Center of Excellence in Energy Efficiency (CEEE)

Annual Progress Report - 8

May 2026

Annual Report Information

Duration (months)	**12**	**Start Date**	May. 2025	**End Date**	May 2026
Director	Dr. Atif Al-Zahrani				
Progress Report Due Date:	May 2026				

Executive summary

This report highlights the key achievements of the Center of Excellence in Energy Efficiency (CEEE) at KFUPM over the current reporting period. Building on its mission to advance energy efficiency practices, CEEE successfully conducted energy auditing projects for two KFUPM student dormitories. These efforts resulted in estimated annual energy savings of approximately 107,689 kWh/year, financial savings of around SAR 58,460/year, and a reduction in CO_2 emissions of about 80,767 kg/year.

CEEE continued to expand its impact in professional capacity building by extending its Certified Energy Manager (CEM) training and sponsorship program beyond KFUPM for the second time. This initiative supported faculty members from institutions in the Riyadh region, including two participants from King Saud University and one from Princess Nourah bint Abdulrahman University, further strengthening regional expertise in energy management.

In collaboration with the Saudi Standards, Metrology and Quality Organization (SASO), CEEE organized a specialized workshop on ISO 50001 Energy Management Systems. The workshop targeted a diverse audience, with approximately 80% participation from KFUPM students and 20% from other universities, enhancing awareness and knowledge of international energy management standards.

CEEE also strengthened academic and industry engagement through multiple initiatives. In collaboration with Quantum ESCO, the Center hosted a workshop aimed at equipping students with real-world project practices and practical insights prior to graduation. Additionally, CEEE partnered with Imam Abdulrahman Bin Faisal University (IAU) to deliver year-long training programs on energy auditing for faculty members, as well as specialized energy efficiency courses for Mechanical Engineering students.

At the international level, CEEE developed and launched an online Energy Efficiency course on the Udemy platform, featuring Dr. Abdulrahman Almerbati as the lead instructor, targeting a global audience and promoting best practices in energy efficiency worldwide. There around 104 students currently enrolled with the average course rating of 4.5.

As part of its outreach and community engagement efforts, CEEE hosted educational visits for students from University Schools and AlHassan High School, providing them with hands-on exposure to energy efficiency concepts and university-level laboratory experiences.

In addition, CEEE contributed to advancing research and consultancy through key projects, including the establishment of the KFUPM Net-Zero Building Living Lab, a real-world platform for testing and demonstrating energy-efficiency and sustainability technologies under actual operating conditions, as well as work towards a “Net Zero KFUPM Campus,” alongside academic publications in peer-reviewed journals. The Center also provided data and content for the annual KFUPM Sustainability Report, supporting institutional sustainability monitoring and reporting.

A major highlight of the year was the organization of the second KFUPM Energy Week. Expanding significantly from its inaugural edition, the event evolved into a national initiative in collaboration with student clubs and 21 universities across the Kingdom, featuring competitions, workshops, and awareness activities aligned with national sustainability goals.

Through these initiatives, CEEE continues to play a leading role in promoting energy efficiency, fostering talent, supporting research, and contributing to the Kingdom’s sustainability vision. In recognition of its awareness and impact initiatives, CEEE was honored with the Saudi Energy Efficiency Awareness and Impact Award during the inaugural Energy Efficiency Award Ceremony in Riyadh, held under the patronage of His Royal Highness Prince Abdulaziz bin Salman.

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I. Introduction & Overview

Founded in October 2016, the Center of Excellence in Energy Efficiency (CEEE) at King Fahd University of Petroleum & Minerals (KFUPM) is dedicated mainly to improving the energy efficiency of buildings and industries in Saudi Arabia and the Middle East region as well. CEEE is a national center created with support from Saudi Energy Efficiency Program (SEEP) in response to Saudi Arabia's Vision 2030 to contribute towards supporting sustainable development, covering energy efficiency and renewable energy solutions, and promoting modern energy technologies and techniques within the country. CEEE offers public and nonprofit services in improving energy efficiency and management through disseminating knowledge and training courses, supporting research and development, promoting innovative technologies and new ideas, and creating public awareness. CEEE also aims to facilitate technology transfer and applied research in the realm. Its establishment was with the support of funding from the King Abdulaziz City for Science and Technology (KACST) as an initiative under the Saudi Energy Efficiency Center (SEEC).

CEEE's Vision: Striving for Educational Excellence in Energy Efficiency

CEEE's Mission: To disseminate knowledge on energy efficiency and to conduct and promote impactful practices in the field of energy efficiency.

CEEE's main objectives:

1. Human Capital Development: Enhancing regional expertise through student engagement, capacity building, and comprehensive energy efficiency (EE) awareness programs.
2. Energy Efficiency Solutions: Bridging research and application through policy assessment, technical studies, and the development of energy-related educational content.
3. Institutional Leadership: Advancing KFUPM's net-zero transition through technical consulting, sustainability reporting, and the implementation of energy-efficient models.

II. Human Capital Development

CEEE at KFUPM is driving sustainability and energy efficiency through collaborations like Quantum Saudi, SASO and various local universities., where hundreds of students enroll in related courses each term.

These efforts focus on equipping participants with both theoretical knowledge and practical skills in energy efficiency and sustainability. The programs include structured courses, professional certifications, internships, and hands-on training opportunities. Some initiatives are led directly by CEEE, while others are implemented in collaboration with academic institutions, industry partners, and external stakeholders, student clubs, ensuring a well-rounded and practice-oriented learning experience.

1. Joint workshop with Quantum Saudi

CEEE strengthened its engagement with industry through collaboration with Quantum Saudi (ESCO company). The Center hosted a two-day workshop aimed at equipping 39 students with real-world project experience prior to graduation. The first day featured a technical lecture at KFUPM, while the second day included site visits to two of Quantum's projects:

- Imam Abdulrahman bin Faisal University
- Institute of Public Administration.

This initiative provided students with practical exposure to energy efficiency implementation in real operational environments.







Figure 1: CEEE and Quantum Saudi two-day student workshop and field visit *(The complete list of certificate recipients is provided in Appendix A).*

2. Joint workshop with Saudi Standards, Metrology, and Quality Organization

CEEE In collaboration with the Saudi Standards, Metrology and Quality Organization (SASO), organized a workshop on ISO 50001 Energy Management Systems presented by Engineer Gaith Almasmoudi , Expert Advisor, engaging a total of 47 students from multiple universities, including Jouf University, Imam Abdulrahman bin Faisal University, Prince Mohammad Bin Fahd University, King Abdulaziz University, and KFUPM.

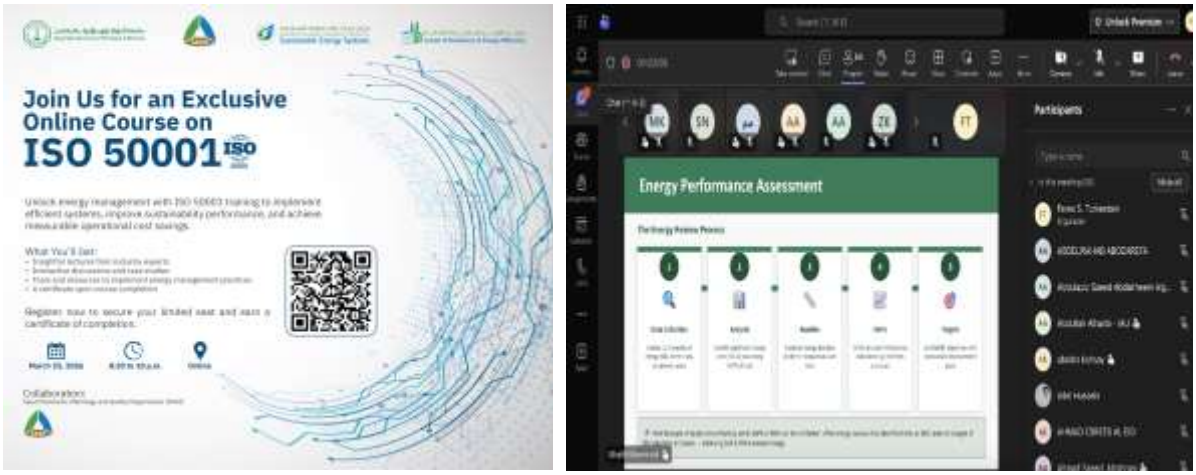


Figure 2: CEEE and SASO collaborative online workshop on ISO 50001 Energy Management Systems.

