



King Fahd University of Petroleum and Minerals
Dhahran- Saudi Arabia

Graduate Program
FOR

Master of Science (MS.)

IN
Architectural Engineering
FOCUSING ON
[Theme]

Sustainable Energy and Indoor Environment
(ARE-SEIE)



September 15, 2022



1. LIST OF COURSES

6.A Program Structure

The revised graduate program of the Architectural Engineering department (**ARE**) is designed to prepare highly qualified professionals and researchers in the field of **ARE** with a specialized and in-depth knowledge and study related to the theme of *Sustainable Energy* (**SE**) and *Indoor Environment* (**IE**) (**ARE-SEIE**).

The M.Sc. Program:

The M.Sc. Program requires 30 credit hours (CRs)		
Course Type	CRs	
Core Courses (CO)	12	4 Courses
Elective Courses (As Follows:)	12	
ARE Elective Courses From the chosen <i>Focus Area</i> (SE or IE)	6	2 Courses
ARE Elective Courses From the Supporting Elective Courses (SU)	3	1 Course
Free Electives Courses Approved KFUPM Graduate Courses (FE)	3	1 Course
M.Sc. Thesis work	6	ARE 610
The M.Sc. Program	30	



Important Notes:

- A. The **M.Sc.** have Zero-credit hour of Research Seminar (**ARE 599**).
- B. The Free Elective Courses (**FE**), **5xx** courses cannot be replaced by ARE Electives (i.e., FA-I, FA-II, or SU Courses) to allow wider exposure of the “ARE” program’s graduates and to expand their study breadth via other graduate courses offered by other disciplines, few are proposed but others “**OPEN**” Free Elective Courses (**FE**) can be flexibly chosen upon the consultation with the *Program Graduate Coordinator* during the preparation, finalization, and submission of the Graduate Student’s Degree Plan.

6.B Core Courses, Specific ARE Electives and General Electives

The program requires three core courses covering the basic competences related to Building Science, Building Indoor Environment, and principle of green buildings and sustainable design. A list of all courses (course title and number only) classified as core and elective courses is given in **Tables 1**. The elective courses are also classified under three major areas of *Sustainable Energy (SE)*, *Indoor Environment (IE)*, Supporting Elective Courses (**SU**), and Required Master Thesis and/or Research Project courses as well as Free Elective (**FE**) Courses offered by other departments at KFUPM.

Table 1: A list of all courses classified as Core and Elective Courses and their Sub-Categories

LIST of ARE CORE Courses			Pre-requisites
	Course No.	Core Courses	
CO-1	ARE 528	Principles of Sustainable Buildings and Design	Graduate Standing
CO-2	ARE 529	Building Indoor Environment	Graduate Standing
CO-3	ARE 530	Building Science	Graduate Standing
CO-4	ARE 531	Informatics for Buildings	Graduate Standing
RE			Required Courses (RE)
RE-1	ARE 599	Research Seminar in Arch. Engineering	Graduate Standing (Equivalent to CEM 599)
RE-2	ARE 600	Research Project	Graduate Standing and ARE 599
RE-4	ARE 610	M.Sc. Thesis	Graduate Standing and ARE 599



Table 1: A list of all courses classified as Core and Elective Courses and their Sub-Categories

