

Based on that investment grade energy audit, it was decided by the GDCA to go for a quality and cost based selection tender for the consulting services for the update of energy efficiency measures (EEMs) of the energy audit from 2019, design documentation of EEMs and construction supervision of the implementation of EEMs. A design and construction supervision consultant was awarded the tender based on the highest combined score of technical and financial offers.

Energy Audit Update

Based on the contractual terms, the design and construction supervision consultant was required to update the EEMs of the final investment grade audit.

Since the last energy audit was done almost a year before the tender, following systems have been reaudited and evaluated by the consultant both from efficiency and comfort improvement points of view:

- Building envelope (exterior walls, roof, basement, windows, etc.)
- HVAC systems
- DHW system
- Pumps and fans
- Plumbing system and mechanical installation insulation
- Solar hot water system
- Lighting system
- Electrical infrastructure and compensation system
- Solar photovoltaic system
- Distributed energy generation systems (cogeneration, trigeneration, biomass, etc.)
- Heat pumps (air, water, ground sourced)
- Building energy monitoring and automation systems

As a result, previous EEMs were revisited and all of them were still found to be plausible. Only the energy and cost savings were updated based on the latest year energy consumption profile, energy unit prices and investment costs.

No	Energy Efficiency Measure (EEM)
1	Thermal Insulation on building blocks
2	Insulation application and retrofit of heating system circulation loop and mechanical installation
3	Renovation of existing circulation pumps with integrated inverter circulation pumps.
4	Replacement of Inefficient Luminaires with Efficient LED Luminaires Project
5	Solar Photovoltaic Panels
6	Integration of Building Automation and Energy Monitoring System

Table 4. Final EEMs

Especially, implementation plan was detailly reconsidered because, it was the in the middle of Covid-19 pandemics period in 2021 and educational facilities were operating with utmost precaution and any wrong doing due to whatsoever reason would be untolerable by the school administration.

Measurement & Verification (M&V) Plan

Measurement and Verification (M&V) is the final assessment of the energy performance of an energy efficiency project and therefore, plays a key role while assessing the overall success of the project. International Performance Measurement and Verification Protocol (IPMVP) is at the epicenter of M&V process in KABEV project.

In order to ensure consistency throughout all KABEV subprojects and provide guidance to Turkish energy efficiency works implementation contractors that have relatively lower level of knowledge about M&V process, a M&V guide[2] in Turkish language was developed by GDCA and published in KABEV's website.

M&V Plan that explained how to verify savings for each EEM, how to adjust the reference energy consumption (or baseline) was prepared by design and supervision consultant. The plan included the verification method of savings, important measures to be taken, the timing of these activities, the duties and responsibilities of the parties and how to ensure quality assurance for this process.

Measurement and verification method per each EEM was selected among applicable options of IPMVP (Options A, B, C and D). GDCA reviewed the M&V plan and asked for revisions until it was satisfied with the baseline energy adjustment formulas, level of uncertainty and reliability. Finally, M&V plan was approved by GDCA and it was saved to be used for measurement & verification period of 12 months after the commissioning of energy efficiency renovation works.

Design Documentation

Energy efficiency renovation projects do not require a full fledged design development process as required in a new building design process. There are particular systems or components or spaces or sections of the building where an intervention is required to improve the energy efficiency and comfort rather than the whole building and all of its systems. Therefore, the design documentation should provide:

- an overview of the existing system which is to be renovated or retrofitted along with its surrounding auxilary components,
- the plans and schematics of the proposed design (improved situation),
- the notes and comments of the designer on the design plans and schematics detailly describing the EEM, what to be done in detail and emphasizing significant details about the scope of the implementation works.

To properly define the requirements and expectations of the design documentation in such a specific energy efficiency implementation works, a design handbook[3] was developed based on GDCA's minimum requirements and expectations. Designers followed this handbook while developing their design plans and documentation.