3. Internships

Demonstrating a strong commitment to mentorship and talent development, Dr. Binash Imteyaz successfully provided specialized internship/training to a diverse cohort of students across various academic levels. At the pre-university level, high

school student Nour Al Madan was mentored as an Ibdaa Student Researcher, working on a project titled "Numerical Investigation of an Integrated Ammonia Synthesis Reactor." Additionally, Dr. Imteyaz supervised undergraduate part-time students Layan Abdullah Al Qahtani and Osama Ahmad Salmeh, who focused on practical sustainability initiatives through the Energy Auditing project. This mentorship highlights the center's active role in fostering both advanced numerical research capabilities and hands-on energy management skills among the next generation of researchers and engineers.

Student Name	Academic Level	Position/Program	Project Title
Nour Al Madan	High School	Ibdaa Student Researcher	Numerical Investigation of an Integrated Ammonia Synthesis Reactor
Layan Abdullah Al Qahtani	Undergraduate	Part-Time Student	Energy Auditing of KFUPM Dormitories
Osama Ahmad Salmeh	Undergraduate	Part-Time Student	Energy Auditing of KFUPM Dormitories

4. Assisting KFUPM Faculty Members in Teaching EE-related Courses

The Center of Excellence in Energy Efficiency (CEEE) continues to support the academic mission of King Fahd University of Petroleum & Minerals (KFUPM) by contributing to the delivery of courses related to energy efficiency. Through collaboration with faculty members from the Mechanical Engineering Department, CEEE facilitates both theoretical and practical learning experiences for students in this field.

CEEE, through Dr. Binash Imteyaz, delivered an Energy Efficiency course (ME 423) to Mechanical Engineering students on November 16, 2025. The course engaged a total of 20 students and focused on enhancing their understanding of energy efficiency principles, methodologies, and real-world applications. The sessions aimed to bridge the gap between theoretical knowledge and practical implementation, equipping students with the necessary skills to address energy-related challenges in engineering practice.



Figure 3: Delivery of the Energy Efficiency course (ME 423) to KFUPM Mechanical Engineering students.

5. Energy Efficiency Certification to Saudi Faculty Members

CEEE continues to strengthen its efforts in human capital development by expanding its Certified Energy Manager (CEM) training and sponsorship program to a broader academic audience. Building on previous initiatives, the Center extended this program beyond KFUPM to include faculty members from institutions in the Riyadh region, namely King Saud University and Princess Nourah bint Abdulrahman University.

As part of the preparation for the CEM certification, CEEE provided participants with a structured online training program covering key aspects of energy management and efficiency. The training addressed core topics such as energy auditing methodologies, energy conservation strategies, performance optimization, relevant codes and standards, and best practices in energy management systems. This preparatory phase aimed to equip participants with the necessary theoretical foundation prior to undertaking the certification exam.

Following this, CEEE sponsored three faculty members:

Name	***Affiliation***	***Department***	***Position***
Dr. Majed Alotaibi	King Saud University	Electrical Engineering	Assistant Professor
Dr. Faisal Alsai	King Saud University	Electrical Engineering	Assistant Professor

Dr. Zahra Shabaihan	Princess Nourah bint Abdulrahman University	Physics	Assistant Professor

to undertake the Certified Energy Manager (CEM) training and certification. Each candidate was sponsored at a cost of SAR 6,900, bringing the total sponsorship amount to SAR 20,700.

This initiative reflects CEEE's continued commitment to nationalizing its efforts and expanding its impact as a leading center for energy efficiency. By supporting faculty members across multiple universities, the program contributes to strengthening regional expertise, fostering collaboration, and promoting the adoption of energy efficiency practices within academic and professional institutions across the Kingdom.



Figure 4: CEEE Certified Energy Manager (CEM) sponsorship and preparatory workshop for external faculty members.

6. Community Outreach

CEEE continued to play an active role in community engagement by organizing educational visits for students from local schools, aimed at promoting awareness of energy efficiency and sustainability concepts.

a. University Schools Visit

CEEE hosted 40 students from University Schools as part of an educational outreach initiative designed to introduce them to energy efficiency principles and real-world applications. During the visit, students were provided with guided tours of CEEE laboratories and facilities, where they observed practical demonstrations of energy systems and technologies. Interactive sessions were conducted to enhance their

understanding of energy conservation practices and the role of engineering solutions in sustainability.



Figure 5: Educational outreach visit of University Schools students to the CEEE facilities.

b. AlHassan High School Visit

CEEE also welcomed 50 students from AlHassan High School, offering them a similar immersive experience within the Center's laboratories. The visit included hands-on exposure to energy efficiency concepts, demonstrations of energy auditing tools, and discussions on sustainability challenges. These activities aimed to broaden students' perspectives and connect theoretical knowledge with practical applications.



Figure 6: Educational outreach visit of University Schools students to the CEEE facilities.

Overall, approximately 100 students participated in these visits. The initiative aimed to inspire young learners, provide early exposure to university-level environments, and encourage interest in pursuing future careers in energy, engineering, and sustainability fields.

7. 2nd KSA Energy week

EEE continued to support student-led initiatives in close collaboration with the Students Energy Clubs, with the crowning achievement being the organization of KSA Energy Week, which successfully evolved into a premier national-level initiative.

The preliminary stages of the event were organized across three primary regions, the **Riyadh region, Western Region, and Eastern Region**, running through the last week of January and the first week of February. The competition saw widespread national engagement, attracting **over 200 participants** from all around the country.

The main regional stages and widespread participant network brought together students from a broad cohort of universities across the Kingdom, including:

- King Saud University (KSU)
- Prince Mohammad Bin Fahd University (PMU)
- Alfaisal University
- Princess Nourah bint Abdulrahman University
- Imam Mohammad Ibn Saud Islamic University (IMSIU)
- Prince Sultan University (PSU)
- Qassim University
- University of Jeddah
- King Abdullah University of Science and Technology (KAUST)
- King Khalid University (KKU)
- Taif University
- Umm Al-Qura University (UQU)
- Islamic University of Madinah
- Taibah University
- Prince Sattam bin Abdulaziz University (PSAU)
- Saudi Electronic University (SEU)
- University of Hafr Al Batin (UHB)

- Al Yamamah University

In addition to competing, several students from these institutions stepped up as active members of the KSA Energy Week organizing team, substantially enhancing multi-institutional collaboration and student leadership at the national level.

Following the regional evaluations, the selected finalist teams advanced to the definitive final round, hosted centrally at the **King Fahd University of Petroleum and Minerals (KFUPM)** from **February 9 to February 13**.

Over 20 premier teams qualified to compete in the final bracket, which was split into three distinct, specialized competitions:

- **Energy Rush**
- **Energython**
- **Energy Debate**

The national initiative concluded with a high-profile closing ceremony, where excellence was rewarded as the top three teams across all three competitions received official prizes for their outstanding performance and innovative contributions.



Figure 7: The Energy Debate Eastern Region IAU



Figure 8: Energython Western Region KAU



Figure 9: Energython Riyadh Region

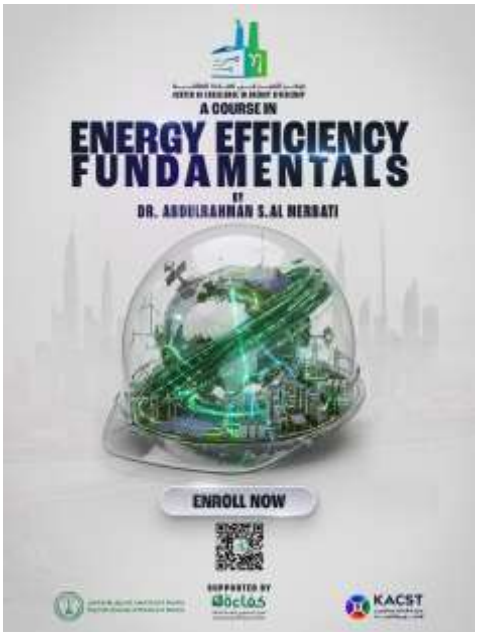


Figure 10: Finals of Energy Competition at KFUPM

8. Online Energy Efficiency Course on Udemy

To expand access to energy efficiency education and promote continuous learning, CEEE launched a free online course titled “Energy Efficiency Fundamentals” on the Udemy platform. Developed and delivered by Dr. Abdulrahman Almerbati, the course provides an introduction to energy efficiency concepts and applications in buildings, HVAC systems, industrial processes, energy auditing, and project evaluation.