List of ARE Specific Elective Courses			Pre-requisites
Course No.	Elective Courses		
SE			Pre-requisites
SE-1	ARE 533	Building Energy Efficiency & Management	ARE 530 or Equivalent or Consent of Instructor
SE-2	ARE 535	HVAC Systems Design	ARE 529 or Equivalent or Consent of Instructor
SE-3	ARE 537	Advanced Building Envelopes	ARE 530 or Equivalent or Consent of Instructor
SE-4	ARE 539	Renewable Energy Systems for Buildings	Graduate Standing
SE-5	ARE 541	Design and Application of Solar Systems	ARE 530 or Equivalent or Consent of Instructor
SE-6	ARE 545	Zero Carbon Energy Transition	Graduate Standing
FE			Pre-requisites
FE-1	ME 539	Solar Energy Utilization	Graduate Standing (Not to be taken with ARE 533)
FE-2	ME 524	Energy Management	Graduate Standing (Not to be taken with ARE 541)
FE-3	ECON 525	Energy Economics	Graduate Standing
IE			Pre-requisites
IE-1	ARE 538	Ventilation and Indoor Air Quality	Graduate Standing
IE-2	ARE 540	Health, Wellbeing and Comfort	Graduate Standing
IE-3	ARE 543	Advanced Lighting Systems	ARE 529 or Consent of Instructor
IE-4	ARE 544	Daylighting Analysis and Design	ARE 529 or Consent of Instructor
IE-5	ARE 546	Acoustics and Noise Control in Buildings	ARE 529 or Consent of Instructor
IE-6	ARE 552	Intelligent Safety and Security Systems	Graduate Standing – [MX-FM]
FE			Pre-requisites
FE-4	ME 564	Acoustics and Noise Control	Graduate Standing (Not to be taken with ARE 546)
SU			Pre-requisites
SU-0	ARE 500	Sustainable Building Materials	Graduate Standing (Equivalent to ARC 511)
SU-1	ARE 501	Building Services	Graduate Standing
SU-2	ARE 502	Selection of Building Systems	Graduate Standing
SU-3	ARE 503	Environmental & Econ. Analysis of Buildings	Graduate Standing
SU-4	ARE 504	Deep Renovation of Buildings	Graduate Standing
SU-5	ARE 505	Intelligent Buildings' Technologies (IBTs)	Graduate Standing
SU-6	ARE 506	Passive Building Design	Graduate Standing
SU-7	ARE 507	Integrated Building Design	Graduate Standing
SU-8	ARE 549	Sustainable Built Environment	Graduate Standing – [MX-SRE]
SU-9	ARE 551	Building Performance Assessment	Graduate Standing – [MX-FM]
SU-10	ARE 554	Automated Bldg. Operation and Maintenance	Graduate Standing – [MX-FM]
SU-11	ARE 590	Advanced Topics in Architectural Engineering	Graduate Standing
SU-12	ARE 606	Independent Research	Graduate Standing and ARE 599
FE			Pre-requisites
FE-5	CRP 514	Geographic Information Systems	Graduate Standing
FE-6	Other(s)	Graduate Courses "OPEN"	Consultation with the program Graduate Coordinator



2. DEGREE PLAN

7.A Master of Science (M.Sc.): Course Requirements

Table 2. The course requirements of the (M.Sc.) Program

Course #	Title	LT	LB	CR
ARE 528	Principles of Sustainable Buildings & Design (CO-1)	3	0	3
ARE 530	Building Science (CO-2)	3	0	3
ARE 529	Building Indoor Environment (CO-3)	3	0	3
ARE 531	Informatics for Buildings (CO-4)	3	0	3
ARE 5xx	ARE Elective-1 (SE/IE)	3	0	3
ARE 5xx	ARE Elective-2 (SE/IE)	3	0	3
ARE 5xx	ARE Elective-3 (SU)	3	0	3
XXX 5xx	Free Elective (FE)	3	0	3
ARE 599	Research Seminar	1	0	0
ARE 610	M.Sc. Thesis	0	0	6
		25	0	30
Elective Courses (12 CRs)				
1. Six (6) credit hours: ARE Elective Courses, must be in the chosen Focus Area (SE or IE)				
2. Three (3) credit hours: Supporting Elective Course (SU)				
3. Three (3) credit hours: Free KFUPM Elective Course (FE) [OPEN Choice]				



3. Six (6) credit hours: Free KFUPM Elective Course (**FE**) [**OPEN Choice**]

Important Notes:

- A. The M.Sc have Zero-credit hour of Research Seminar (**ARE 599**).
- B. The Free Elective Courses (**FE**), **5xx** courses cannot be replaced by ARE Electives (i.e., FA-I, FA-II, or SU Courses) to allow wider exposure of the “ARE” program’s graduates and to expand their study breadth via other graduate courses offered by other disciplines, few are proposed but others “**OPEN**” Free Elective Courses (**FE**) can be flexibly chosen upon the consultation with the *Program Graduate Coordinator* during the preparation, finalization, and submission of the Graduate Student’s Degree Plan.