[2]https://www.kabev.org/en/wp-content/uploads/2021/11/OLCME-VE-DOGRULAMA-KILAVUZU.pdf

[3]https://www.kabev.org/en/wp-content/uploads/2022/03/TASARIM_EL_KITABI.pdf

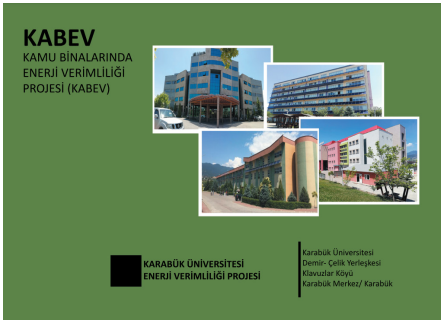
Design documentation was carried out by the design and supervision consultant and submitted to GDCA for the final approval. This design submittal and approval process was for the purpose of ensuring the common understanding of the scope of energy efficiency measures' implementation works for design and supervision consultant, GDCA (client) and the construction company to be awarded after a construction works tender. For example, the lighting bulbs are to be changed as an EEM but, are the lighting fixtures going to be changed as well or is the ceiling which the lighting fixtures are mounted on going to be painted? In order to clear out such possible conflicts, the design documentation shall provide a clear picture about the scope of works and goal of the implementation works.

Finally, design and supervision consultant provided its design documentation including all plans, technical specifications, material definitions, etc. Based on the approval of the GDCA, the energy efficiency renovation construction works were tendered by GDCA.

Before the construction process, environmental and social management plan of Karabük University[4] project was developed based on the environmental and social framework[5] of the overall KABEV project. Stakeholder engagement meetings were carried out with all the relevant stakeholders such as school administration, educational personnel.

Picture 10. Stakeholder engagement meeting

In order to enhance the stakeholder engagement further and increase awareness among educational facility occupants, a project specific booklet was developed and distributed.



Picture 11. Project specific booklet

[4]https://www.kabev.org/wp-content/uploads/2022/09/KARABUK_UNI_CSYP_Nihai_R1.pdf

[5] Environmental and Social Framework of KABEV Project: https://www.kabev.org/cevresel-sosyal-yonetim/

In order to further increase awareness, a big billboard was hanged over the building façade indicating that "energy efficiency renovation works are being carried out in this building".

Procurement Process (Construction)

Based on the design documentation submitted by the design and supervision consultant, GDCA prepared the administrative specifications and completed the tender binder. Finally, the tender was announced in KABEV project website: https://www.kabev.org/ihale-ilanlari/

Tender type was cost based selection provided that the tenderers match the minimum technical, financial and administrative requirements of the tender. Similar work experience was required from the tenderers because, this assignment required specific knowledge and experience in terms of energy efficiency. The aim of this project was not to solely replace the old boilers but, to provide specific amount of energy savings and carbon emissions reduction. Therefore, it was required from the tenderer contractors to have at least the basic level of understanding of energy efficiency, carbon emission reduction, and aim this project.

Construction and Supervision Process

After the finalization of energy efficiency renovation construction tender, site implementation works and consequently the construction supervision works began. Supervision consultant company, which was selected before the energy efficiency renovation construction tender process and works as GDCA's consultant, carried out all the supervision works. Supervision consultant managed the site implementation works, revision requests of the construction contractor, monitored budget and construction progress both in terms of quality and quantity, coordinated and witnessed commissioning process and finally organized the provisional acceptance process.

Commissioning Process

Commissioning of systems plays a significant role especially in an energy efficiency focused project. Hence, commissioning and test of systems not only at the functional level but also from energy performance point of view is crucial. Since this was an energy efficiency renovation construction project, it was especially important to find out whether the expected energy savings were achieved and commissioning had a crucial role in doing so.

Therefore, a commissioning handbook[6] was developed by GDCA to provide guidance to implementation contractors and supervision consultants. Based on this guidance, commissioning process was

6https://www.kabev.org/en/wp-content/uploads/2022/03/D5.2_Commissioning-Handbook_ENG_Web_version_Final.pdf

supervised by the supervision consultant and executed by construction contractor.

Prefunctional checks and functional performance tests of implemented EEMs were carried out by previously defined test methodologies.

Once the tests were finalized and the final commissioning report was submitted, GDCA reviewed the submited report via its technical consultant.