Designed for students, engineers, facility managers, and sustainability professionals, the course combines practical knowledge with real-world applications and offers participants a certificate of completion. This initiative enables CEEE to reach a broader audience and further supports its mission of advancing energy efficiency awareness and capacity building at both national and international levels.



https://www.udemy.com/course/fundamentals-of-energy-efficiency-ceee/

9. Awards and Recognition

The Center of Excellence in Energy Efficiency (CEEE) is proud to share another great achievement. During the inaugural Energy Efficiency Award Ceremony in Riyadh, held under the patronage of His Royal Highness Prince Abdulaziz bin Salman, CEEE was honored with the Saudi Energy Efficiency Awareness and Impact Award. The award reflects CEEE’s role in building excellence in developing human capabilities in energy efficiency and delivering hands-on initiatives that have benefited hundreds of participants. CEEE has supported more than 300 participants through “Energy Week,”

and trained 640 male and female students through practical training programs, in addition to providing training to employees from the industrial sector. The Center also conducted energy audits for 20 buildings together with students, reinforcing its ongoing role as a national reference in raising awareness and advancing energy efficiency in alignment with Saudi Arabia's Vision 2030.



Figure 11: CEEE receiving the Saudi Energy Efficiency Awareness and Impact Award in Riyadh.

III.Energy Efficiency Solutions

1. Project Completion and Expanded Collaboration with Yokogawa

This study successfully investigated a multi-stage ammonia production system, assessing the feasibility of low-pressure technology integration and conducting a techno-economic analysis to develop an optimized digital twin model for **Yokogawa**, ultimately enhancing operational efficiency. The research explored incorporating a low-pressure hydrogen supply and analyzed various operating conditions and parameters to identify key optimization opportunities for improved efficiency and cost-effectiveness. Having achieved all of its objectives, the project is now in the final stages of closure, and the final report is being prepared.

The initial phase of this collaboration has already yielded two peer-reviewed articles (one in a high-impact journal and one at a reputed international conference), with several additional manuscripts currently under development or review:

1. Adib Adnan, Ayman Al Mukahhil, Binash Imteyaz, Mustafa Al Naser, Esmail M.A Mokheimer, Parametric Analysis of Non-Adiabatic Internal Direct Cooling Ammonia Synthesis Reactor, Canadian Society for Mechanical Engineering International Congress, 31st Annual Conference of the CFD Society of Canada, May 26-29, 2024-University of Toronto.
2. Adnan, A., Al Mukahhil, A., Imteyaz, B., Al Naser, M. and Mokheimer, E.M.A., 2025. Green Ammonia Production and Integration in Multigeneration Systems: A Review. Arabian Journal for Science and Engineering, pp.1-37.

Based on the successful outcome of this milestone and an excellent collaborative experience, Yokogawa has again approached our team to initiate a new collaborative project. This next venture will focus on the Optimization of Green Ammonia Production under Renewable Intermittency using CSP + Thermal Energy Storage.

2. Development of a unified curriculum for SEEC energy efficiency course.

On the request from the Saudi Energy Efficiency Center, our center successfully developed a comprehensive course outline for Energy Efficiency Fundamentals, a 3-credit hour, senior-level undergraduate course designed for multiple engineering and architecture programs. The curriculum is structured to bridge foundational knowledge with practical field applications, spanning core thermodynamics and energy value chains to advanced sector-specific optimization strategies in buildings, transport, and heavy industry. Emphasizing real-world competence, the syllabus integrates hands-

on data logging and measurement practices, life-cycle cost analysis, and contemporary frameworks such as circular economy principles and carbon trading. This strategic educational initiative underscores our center’s commitment to fostering regional environmental sustainability, advanced energy management, and the development of specialized technical expertise aligned with national energy goals (Appendix C).

IV. Institutional Leadership

CEEE played an active role in supporting the preparation of the annual KFUPM Sustainability Report by providing data, technical inputs, and documented evidence of sustainability-related activities. These contributions supported the University's alignment with international frameworks, including the Times Higher Education (THE) Impact Rankings, and demonstrated KFUPM's commitment to the United Nations Sustainable Development Goals (SDGs).

The Center prepared comprehensive content covering key areas such as energy efficiency initiatives, capacity-building programs, research activities, and stakeholder engagement. This included documentation of technical seminars, workshops, and knowledge exchange activities focused on advancing sustainable energy systems and promoting best practices in energy management.

CEEE also supported the reporting of training and educational initiatives, including student-focused programs, research enrichment activities, and outreach efforts targeting both university and pre-university students. These contributions highlighted the Center's role in developing human capital and raising awareness of sustainability and energy efficiency.

Through these efforts, CEEE ensured accurate and impactful representation of KFUPM's sustainability performance, strengthening the University's position in global rankings and reinforcing its commitment to advancing sustainability at both the national and international levels.

1. Energy Auditing of Student Dorms

The audit involved detailed energy performance assessments and the identification of potential Energy Efficiency Measures (EEMs) aimed at reducing energy consumption and operational costs. As part of this initiative, CEEE also emphasized hands-on capacity building by actively training participating students in conducting professional energy audits, equipping them with practical skills aligned with industry standards. This project was carried out by a multidisciplinary team comprising two KFUPM students, one staff member, and one research scientist.

This project examined and assessed lighting conditions, cooling consumptions and thermal leakage or hot spots in two student dormitories. The selected buildings were

strategically chosen as one conventional (820) and one renovated (841) building. The CEEE team hired two part time undergraduate students (one from mechanical Engineering and one from electrical engineering) and supervised them in conducting the measurements, analyzing the measured data, and in writing the energy audit report in the two buildings. Overall, the estimated annual savings amount to 107,689 kWh/year, a reduction in CO_2 emission of about 80,676 kg/year, a financial savings of about 58,461 SAR/year.

Building Energy Consumption Estimation is 316,000 kWh/year and 403,000 kWh/year for Building 820 and Building 841, respectively.

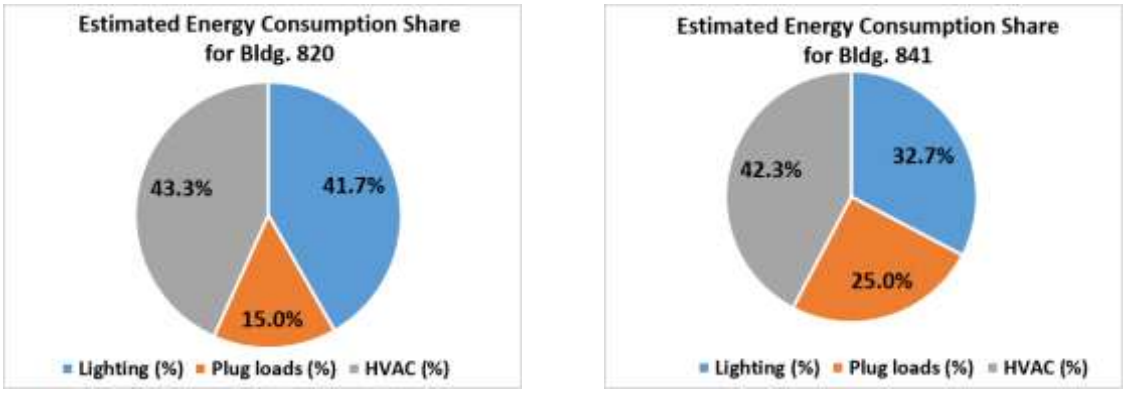


Figure 12: Estimated energy consumption breakdown for Buildings 820 and 841.

Following the implementation of the proposed energy efficiency measures (EEMs), projected annual energy use drops to roughly 262,997 kWh/year for Building 820 and 348,314 kWh/year for Building 841. Consequently, the revised Energy Use Intensity (EUI) decreases to 62.6 kWh/m²·year and 82.9 kWh/m²·year, respectively.

	Energy Saving (kWh/year)		CO_2 reduction (kg/year)*		Annual cost saving (SAR/year)		Estimated project cost per building (SAR)		
EEM	Bldg 820	Bldg 841	Bldg 820	Bldg 841	Bldg 820	Bldg 841	Estimated project cost	Simple payback (Years) for 820	Simple payback (Years) for 841
Lighting retrofit	38,804	38,804	29,103	29,103	12,417	12,417	16,000	1.3	1.3
Lighting control in selected common areas	7,360	7,360	5,520	5,520	2,355	2,355	7,458	3.2	3.2
HVAC optimization of AHU during Vacations	6,839	8,522	5,129	6,392	2,188	2,727	6,000	2.7	2.2
Power factor correction	0	0	0	0	12,000	12,000	16,000	1.3	1.3
Total	**53,003**	**54,686**	**39,752**	**41,015**	**28,961**	**29,500**	**45,458**	**1.6**	**1.5**
% Savings	**16.8%**	**13.6%**							
Average Savings for two Bldg	**15.0%**								

Figure 13: Summary of estimated savings, costs, and payback periods for proposed Energy Efficiency Measures (EEMs) in Buildings 820 and 841.