7.C Master of Science (M.Sc.) Degree Plan (**Semester Wise**)

Table 3. MASTER OF SCIENCE (M.Sc.) PROGRAM (Semester Wise**)**

Course #	Title	LT	LB	CR	CUM. TOTAL
First Semester					
ARE 528	Core Course (CO-1)	3	0	3	
ARE 530	Core Course (CO-2)	3	0	3	
ARE 5xx	ARE Elective-1 (SE/IE)	3	0	3	
		9	0	9	9
Second Semester					
ARE 529	Core Course (CO-3)	3	0	3	
ARE 531	Core Course (CO-4)	3	0	3	
ARE 5xx	ARE Elective-2 (SE/IE)	3	0	3	
		9	0	9	18
Third Semester					
ARE 5xx	ARE Elective-3 (SU)	3	0	3	
XXX 5xx	Free Elective (FE)	3	0	3	
ARE 599	Research Seminar	1	0	0	
		7	0	6	24
Fourth Semester					
ARE 610	M.Sc. Thesis	0	0	6	
		0	0	6	30
					30

**3. COURSE DESCRIPTION****3.A Core Course**

1. Course Information	
Course Number:	ARE 528
Course Title:	Principles of Sustainable Buildings and Design
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Core Course (CO-1)
4. Course Description	Green and sustainable buildings; objectives; definitions; elements of green buildings, economics, social and environmental benefits. Principles of sustainable built environment; applicable strategies. Green building practices: energy efficiency, water efficiency, materials efficiency, Indoor environmental quality, waste reduction. Renewable energy, Green building materials, products, and selection criteria; World's leading green building organizations. Standards, assessment and rating systems. Case Studies.
5. Prerequisites	Graduate Standing
1. Course Information	
Course Number:	ARE 529
Course Title:	Building Indoor Environment
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Core Course (CO-2)
4. Course Description	Design of sustainable indoor environment. Total indoor environmental quality (TIEQ). Wellbeing, health and productivity of building occupants. Human physiological factors influencing indoor environmental quality (IEQ). Thermal, visual, and acoustical comfort. Ventilation and indoor air quality (IAQ). Requirements and design criteria. Environmental impact, standards and regulations. Assessment measurements and rating systems.
5. Prerequisites	Graduate Standing
1. Course Information	
Course Number:	ARE 530
Course Title:	Building Science
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Core Course (CO-2)
4. Course Description	Weather and climate interaction with buildings; thermal radiation in the environment; water in the environment and its interaction with buildings; heat transfer in building structures; solar radiation influences on buildings. Effect of wind on buildings; air leakage and ventilation. Energy loads under different climates, energy management and renewable energy in buildings.
5. Prerequisites	Graduate Standing
1. Course Information	



Course Number:	ARE 531	
Course Title:	Buildings' Informatics	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Core Course (CO-1)	
4. Course Description	Computer-aided information management in building design, construction, and operations, including developing and managing relational databases, querying databases using SQL, concepts and application of data mining techniques, and application of computers in the planning, organizing, and controlling during the building lifecycle.	
5. Prerequisites	Graduate Standing	

8.B Specific ARE Elective Courses (SE)

1. Course Information		
Course Number:	ARE 533	
Course Title:	Building Energy Efficiency and Management	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-1)	
4. Course Description	Energy use and trends. Heat flow in buildings, heating and cooling energy requirements, energy estimating methods. Building energy modeling and optimization. Building energy audits, analysis of alternative building energy-efficiency measures. Energy management. Energy codes and standards. Net zero energy buildings.	
5. Prerequisites	ARE 530 or Equivalent or Consent of Instructor	

1. Course Information		
Course Number:	ARE 535	
Course Title:	HVAC Systems Design	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-2)	
4. Course Description	Thermal comfort requirements, ventilation and air quality requirements, thermal load calculations. HVAC systems types, analysis, and selection. Air distribution design, duct design. Energy efficiency considerations. Computerized HVAC systems analysis and design.	
5. Prerequisites	ARE 529 or Equivalent or Consent of Instructor	

1. Course Information		
Course Number:	ARE 537	
Course Title:	Advanced Building Envelopes	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-3)	
4. Course Description	Concepts of advanced building envelopes. Envelope materials, mechanical, chemical and physical properties, and durability performance. Components of building envelopes, dynamic and	



	interactive facades. Environmental-response and adaptive facades. Glazing system types and technologies. Innovative technologies for building skins, architectural membranes, and phase change materials. Integrating photovoltaics and solar thermal technologies. Double skin and cavity facades. Kinetic skins, biomimicry and biomimetics. Envelope Intelligent sensing and control. High-tech lightweight building envelopes. Green walls and roofs.
5. Prerequisites	ARE 530 or Equivalent or Consent of Instructor