Measurement & Verification (M&V) Process

Quarterly M&V reports and final M&V report at the end of the first year were prepared by design and supervision consultant based on M&V plan approved by GDCA before implementation works begin.

The measurement and verification methods table for Karabük University project is provided in below table.

No	Energy Efficiency Measure (EEM)	M&V Option
1	Thermal Insulation on Foreign Languages Institute Building	Natural Gas Option C
2-1	Heating Water Circulation Loop and Mechanical Installation Retrofit	
5	Integration of Building Automation and Energy Monitoring System	
2-2	Heating Water Circulation Loop and Mechanical Installation Retrofit	Electricity Option A
3	Renovation of existing circulation pumps with integrated inverter circulation pumps	
4	Replacement of Inefficient Luminaires with Efficient LED Luminaires Project	Electricity Option A
6	Rooftop Solar PV System	Electricity Option B

Table 5. IPMVP Option Table

Required measurements to prepare the M&V report were conducted quarterly. Supervision consultant compared the baseline and final energy bills, adjustments for degree days (HDD), changes in operating use, changes in energy prices, occupancy rates, etc. and finally submitted to GDCA.

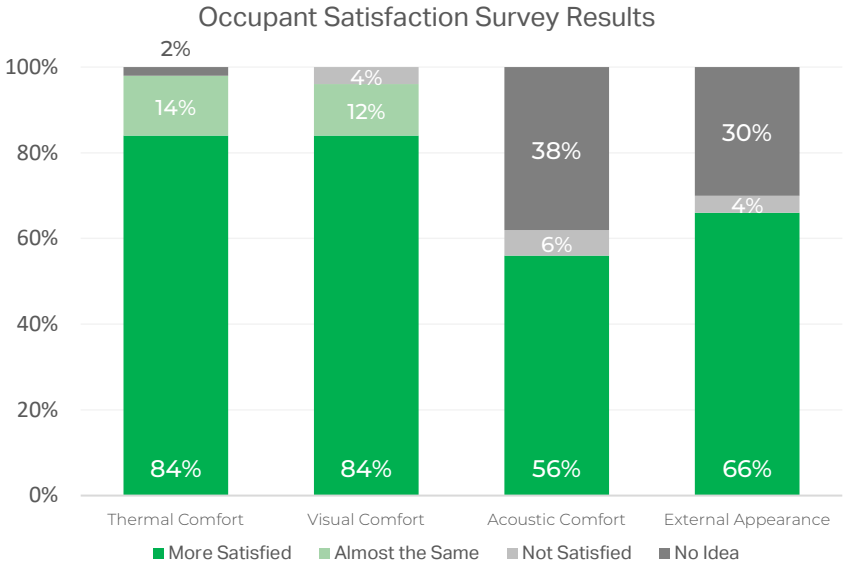
Final M&V report was prepared one year after the renovation works were completed. GDCA reviewed and approved the M&V report after a few revision requests on the report. Revision requests originated from the fact that this sort of M&V process was conducted not conducted many time before in public sector in Türkiye. The M&V report demonstrated the amount of savings realized by comparing the actual energy consumption with the reference energy consumption in which the necessary adjustments were made according to IPMVP.

Energy monitoring system that was installed within the EE implementation works provided qualified and consistent data for M&V process. Hence, energy monitoring system and associated meters and sensors proved to be a useful tool to provide reliable data to M&V calculations.

BUILDING OCCUPANT EXPERIENCE

During the renovation process, two methods were implemented to gather user suggestions, satisfaction, or complaint cases. Pre and post-renovation surveys were conducted among randomly selected individuals out of 450 building users to assess their feedback.

Satisfaction surveys were selected as the method for elaborating on recommendations and feedback. Occupant satisfaction rates were measured for four comfort criteria (thermal, visual, acoustic, and external appearance) and the results are provided at below Graph 5.