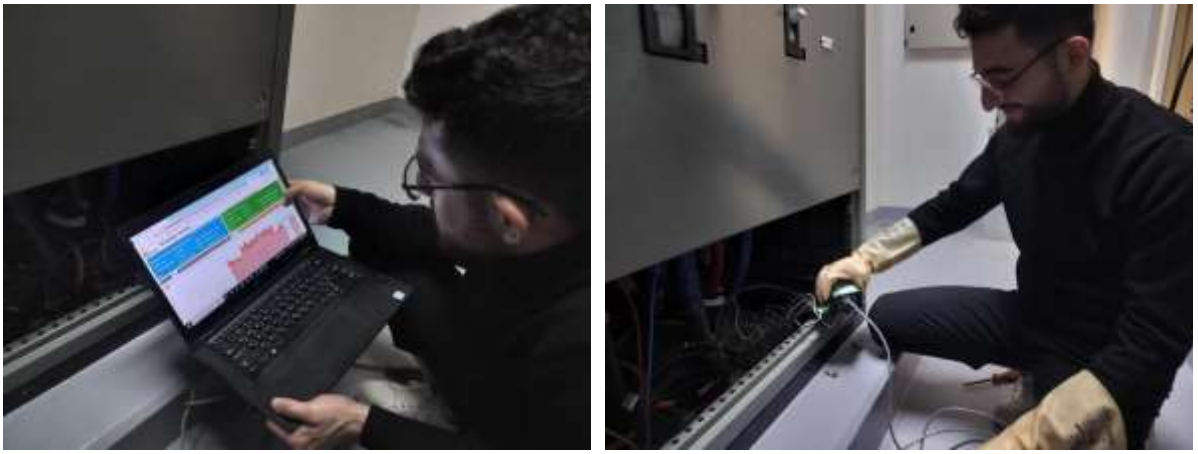


Figure 14: Monitoring of Energy Consumption of Student Dorms

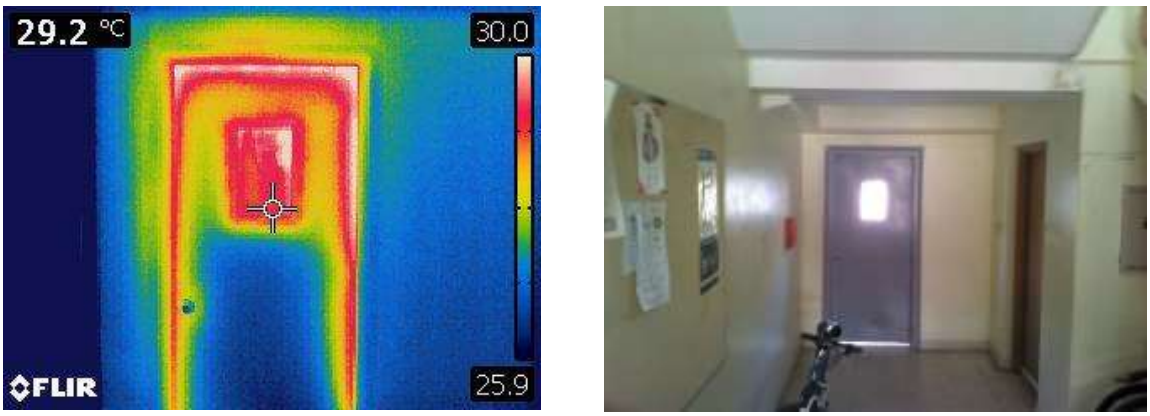


Figure 15: Thermal inspection and analysis of the building envelopeMonitoring of Temp, Humidity and CO_2 Levels

2. Sustainable mobility at KFUPM

A prominent research output from the center is the paper *"Towards Sustainable Campus Mobility: Optimal Transition Planning for Battery Electric Bus Fleets,"* which was presented at the KFUPM Smart Mobility Conference (SMilE 2026) and is now published. The study introduces an optimization framework to guide the transition of KFUPM's bus fleet from diesel to battery electric power over a 20-year horizon, balancing fleet replacement schedules, charging infrastructure, maintenance, and energy use to achieve significant emission reductions without disrupting operations. Concurrently, CEEE published a study in the Q1-ranked journal *Energy Conversion and Management: X*, titled *"Decarbonizing Campus Transportation through Electric Bus Fleet Electrification: Resource and Environmental Implications."* Applying a mixed-integer optimization model to the KFUPM network, this work highlights the viability of complete fleet electrification, projecting a 41% decrease in carbon emissions under the baseline grid and up to 46% with expanded renewable

integration. The resulting decision-support framework advances institutional decarbonization and climate action objectives.

3. Net Zero building (living lab)

The KFUPM Net-Zero Building Living Lab was established to address the lack of a dedicated real-world environment for demonstrating energy-efficiency and sustainability technologies at TRL 6. An old residential building in the former American Consulate area was repurposed for the facility (26°18'10.8"N, 50°09'27.7"E). As a living laboratory, the building will continuously host evolving research projects where technologies can be installed, operated, monitored, and improved under actual Saudi climatic and operating conditions. It will also enable researchers to assess how active and passive technologies perform individually and as integrated systems, generate real-world performance data, and demonstrate their readiness for wider deployment.

A 3D CAD model of the building was developed to plan the placement and integration of the identified projects and determine the required modifications. The first active project is assessing tiles manufactured from recycled plastic and industrial-waste by-products in a residential setting. In parallel, civil works are underway to prepare dedicated spaces for future projects, ranging from wastewater treatment and reuse to the DEMA Energy system, which will integrate solar energy, battery storage, smart energy management, an electric-vehicle charger, and building-performance monitoring.



Figure 16: Aerial location and exterior view of the repurposed building for the KFUPM Net-Zero Building Living Lab.

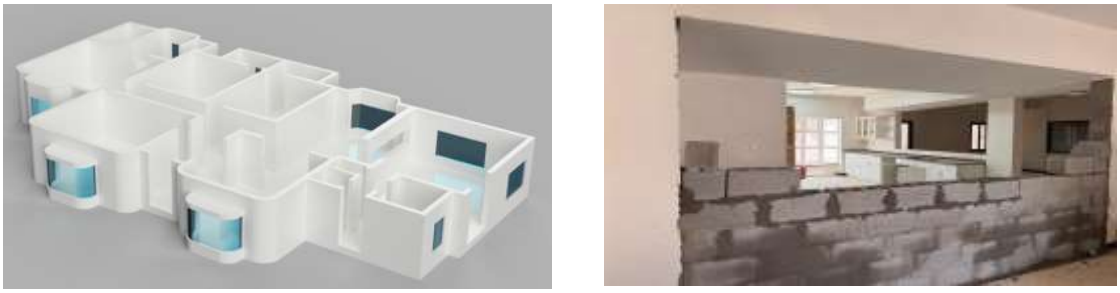


Figure 17: 3D CAD model (left) and ongoing civil preparation works (right) for the KFUPM Net-Zero Building Living Lab.



Figure 18: Infographic of the first KFUPM Living Lab project: Real-time assessment of recycled plastic and industrial waste tiles.

V. Summary

1. CEEE Key Performance Indicators (up to May. 2026)

CEEE's Key Performance Indicators (KPI) illustrates the main activities of the center (up to May 2026) as shown in the table below.

CEEE KPI (up to May. 2026)	
Measures	**Comments**
Conduct at least 5 energy-focused events (seminars, workshops, competitions)	• Organized an in-person engagement with the Quantum ESCO company, including a lecture for students and a site visit to provide real-life project exposure and practical experience. • Delivered a remote ISO 50001 energy • Conducted **two** school visits. • Organized Energy Week (including Hackathon, Energy Rush, and Debate).
Train 80 students and professionals in energy efficiency.	• Delivered a remote ISO 50001 energy management course in collaboration with SASO, (toward the target mix of 80% KFUPM students and 20% students from other universities **47 students** in total). • Conducted an Energy Efficiency course for ME students led by Dr. Binash (**20 students**) • Provided ESCO Workshop training to **39 students**. • Supported **3 faculty** members for CEM certification.
Develop a new online module or course components.	• Developed an online energy-efficiency course with Dr. Abdulrahman Almerbati and published it publicly on Udemy.
Conduct 3 outreach programs.	• Energy Week competition • High school AlHassan visit to CEEE • University High school visit to CEEE
Complete a consultation project (policy assessments, curriculum, toward a net zero KFUPM campus).	• KFUPM Smart Mobility (SMilE2026) conference, paper accepted, presented , and published. • Development of a unified curriculum for SEEC energy efficiency course.