1.Course Information	
Course Number:	ARE 539
Course Title:	Renewable Energy Systems for Buildings
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-4)
4. Course Description	Renewable energy resources, classification of renewable resources, renewables resource assessment, renewable technologies for buildings, hydropower, solar energy technologies, wind power, geothermal energy, ground and air source heat pumps, wave and tidal power, application of renewable technologies in buildings, techno-economics of renewables in buildings, renewable support policy mechanisms, renewable system design principles, software tools.
5. Prerequisites	Graduate Standing

1.Course Information	
Course Number:	ARE 541
Course Title:	Design and Application of Solar Systems
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-5)
4. Course Description	Solar radiation, solar geometry, solar technologies, types of solar PV, classification of PV systems, design and application of PV systems, solar water heating, passive and active solar heating and cooling, energy storage for solar systems, economics of solar systems. Software/modelling tools
5. Prerequisites	ARE 530 or Equivalent or Consent of Instructor

1. Course Information	
Course Number:	ARE 545
Course Title:	Zero-Carbon Energy Transition
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SE-6)
4. Course Description	Energy resources, global warming and climate change, energy technologies and environmental emissions, carbon-neutral and zero-carbon energy transitions, key drivers of energy transition, dynamics of energy transition, decarbonization, distributed generation, digitalization, decreasing use of energy, renewable and low-carbon technologies, energy transition stakeholders, global energy transition trends and policies.



5. Prerequisites	Graduate Standing
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8.B Specific ARE Elective Courses (IE)

1. Course Information	
Course Number:	ARE 538
Course Title:	Ventilation and Indoor Air Quality
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-1)
4. Course Description	Indoor air quality factors, effects on building occupants' health, sick building syndrome, sources of pollutants indoors, standards, methods of measuring, sampling and analyzing contaminants, influence of infiltration and ventilation on air quality, modeling of indoor air quality, removal rate, dilution control, assessment of ventilation effectiveness, air exchange efficiency and air distribution, analysis of ventilation design decisions.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 540
Course Title:	Health, Wellbeing and Comfort
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-2)
4. Course Description	The concept of integrated building design for enhancing inhabitant comfort, wellbeing and health. Main factors affecting health, wellbeing, human performance and comfort in building design/operation. The cause, alleviation and possible cure of unhealthy buildings. The psychological and physiological responses to the built environment, mainly workplaces. Wellbeing "standards" and methods of evaluating wellbeing in relation to occupant performance and physiological responses.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 542
Course Title:	Advanced Lighting Systems
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-3)
4. Course Description	Energy-efficient lighting systems components and characteristics. Impact of lighting on human perception and interaction with space; human factors in lighting. Advanced analysis, design, and modeling of luminous environments; light measurement technologies, effective and efficient integration of daylighting and artificial lighting, relative visual performance, visual comfort probability; discomfort glare; and unified glare rating systems. Advanced modeling, simulation and analysis of light sources and conditions in spaces. Smart lighting and control systems.
5. Prerequisites	ARE 529 or Consent of Instructor



1. Course Information	
Course Number:	ARE 544
Course Title:	Daylight Analysis and Design
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-4)
4. Course Description	Introduction to daylighting, sources of daylight and availability, sky luminous conditions. Traditional performance and emerging metrics. Daylight transmission through openings. Advanced glazing systems, and shading devices. Solar geometry and design of sun-shading devices. Daylight design requirements and considerations. Daylighting advanced analysis. Design of openings in desert areas. Computer applications. Energy conservation and daylighting.
5. Prerequisites	ARE 529 or Consent of Instructor
1. Course Information	
Course Number:	ARE 546
Course Title:	Acoustics and Noise Control in Buildings
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-5)
4. Course Description	Sound propagation and quantification; people perception of sound and noise; indoor noise sources; noise criteria and rating systems. Control techniques of air-borne and structure-borne noise, acoustical comfort requirements; sound quality assessment. Noise and vibration of mechanical and electrical equipment. Analysis techniques for noise reduction of HVAC, plumbing, mechanical, and electrical systems. Vibration isolation and control strategies. Computer applications in acoustical measurements, modeling, simulation and analysis.
5. Prerequisites	ARE 529 or Consent of Instructor
1. Course Information	
Course Number:	ARE 552
Course Title:	Intelligent Safety and Security Systems
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (IE-6)
4. Course Description	Safety and security concepts in building design and operation. The role of the facilities manager. Risk assessment processes, emergency preparedness, response, and recovery. Intelligent security systems in buildings. Fire development, propagation, and severity in buildings. Smart fire detection, notification, and suppression systems. Smoke management techniques. Fire-resisting elements. Evacuation strategies. National and International Safety codes and standards. Challenges of fire safety for building sustainability. Innovative technologies. Potentials of IoT technologies for fire prevention in smart facilities. BIM tools and computer-predictive simulations for fire safety management. Case studies.
5. Prerequisites	Graduate Standing