Graph 5. Occupant Satisfaction Survey Results

What's more, Karabuk University won the first prize in the energy efficiency contest among universities (UNVER). First prize in the energy efficiency contest got attention from the national media and public which can be observed in the following news links:

https://kulliye.karabuk.edu.tr/universiteler-arasi-enerji-verimliligi-yarismasinda-kbu-birinci-oldu/

https://www.haberturk.com/karabuk-haberleri/30726374-karabuk-universitesi-universiteler-arasi-enerji-verimliligi-yarismasinda-birinci-oldu

LESSONS LEARNED

Karabük University energy efficiency improvement project was not a common renovation project and a lot of things were experienced for the first time for all parties including the project implementation unit (GDCA), supervision consultant, implementation contractor, beneficiary, etc. Therefore, several lessons were learned as an outcome of this specific project:

Energy Efficiency Renovation Contract Scope:

This project aimed for energy efficiency predominantly. Therefore, all of the site implementation measures were related with energy efficiency and carbon emission reduction. On the other hand, beneficiary administration had default expectations fom a renovation project such as renovation of interior architecture, furniture, flooring, bathrooms, façade, paints, etc. This lead to a mismatch between the contract scope and beneficiary expectations.

Expectations of beneficiary were aligned after stakeholder engagement meetings. The lesson learned from this issue is to manage expectations of beneficiary at the early stages of the project with more focused and clear communication about the exact scope and specific target of the project.

Design Documentation Process:

Design and supervision consultant was required to develop design documentation and submit to GDCA approval. The buildings did not have architectural plans of the existing situation. For this reason, design and construction consultant had to make architectural survey to come up with the up to date architectural plans. This process was the prerequisite to pass to stage of design documentation of energy efficiency measures. However, the level of detail of survey plans expected by GDCA were much higher than the required level of detail for an energy efficiency project because, GDCA was living up to the highest expectation for contruction projects as a general character of the organization. This caused a delay in approval of the survey plans leading to delay of the finalization of the the On the other hand, this was not a ground up construction project and did not need evey detail of the building and floors which were not relevant to energy efficiency measures. For example, frame or divider width of every single window should not be required in a project where there's window replacement. Interior door dimensions or baseboard height of an interior wall may not be relevant for an energy efficiency measure. Bathroom and restroom interior details are generally not relevant for an energy efficiency project.

Lesson learned from this project was to align the expectation of GDCA from a survey plan so that only relevant elements of a floor or a system will be required for an energy efficiency renovation project. In addition, survey plan approval was removed from the design documentation process. Instead, only energy efficiency renovation design plans in each discpline are decided to approved by GDCA.

Formal Permits:

Formal permit procedures could have been planned or initiated before the tender for systems such as solar photovoltaic energy system which had to go through various authorities for the formal approval procedure. Consequently, the provisional acceptance and permit for grid connection could have been obtained renewable energy systems could have begun generating electricity several months before.

Tender Terms:

In a relatively infant building energy efficiency renovation market, the financial terms and conditions of the tender could have been more flexible and attractive in order to attract more interest from implementation contractors both locally and internationally.

The financial terms of this tender was with fixed prices in local currency which was under high pressure both from exchange rate risks aganist international currencies and high domestic inflation making all the overheads, general admin, material and labor costs difficult to predict during the implementation period. Therefore, the tender prices could have been done in internationally more stable currencies which would limit the price fluctuations at least in equipments and materials leading to less risk perception in interested tenderers. It would attract more international contractors making them not to think about local currency exchange rate and high domestic inflation risks. A price adjustment mechanism could also be embedded into tender financial terms for limiting the risks regarding domestic costs based on local currency. This would decrease the risk perception in financial terms of the tender and lead interested contractors turn their utmost attention into more technical aspects of the tender.

Measurement & Verification:

Lack of measurement and verification process experience lead to a delay in finalizing the measurement and verification plan. M&V plan went back and forth between design and supervision consultant and GDCA due to the fact that local M&V professional prepared such a compherensive M&V plan with too many EEMs for the first time. Hence, it was a learning process for both design and supervision consultant and GDCA.

More M&V professionals are necessary for a healthy operating energy efficiency market. Ministry of Energy and Natural Resources will consider to accept the accreditation of M&V professionals having certified from international M&V accreditation schemes.