Complete 1 technical study (energy-related).	• Energy Audit project for KFUPM Dorm • KFUPM Smart Mobility (SMilE2026) conference, paper accepted, presented , and published.
Provide data and content for the annual KFUPM sustainability report per year.	• Completed and submitted.

2. Future Goals & Strategic Plans

Energy Efficiency Village (EEV) Initiative CEEE developed a comprehensive proposal for the establishment of the Energy Efficiency Village (EEV), a national platform supporting energy efficiency education, innovation, and policy development. The full proposal is included in Appendix D.

Based on this the new KPI (May 2026-May 2027) include:

CEEE KPI (up to May. 2027)	
Measures	**Comments**
Conduct at least 5 energy-focused events (seminars, workshops, competitions)	
Train 80 students and professionals in energy efficiency.	
Conduct 3 outreach programs, including exporting energy audit practice.	
Complete one implementation of net zero building project	
Provide data and content for the annual KFUPM sustainability report per year.	
Develop a detailed scope for energy efficiency village	

VI. Appendices

Appendix A

Workshop with ESCO Students Names
Abdullah Alharbi
BASHIR AHMED JOHAN
farrukh.baig
Md Tasbirul Islam
Munirah Ziyad Alzaid
Oluwatobi Adewale Adeyeba
Sikandar Abdul Qadir
Thamer Abdullah Alharbi
Abdalla hany Baioumy othman
Abdelrahim Abdalla
Ahmed Almatar
Areej Aldossary
Ayhem Alawneh
Batool muhanna AlRamadan
Danyah Hassan Alzouri
Fatimah nasser aljubran
Hajar Ameen Alhussain
Hussain Almusallam
Khalid Hashim Al-Zahrani
Makram Jaber
Noor Alaalawi
Rahaf Ali Almudarhim
Rawan Alghamdi
Rayan Mohammed Albasri
Rayhanah mohammed Alkhazal
Redha Al Ghazal
Reem Wasil Alhussain

Reemas Alashwan
Samaa Hussain Alhani
Sami Jradat
Semat Fawzi Albiek
Shahad Mohammed Alhajri
Tofoof Alghasham
Yaqeen Alnasif
Zahra Mahdi Alshulah
Zahrah Al Ajmi
Zainab al dahi
Zainab Munir Alshaikh
Abdullah Alharbi

Appendix B

Joint workshop with SASO Students list
Abdelwahab Ahmed Hussien Elsayed
Abdulaziz Mari
Abdullah Munif Alharbi
Abdullatif Bandar Alhabah
Abraha Kahsay Kiros
Adel Hussein
Ahmad Alzahrani
Ahmad Edrees Al-Eid
Aliaa Alrashidi
Aseel Mansour Al-Fahigi
Asim Ahmad
Asma khaled Al Maduh
Atheer Alnassir
Hala Alsulaiman
Hassan Al Garni
Hassan Alsobaie
Ibrahim Mohammed Al-Sultan
Ismail Salihu
Lama Albadran
Majed Abdullah bagarish
Manaf Murtada Alalsayedsalih
Mansour saad Alotaibi
Maryam Al Al Lashit
Maryam Alshehri
Maryam Musa Musaqlab
Mazen Yousif Ali Mohamed
MD ROKONUZZAMAN
Mihretab Woldetsadik Ossa
Mohamed Ibrahim Soliman
Mohammed Abdulghani Aman
Mohammed Mahnashi
Mohammed Wadhah Alyousif

Muhammad Salman Khalid
Nawra Alsharfa
Nazir Muhammad
Nuradin Abdukadir Ahmed
Omar Anas Abdulaziz Fadel
Rana Alkhaldi
Rand Saad Alqarni
Saeed Alnoman
Salah Aljuwaysir
Sarvar Hussain Nengroo
Syed Zaighum Abbas Bukhari
Yewondwosen Gzate Ayalew
Yousif Alghamdi
Youssef Maanee
Zahra Hussain Alnaji

Appendix C

Course Title: **Energy Efficiency Fundamentals**

A. COURSE IDENTIFICATION AND GENERAL INFORMATION

1. Course title: Energy Efficiency Fundamentals
   Course code: Course Credit Hours: 3
2. Program(s) in which it is offered as core course: Mechanical Engineering Science, Applied Mechanical Engineering, Electrical Engineering, Architecture Engineering
3. Level at which this course is taught: **UG (Level 4)**
4. Pre-requisites for this course (if any): Thermodynamics, Heat Transfer, Basic Electricals.
5. Co-requisites for this course (if any):
6. Location: **Campus**
7. Mode of Instruction: Lecture and visits

Mode of instruction	**Percentage (%)**
in class (face to face)	90
Other (Specify): Visits	10

Comments:

8. **Course Components** (total contact hours and credits):

	Lecture	**Tutorial**	**Laboratory or Studio**	**Practical**	**Others**	**Total**
Contact Hours (per semester)	40				5	45
Credit Hours	3					3

	Study	**Assignments**	**Library**	**Project/ Research Essay/These**	**Others**	**Total**
Self-Learning Hours (Estimation per semester)	**50**	**30**		**20**		**100**

Total learning hours =Total contact Hours + Total self-learning Hours =	145

B. OBJECTIVES & LEARNING OUTCOMES

1. **The objectives** of this course are to:
   - Grasp core concepts, importance, and role in global energy management, environmental sustainability, and demand-side management.
   - Learn to evaluate and analyze energy consumption patterns in buildings and industrial facilities.
   - Develop skills in performing energy audits, utilizing measurement equipment, and analyzing data for improvements.
   - Formulate energy-efficient solutions, conduct cost-life analysis, and assess their financial viability.
   - Master the creation of detailed energy auditing reports and effective communication of recommendations.
   - Understand global energy efficiency policies, circular economy principles, and carbon markets.

2. **Map Course-level Student Learning Outcomes** with the **P**rogram-level Student **L**earning **O**utcomes (**PLO**s).

Code#	CLOs	Aligned PLOs
		PLO's code
1	**Knowledge**	
1.1	Understand energy fundamentals: concepts, units, and interrelationships.	1
1.2	Describe energy value chains and consumption drivers across key sectors.	1,7
1.3	Identify diverse energy reduction methods and technologies.	1
1.4	Explain the business (financial/economic) aspects of energy efficiency projects.	11
1.5	Summarize global EE policies, circular economy, emissions, and carbon trading.	6,7
2	**Skills**	
2.1	Study energy auditing process.	1,2,4,6
2.2	Apply methodologies to quantify energy parameters and efficiency improvements.	1,2,4,6
2.3	Perform basic financial calculations for EE project viability.	11
3	**Competence**	

3.1	Study energy auditing process.	7
3.2	Formulate a structured approach for preliminary energy assessments.	3,4, 9
3.3	Engage in self-directed learning for EE advancements and trends.	12

C. COURSE DESCRIPTION

1. Catalog Course Description (General description in the form used in Bulletin):

Explores the Fundamental principles, applications, future trends of energy efficiency. Terminology, energy value chains, measurement techniques. Buildings, industrial, transportation energy. Energy economics, generation/transmission/distribution efficiency. Process overview, bill analysis, economic/life cycle costing. Electric systems, lighting, motors, building envelopes, HVAC, boilers, compressed air, renewables, wastewater. Facility energy management, human behavior. Demand-side management (DSM), policies, international practices, smart grids, circular economy, carbon markets.