**8.B Specific ARE Elective Courses (SU)**

1. Course Information	
Course Number:	ARE 500
Course Title:	Sustainable Building Materials
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-0)
4. Course Description	The concept of high performance green and sustainable buildings. Traditional and advanced building materials. Sustainable building materials characteristics and selection criteria. The three phases of the building material life cycle. Embodied energy and material performance recycled content, rapidly renewable materials, low VOC materials. Pollution prevention and waste reduction measures in materials manufacturing; natural materials, reduction of construction waste, non-toxic or less-toxic materials, reusability, recyclability, biodegradability. Reduction of the ecological footprint of construction operations.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 501
Course Title:	Building Services
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-1)
4. Course Description	Building services, functions, technological advances in building services for high-performance buildings including vertical transportation, fire detection and protection, water supply and conservation measures, rainwater harvesting, smart systems; greywater recycling; drainage and waste system. Heating and cooling, lighting, safety and security systems and data networking. Principles of selection, and operation of service systems in buildings. The implications of service design decisions on building operational performance.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 502
Course Title:	Selection of Building Systems
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-2)
4. Course Description	Building systems evaluation and selection approach. Decision-Making Process, Creativity Approach, Overall performance requirements, Assessment/rating systems, selection criteria and alternatives evaluation, Building Systems Development, Evaluation and selection of sustainable and environmentally responsible materials; Building Performance & Problems; Evaluation and selection case studies to include: Green Buildings, HVAC systems, smart and intelligent buildings, building



	envelope; Computer Application/Tools
5. Prerequisites	ARE 500 or consent of the instructor

1. Course Information	
Course Number:	ARE 503
Course Title:	Environmental and Economic Analysis of Buildings
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-3)
4. Course Description	Global warming and climate change, buildings and sustainable development, building life cycle, material selection and recycling, environmental impacts of building, life cycle assessment (LCA) and ecological footprint of buildings, international trends and best practices, economic features of buildings, life cycle costing of buildings, life cycle costing techniques, and computer applications.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 504
Course Title:	Deep Renovation of Buildings
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-4)
4. Course Description	Basics of deep renovation (DR) in buildings. Towards 2050 carbon neutrality. Formulation of DR objectives, strategy, data analysis and information evaluation. DR based on passive and active technologies, their potentials, and limitations. DR process, supporting decision and guidelines. Methodologies and tools to achieve a deep renovation project responding to the requirements of energy, comfort, costs, implementation time, and environmental impact. Integration of renewable energy technologies. Building performance calculation and data analysis: definition, procedure, data flow and results representation. Case studies.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 505
Course Title:	Intelligent Buildings' Technologies (IBTs)
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-5)
4. Course Description	Building's reaction and adaptation to its environments through interconnected building technologies. Intelligent Building Technologies (IBTs). Advanced analytics and cyber-physical systems. Advances in building technology, the application of the Internet of Things (IoT) and digital twins, big data analytics, artificial intelligence (AI) and machine learning (ML), occupancy management, and pandemic-era innovations. Practical aspects of intelligent building creation at different levels. Intelligent Building Management Systems (BMS), Building Automation System (BAS). Smart sensors, smart materials, intelligent building skins, smart renewable energy resources. Smart homes. Case studies.