List of Topics	No. of Weeks	Contact hours
1. **Introduction to Energy Efficiency** - Importance & Global Context - Benefits (Environmental, Economic, Security)	1	2.5
2. **Energy Fundamentals & Terminology** - Energy vs. Power - Units of Energy & Power (J, Wh, BTU, kWh, kW, HP) - Efficiency Definitions & Calculations	1	2.5
3. **Energy Value Chains & Consumption Drivers** - Part 1 - Overview of Primary Energy Sources, Electricity Generation & Distribution, Major Energy Consumers & End-Uses, Energy Demand in Buildings (HVAC, Lighting, Appliances), Energy Demand in Industry (Motors, Boilers, Process Heat), Energy Demand in Transportation (Vehicles, Fuels), Energy Audits: Introduction and Methodologies	3	7.5
4. **Energy Efficiency in Buildings** - Building Envelope (Insulation, Windows) - HVAC Systems Optimization, Lighting Technologies & Controls, Smart Building Systems & Appliances.	2	5
5. **Energy Efficiency in Industry** - Motors & Variable Speed Drives, Compressed Air Systems, Pump and Fan Systems, Boilers & Steam Systems, Process Heat & Heat Recovery, Industrial Symbiosis	2	5
6. **Energy Efficiency in Transportation** - Vehicle Technologies (Hybrid, EV), Fuel Efficiency Strategies, Logistics & Behavioral Aspects	1	2.5

7. **Measuring Energy Consumption** - Introduction to Energy Measurement Equipment (Power Meters, Thermal Imagers), Data Logging and Analysis, Practical Applications in Buildings and Industry, Hands-on or Case Studies with Measurement Data	2	5
8. **Business Aspects of Energy Efficiency** - Financial Metrics (ROI, Payback Period, NPV), Economic Incentives & Financing Models, Cost-Benefit Analysis of EE Projects, Case Studies on Financial Viability	2	5
9. **Global Energy Efficiency Frameworks** - International Policies & Standards, Circular Economy Principles & Application to EE, Emissions Reporting & Carbon Footprinting	1	2.5
10. **Carbon Trading & Future Trends** - Carbon Markets (ETS, Offsets), Emerging Technologies & Future of Energy Efficiency	1	2.5

D. TEACHING AND ASSESSMENT

1. Course-level student **L**earning **O**utcomes **(CLO)** and Alignment with Teaching Strategies and Assessment Methods

Code#	CLO	Course Teaching Strategies	Course Assessment Methods
1	**Knowledge**		
1.1	Understand energy fundamentals: concepts, units, and interrelationships.	Lecture	Test Question
1.2	Describe energy value chains and consumption drivers across key sectors.	Lecture	Test Question Assignment
1.3	Identify diverse energy reduction methods	Lecture	Test Question Assignment
1.4	Explain the business (financial/economic) aspects of energy efficiency projects.	Lecture	Test Question Assignment
1.5	Summarize global EE policies, circular economy, emissions, and carbon trading	Lecture	Test Question Assignment
2	**Skills**		
2.1	Study energy auditing process.	Lecture Web search	Test Question Assignment
2.2	Apply methodologies to quantify energy parameters and efficiency improvements.	Lecture	Test Question Assignment Project

2.3	Perform basic financial calculations for EE project viability.	Lecture	Test Question Assignment Project
3	**Competence**		
3.1	Study energy auditing process.	Lecture	Assignments Project
3.2	Formulate a structured approach for preliminary energy assessments.	Term Project	Report and presentation
3.3	Engage in self-directed learning for EE advancements and trends	Web Search, Field Trips	Field visits

2. Schedule of Assessment Tasks for Students During the Semester

	Assessment task (e.g. essay, test, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment Score
1	Classwork (Assignments, attendance and Quizzes)	Biweekly	25%
2	Midterm exam	Week 8	20%
3	Term Project	Week 15	20%
4	Final Exam	Week 16	35%

E. OFFICE HOURS

1. The amount of time teaching staff are expected to be available each week

3 hours per week

F. LEARNING RESOURCES

1. List Required Textbooks

No text book

2. List Essential References Materials (Journals, Reports, etc.)

3. List Recommended Textbooks and Reference Material (Journals, Reports, etc)

"Energy Efficiency and Management for Engineers" by Mehmet Kanoğlu and Yunus A. Çengel

"Handbook of Energy Engineering" by D. Paul Mehta and Albert Thumann

“Energy Management Handbook”, 9th Edition, by Steve Doty, Wayne C. Turner, Stephan A. Roosa

4. List Electronic Materials, Web Sites, Facebook, Twitter, etc.

Blackboard System
5. Other learning material such as computer-based programs/CD, professional standards or regulations and software.

G. COURSE EVALUATION

1. Strategies for Obtaining Student Feedback on Effectiveness of Teaching (e.g. face to face meetings, student in class evaluation, student survey, focus groups, etc.) Students evaluation system

H. Other NCAAA Program Accreditation Requirements (OPTIONAL)

1. Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice, in addition to the instructor office hours. Arrangements can be done by an appointment
2. Facilities Required (Accommodation, e.g. classrooms and laboratories; Technology Resources, e.g. data show and smart board; other resources, e.g. laboratory equipment, etc.) Modern Smart and Intelligent class rooms.
3. Other Course Evaluation Methods (e.g. by faculty, program leaders, peer reviewer, others) N/A

Appendix D

Energy Efficiency Village (EEV) Funding Proposal

ENERGY EFFICIENCY VILLAGE

Education · Innovation · Policy

A National Living Laboratory for Energy Efficiency

Funding Proposal submitted to the Board of Directors of CEEE

Version 3.0 | 2026 | Confidential

1. Executive Summary

The Energy Efficiency Village (EEV) is a proposed national living laboratory, hosted at KFUPM. It is built on three integrated pillars — Education, Innovation, and Policy — each directly addressing a gap that currently limits Saudi Arabia's energy efficiency transition.

Pillar	Strategic Purpose	How EEV Delivers
EDUCATION	Build national human capital	Structured programs for students, engineers & policymakers; certification pathways; public awareness
INNOVATION	Accelerate technology readiness	Pre-commercial testing, R&D partnerships, IP development, startup support, industry co-investment
POLICY	Enable evidence-based regulation	SBC 601 testbed, M&V data for SEEC, regulatory sandbox, national standards input

The building sector accounts for approximately 80% of the Kingdom's electricity consumption, driven by cooling demand. The greenhouse sector, critical to food security, carries substantial energy and water intensity. Neither sector has a dedicated national facility for rigorous, climate-specific technology testing, workforce development, or evidence-based code development. The EEV fills all three gaps in a single integrated platform.

~80%	3	3	First
of KSA electricity consumed by buildings	Integrated test environments	Pillars: Education · Innovation · Policy	of its kind nationally

2. Problem Statement

- No national test platform: Technology developers, contractors, and policymakers lack a local, climate-specific facility to validate solutions before deployment or codification.
- Classroom training without experiential learning: Existing energy efficiency programs in the Kingdom are almost entirely classroom-based. Engineers, auditors, and facility managers can learn the theory, but have nowhere to apply it to real systems, in real buildings, under Saudi climate conditions. The gap is not awareness — it is the absence of hands-on, evidence-based practice that converts knowledge into professional competence.
- Weak research-to-regulation feedback: SBC 601 and related codes lack a controlled empirical testbed under real Saudi Conditions. The absence of fully localized frameworks comparable to ASHRAE energy standards slows evidence-based policy and increases compliance risk.

These gaps compound each other. The EEV resolves all three simultaneously.

3. Project Concept

The EEV comprises three integrated test environments on a 16,900 m² site (~4,000 m² developed), supported by a unified site energy infrastructure. Each environment maps directly to one or more strategic pillars.

3.1 Intelligent Energy Building (IEB) [Education · Innovation]

The IEB is the EEV's flagship structure — a fully operational, next-generation building where every system is smart, interconnected, and grid-interactive. It goes far beyond a conventional showcase: the IEB is a live, self-optimizing energy system that demonstrates what the future of buildings looks like in Saudi Arabia.

At its core is an AI-driven building management platform that integrates PV generation, battery storage, HVAC, lighting, plug loads, and EV charging into a unified intelligent system. This system communicates bidirectionally with the utility grid — shifting loads, exporting surplus energy, and responding to grid pricing signals in real time. A live digital twin runs continuously alongside the physical building, enabling predictive analytics, fault detection, and scenario simulation for research and teaching.

Smart System	Description	- Impact
AI-Driven Building Brain	Central AI platform integrating all building systems; learns occupancy patterns, ambient conditions, and grid signals to self-optimize	Autonomous demand management, reducing energy consumption
Grid-Interactive Operation	Two-way communication with the utility grid; dynamically shifts loads, exports surplus PV, and responds to grid pricing or frequency signals	Demand response & grid stabilization
Multi-Source Energy Orchestration	Real-time coordination of PV generation, battery storage, EV charging, and HVAC loads under a unified energy management system	Zero-peak-demand operation
Digital Twin	Live virtual replica of the building updated continuously from sensor data; used for predictive analytics, fault detection, and scenario simulation	Research & operational intelligence
Adaptive Façade & Envelope	Electrochromic glazing, dynamic shading, and smart insulation panels that respond automatically to solar angle, temperature, and occupancy	Passive load reduction
Indoor Environment Optimization	AI-controlled HVAC, lighting, and ventilation that maintain comfort while minimizing energy — adjusting zone-by-zone in real time	Comfort with lower energy use

Visitor Interaction Layer	Real-time dashboards, mobile app, and immersive displays showing live energy flows, savings, and system logic to any visitor or student	Education & public engagement

For visitors, students, and policymakers, the IEB makes energy performance visible: real-time dashboards and interactive interfaces present live energy flows, system decisions, and cumulative savings in an accessible, engaging format. This is not passive observation — visitors understand how intelligent buildings operate in practice.

> **The IEB is simultaneously a research platform, an educational showcase, and a living proof-of-concept for grid-interactive smart buildings under Saudi Arabia's hot-arid climate — the first of its kind in the Kingdom.**

3.2 Demonstration Building — Four-Bay Experimental Sandbox [Innovation · Policy]

A modular building divided into four independently instrumented bays, each dedicated to a specific building subsystem. Technologies, materials, and configurations can be installed, compared, and swapped within each bay under identical outdoor conditions — enabling rigorous, side-by-side performance comparison that no simulation or laboratory test can replicate.

Bay	What Is Tested	Measurements & Outputs	Research / Policy Question Addressed
BAY A: Envelope & Insulation	Replaceable wall panels with different insulation materials (mineral wool, aerogel, VIP, PCM composites); variable U-value measurement	Real-world thermal performance comparison under Saudi climate; input to SBC 601 envelope requirements	Which insulation materials deliver the best ROI under extreme heat? What U-values should the code mandate?
BAY B: Fenestration & Glazing	Interchangeable window systems: single, double, triple-glazed, low-E, electrochromic, BIPV; framing type variation	Solar heat gain coefficient (SHGC) and U-value validation; daylighting vs. cooling load trade-off analysis	What glazing specifications should SBC 601 require for east/west/south facades in hot-arid climates?
BAY C: HVAC Systems	Four side-by-side HVAC setups: conventional split system, variable refrigerant flow (VRF), district cooling connection, radiant cooling + DOAS	Energy intensity benchmarking of HVAC technologies; humidity and comfort performance under Saudi summer conditions	Which HVAC system types deliver optimal efficiency and comfort for Saudi building typologies?
BAY D: Reference	A conventionally constructed roof	Continuous baseline measurement of heat flux,	How much energy does the current SBC 601 roof

Roof (SBC 601 Baseline)	assembly built strictly to current SBC 601 specifications, using standard materials and configurations representative of typical Saudi construction practice, serves as the control condition for all roof-related experiments	roof surface temperature, and cooling energy under current code compliance; all Bay A–C innovations are benchmarked against this control	practice actually consume? What is the quantified improvement delivered by each innovation tested in the other bays relative to today's code baseline?

Each bay is equipped with a dense sensor network measuring thermal flux, surface temperatures, energy consumption, humidity, and indoor comfort parameters. Data is logged continuously and made available for research analysis and policy reporting. The four-bay format means multiple technologies can be evaluated simultaneously, dramatically increasing throughput compared to sequential testing.

> **The four-bay building is the EEV's primary policy engine: Bay D provides a permanent, measured SBC 601 baseline, while Bays A–C test proposed improvements against it under identical conditions. Any proposed code revision arrives with a quantified performance delta — not a simulation, a real building result.**

3.3 Greenhouse Facility — Energy–Water–Food Nexus Lab [Innovation · Education]

A 100 m² research-grade, semi-closed controlled environment greenhouse with four independently controlled compartments and reconfigurable partitions. Each compartment enables targeted testing of key systems within the energy–water–food nexus, including HVAC and climate control strategies, irrigation and water efficiency, crop production optimization, and renewable energy integration. Together, these components make the facility a self-contained platform for advanced research and innovation.

The facility serves as both an innovation hub and a hands-on training environment, enabling applied research in energy-efficient agriculture while equipping students and professionals with practical skills in advanced controlled environment systems. This directly supports Vision 2030 priorities in food security, local capacity building, and reducing the energy intensity of domestic food production.

Compartment	What Is Tested	Measurements & Outputs	Research / Policy Question Addressed
Compartment A – Climate Control & HVAC Strategies	Performance of fully mechanical HVAC systems (chiller-based cooling, dehumidification, closed vs semi-closed operation, airflow strategies such as	Temperature, humidity, airflow distribution, cooling load, energy consumption, and dehumidification efficiency	What HVAC strategies deliver optimal cooling and humidity for controlled agriculture in hot-arid climates without evaporative cooling?

	ducted, under-bench, displacement)		
Compartment B – Irrigation & Water Efficiency	Advanced fertigation, irrigation strategies (multi-loop systems), water treatment (RO, UV), and water reuse systems	Water consumption, nutrient delivery (EC/pH), drainage recovery, and irrigation efficiency	How can water use be minimized while maintaining crop productivity in controlled environment agriculture in arid regions?
Compartment C – Crop Production & Growth Optimization	Hydroponic and soil-based cultivation, CO_2 enrichment, LED lighting strategies, and crop response under controlled conditions	Crop yield, growth rate, energy input per yield, CO_2 levels, light intensity.	What are the most energy-efficient crop production strategies for sustainable food production in controlled environments?
Compartment D – Energy Systems & Integration	Integration of PV, BESS, and energy management systems with greenhouse operation	Energy generation (PV), storage performance, load profiles, system efficiency, peak demand	How can renewable energy and storage be optimally integrated to reduce energy demand and improve resilience of controlled agriculture systems?

3.4 Site Energy Infrastructure

The EEV's three buildings are unified by a shared intelligent energy infrastructure that spans the full 16,900 m² site. This is not a support facility — it is the platform's energy backbone and a demonstration asset in its own right.

Infrastructure Element	Description	Impact
Rooftop & Canopy Solar PV	PV arrays on building rooftops and parking/walkway canopies; sized to serve the full EEV site load with surplus for grid export	On-site renewable generation reduces operational cost and serves as a live PV performance testbed
Battery Energy Storage System (BESS)	Centralized battery storage connected to the site microgrid; enables peak shaving, overnight supply, and grid-interactive discharge	Energy resilience; supports IEB grid-interactive experiments and demonstration
Site Microgrid & Switchgear	Intelligent low-voltage distribution network connecting all buildings, PV, and BESS; capable of islanded or grid-connected operation	Platform for microgrid control research and demand response demonstrations

EV Charging Infrastructure	Smart EV charging points across the site; load-managed by the site energy controller to avoid grid peaks	Vehicle-to-grid (V2G) research capability; real-world EV integration demonstration
Utility Connections & Metering	Dedicated grid connection with sub-metering at each building and system, enabling precise energy accounting across the full site	M&V data infrastructure for research, policy reporting, and operational management

The site microgrid is designed to operate in both grid-connected and islanded modes, enabling research into energy resilience and demand response strategies relevant to Saudi Arabia's national grid modernization agenda.

4. Education & Capacity Building

Education is a primary function of the EEV, not a secondary benefit. Saudi Arabia already has classroom-based energy efficiency training through universities, SEEC programs, and professional courses. What does not exist is experiential learning: the opportunity to work on live systems, compare real technologies side by side, and observe building performance under actual Saudi climate conditions. The EEV fills this gap. The IEB, the four-bay Demonstration Building, and the Greenhouse are not just research platforms — they are teaching environments where knowledge is translated into practical competence.

Program	Description	Target Audience
University Curriculum Integration	KFUPM undergraduate & graduate courses using EEV as a live laboratory for hands-on learning and research	Students, graduate researchers
Professional Certification Programs	Training programs in energy auditing, BMS, HVAC, and building codes — aligned with SEEC requirements	Engineers, energy managers, ESCOs
Government & Policymaker Workshops	Data-driven workshops translating real performance results into regulatory and policy insights	SEEC, MoE, municipalities
Industry Immersion Programs	Practical and hands-on technology evaluation sessions for developers and contractors	Developers, contractors, suppliers
Public Awareness Tours	Interactive tours and guided visits for schools, media, and the public, showcasing energy performance through the IEB's real-time interactive systems	General public, K–12 students

Target: 500 training hours and 100 trained professionals annually

All professional programs will be developed in coordination with SEEC to ensure alignment with national certification frameworks. The EEV will be formally integrated into KFUPM curricula and established as a national hub for education and training in building energy efficiency.

5. Innovation Pathway

The EEV moves technologies from concept to market through a structured five-stage pathway. It is not a passive showcase — it is an active platform where industry partners, researchers, and startups co-develop and validate solutions under real Saudi conditions.

Stage	Activity	Output
Technology Intake	Companies submit technologies for structured evaluation against Saudi climate benchmarks	Technology readiness and feasibility assessment
Controlled Testing	Side-by-side performance comparison in the four-bay Demonstration Building	Validated, comparable performance data
R&D Co-development	Joint projects with Saudi Arabia researchers.	Publications, IP, prototypes
Pre-Commercial Validation	Independent third-party performance certification under Saudi conditions	Certified, Market-ready technologies
Market Deployment Support	Referral to ESCOs, developers, and government procurement programs	Commercialization pathway

Industry partners co-invest in validation programs in exchange for validated performance data and independent certification — reducing their market entry risk while generating revenue to support EEV operations.

> **The four-bay Demonstration Building enables 4+ technologies to be evaluated annually at full scale under actual Saudi climate conditions at the same time — a capability no other facility in the region offers.**

6. Policy Interface

The EEV's relationship with policy is explicit, structured, and time-bound — not aspirational. Every major research output is designed to feed a specific regulatory or standards process.

Mechanism	Description	Output
SBC 601 Testbed	Proposed building energy code provisions tested in the four-bay building before national enforcement	Evidence-based code validation packages for SEEC / MoE
M&V Data Pipeline	Continuous performance data shared with SEEC and MoE on agreed cadence	Quarterly data reports
Regulatory Sandbox	New technologies trialled under controlled exemptions prior to codification	Pre-approval recommendations
Standards Input	Formal technical submissions to SASO on materials, systems, and performance thresholds	Draft standards and technical guidelines

Policy Briefs	2–4 page summaries translating technical findings for decision-makers	Annual policy brief series

The SBC 601 Testbed is the EEV's most distinctive policy contribution. Currently, building energy code provisions are revised without a controlled empirical validation platform. The four-bay Demonstration Buildings address this gap by enabling proposed code clauses that can be physically implemented, monitored over a defined period, and evaluated before national adoption. This reduces compliance failures, lowers implementation costs, and increases industry confidence.

> **The EEV will deliver regular data outputs and technical inputs aligned with national policy cycles, including annual code recommendations and quarterly performance reports.**

7. International Benchmarking

The EEV was benchmarked against five leading global facilities across four capability dimensions: Education, Innovation, Policy interface, and hot-arid climate specificity. The comparison below shows both where global leaders excel and where the EEV fills gaps none of them address.

Facility	Education	Innovation	Policy	Hot-Arid Climate	Key Differentiator / Gap
KIT – Living Lab Energy Campus (Germany)	✓	✓	Partial	—	Strong on system integration and smart grids; limited education programs; no hot-climate adaptation; no greenhouse or food nexus
NREL RSF & ESIF (USA)	Partial	✓	—	—	World-class innovation platform; not designed for public/professional education; policy link is indirect; cold/temperate climate
Fraunhofer ISE (Germany)	—	✓	Partial	—	Strongest on modular innovation testing (direct parallel to Bay system); limited education access; policy role is advisory only

Wageningen Greenhouses (Netherlands)	Partial	✓	—	—	Global leader in controlled agriculture research; no building energy focus; no policy interface; temperate climate
Masdar City (UAE)	✓	Partial	Partial	✓	Most climatically relevant benchmark; city-scale, not testbed-scale; limited modular experimentation; stronger on showcase than validation
EEV — This Proposal	✓	✓	✓	✓	**Only facility combining all four capabilities in a hot-arid climate; modular bay system unique regionally; explicit SBC 601 policy interface**

The benchmarking reveals a consistent global pattern: existing facilities excel in one or two dimensions but not all four. KIT and NREL lead on innovation but have limited policy interfaces and no hot-climate adaptation. Fraunhofer ISE's modular testing approach is the closest parallel to the four-bay concept, but it is a closed research facility without public education or direct policy engagement. Masdar City is the most climatically relevant precedent but operates at urban scale — it is a demonstration city, not an experimental testbed where individual technologies can be isolated, tested, and validated under consistent conditions.

> **The EEV is the only facility — globally or regionally — that combines all four capabilities within a hot-arid climate context. This is not an incremental improvement on existing models, but a new class of infrastructure that does not currently exist in Saudi Arabia or the wider Gulf region.**

8. Governance & Institutional Structure

KFUPM–CEEE leads and operates the EEV, ensuring academic independence and long-term continuity. A multi-stakeholder board provides strategic oversight and ensures all three pillars remain aligned with national priorities.

Role	Entity	Contribution
Lead Institution	KFUPM – CEEE	Host, academic oversight, research direction, day-to-day operations
Board Oversight	SEEC, KACST, Ministry of Energy	Strategic guidance, policy alignment, annual performance review
Technical Partners	Industry & Technology Providers	Technology supply, co-funding, testing agreements
Research Partners	National & International Universities	Joint R&D, student programs, publications
End Users	Government, ESCOs, Consultants	Technology evaluation, training, standards input

Annual performance reviews against agreed KPIs will be reported to the board. An independent advisory panel of international experts will conduct a biennial scientific review of research quality and innovation outputs.

9. Implementation Plan

The EEV will be delivered over 48 months across four phases.

Phase	Activity	Timeline	Budget
Phase 1	Stakeholder workshops, Concept Approval & Detailed Engineering Design	Months 1–12	SAR 450,000
Phase 2	Site Preparation & Construction	Months 13–24	SAR 3,750,000
Phase 3	System Integration, Commissioning & Testing	Months 25–36	SAR 1,350,000
Phase 4	Operations Launch — Education, Research & Policy Programs	Months 37–48	SAR 450,000

Total project budget: SAR 6,000,000. A detailed budget breakdown will be developed during Phase 1 (Detailed Engineering Design) and presented for approval at the next Board of Directors meeting.

10. Success Metrics

KPIs are organized by pillar and reported annually to the board. Year 1 targets reflect the initial operational period; Year 3 targets reflect full ramp-up.

Pillar	KPI	Annual Target
Education	Training & certification hours delivered	500 hrs
Education	Researchers & professionals trained	100
Education	University courses using EEV as a live lab	2
Innovation	Technologies validated & benchmarked	4
Innovation	Industry co-investment agreements	1
Innovation	Publications & technical reports	2
Policy	Technical inputs to SBC 601	1 report
Policy	M&V data reports delivered to SEEC/MoE	1
Policy	Policy briefs issued	1

11. Strategic Alignment

- Aligned with UN Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 4 (Quality Education), SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action)
- National economic diversification, local capacity building, and sustainable infrastructure development.
- Directly enables SEEC's mandate to reduce national energy intensity in the building and agriculture sectors.
- Provides the Kingdom's first empirical testbed for building energy code validation before enforcement.
- Accelerates validated low-carbon technology adoption in buildings and controlled environment agriculture.
- Advances energy-efficient, water-smart controlled environment agriculture relevant to domestic production targets.
- Provides a national platform for applied research, IP development, and technology commercialization.
- The IEB and site microgrid serve as testbeds for demand response, grid-interactive buildings, and smart energy management relevant to Saudi Arabia's national grid transformation.

12. Conclusion & Board Decisions Required

The Energy Efficiency Village is not a conventional building project. It is a national capability — the infrastructure Saudi Arabia needs to build a trained workforce, validate technologies at scale, and develop energy regulations on a sound empirical basis.

Its integrated three pillars are mutually reinforcing: trained professionals validate technologies; validated technologies inform policy; better policy drives demand for trained professionals. The Intelligent Energy Building demonstrates next-generation smart building performance. The four-bay Demonstration Building proves which technologies and codes actually work. The Greenhouse closes the energy–water–food loop. The site infrastructure ties it all together as a functioning energy ecosystem.

As a university-led, board-governed initiative with active participation from SEEC, KACST, and the Ministry of Energy, the EEV is positioned to deliver measurable national impact within 48 months and sustain long-term value aligned with Saudi Arabia's energy efficiency and sustainability objectives..

Board Decisions Required

#	Decision	Approve	Reject	Approve with Comments
1	Approve proceeding with the Energy Efficiency Village project	☐	☐	☐
Comments: _____				
2	Allocate up to SAR 6,000,000 as the project budget ceiling	☐	☐	☐
Comments: _____				
3	Authorize commencement of Phase 1 (Detailed Engineering Design), with the confirmed budget to be submitted for final approval at the next Board of Directors meeting	☐	☐	☐
Comments: _____				