5. Prerequisites	Graduate Standing
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1. Course Information	
Course Number:	ARE 506
Course Title:	Passive Building Design
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-6)
4. Course Description	Passive design approach to environmental design. Influence of the building form, envelope, and other parts of the building fabric in modifying the indoor climate. Use of ambient energy to achieve comfort without mechanical building services. Passive design principles and basic strategies for lighting, ventilation, acoustics, heating, and cooling of buildings. Passive design considerations in hot climates. Case studies.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 507
Course Title:	Integrated Building Design
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-7)
4. Course Description	Collaborative and integrated building design principles. Holistic approaches to building design. Creativity, communication, and coordination in multidisciplinary design teams. Design principles to integrate structural, mechanical, electrical/lighting, technological, and environmental systems requirements, iterative and integrated building design process. Use of digital tools and BIM strategies. Technical aspects and choice of materials at the design stage; codes, standards, and performance considerations in design. Case Studies.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 549
Course Title:	Sustainable Built Environment
2. Credit Hours:	2 Lecture/week (75 minutes) (L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-8)
4. Course Description	Energy use in buildings, energy efficient buildings, sustainable building design features, renewable energy including solar and wind, sustainable energy solutions for buildings, low-carbon technologies, renewables integration in buildings, renewable energy trends and policies, renewables modeling and life cycle assessment.
5. Prerequisites	Graduate Standing

1. Course Information	
Course Number:	ARE 551
Course Title:	Building Performance Assessment



2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-9)	
4. Course Description	Building performance and influencing factors, facilities manager's role in operating healthy and sustainable facilities. Post-Occupancy Evaluation (POE) use and benefits. Elements of building performance: technical, functional, and behavioral, POE levels of effort, phases, and steps. Data collection and analysis methods. Performance measurement protocols, metrics, and instrumentation. Advanced rating systems of high-performance buildings. Emerging technologies and computer applications. Case studies	
5. Prerequisites	Graduate Standing	

1. Course Information		
Course Number:	ARE 554	
Course Title:	Automated Bldg. Operation and Maintenance	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-10)	
4. Course Description	Intelligent buildings, design, operation, and maintenance. Building systems functions, components, operational requirements, and automation. Commissioning and diagnostic technologies for building systems and equipment. Sustainable control, operation, and maintenance of mechanical, lighting, and electrical systems in buildings. Operation and maintenance strategies and AI and IoT applications for intelligent buildings. Maintenance accessibility for building systems. Fault detection and automated diagnostics. BIM-based operation and planning of facilities maintenance. Case studies.	
5. Prerequisites	Graduate Standing	

1. Course Information		
Course Number:	ARE 590	
Course Title:	Advanced Topics in Architectural Engineering	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course (SU-11)	
4. Course Description	Advanced topics selected from the major areas of Architectural Engineering to provide the students with advanced applications and state-of-the-art developments in the design, and operation of high performance and sustainable buildings.	
5. Prerequisites	ARE 328 and Consent of Instructor	

1. Course Information		
Course Number:	ARE 606	
Course Title:	Independent Research	
2. Credit Hours:	2 Lecture/week (75 minutes)	(L=3, LAB=0, CR=3)
3. Designation	Elective Course	
4. Course Description	This course is intended to allow the student to conduct research in advanced problems in his M.Sc. research area. The course is offered on a student-to-faculty basis. For a student to register in this course with a specific faculty member, a clear <i>Research Plan</i> of the intended research work during the course is required to be approved by the	



	<i>Graduate/Research Committee</i> of the department and reported to the <i>Deanship of Graduate Studies</i> . The student is expected to deliver a public seminar to the <i>department Graduate/Research Committee</i> and a report on his research outcomes at the end of the course.
5. Prerequisites	Graduate Standing and ARE 599 (or CEM 599)

3.B required ARE Courses (RE)

1. Course Information	
Course Number:	ARE 599
Course Title:	Research Seminar in Architectural Engineering
2. Credit Hours:	1 Lecture/week (75 minutes) (L=1, LAB=0, CR=0)
3. Designation	Required Course (RE)
4. Course Description	Identification of a research topic, literature survey, and topic development. Structured presentation on a selected topic. Submission of a research paper.
5. Prerequisites	Graduate Standing (Equivalent to CEM 599)

1. Course Information	
Course Number:	ARE 600
Course Title:	Research Project
2. Credit Hours:	0 Lecture/week (L=0, LAB=0, CR=3)
3. Designation	Required Course (RE)
4. Course Description	Research study that deals with the analysis and/or design of a significant problem related to the field of Architectural Engineering focusing on Sustainable Energy and Indoor Environment and prepared under the supervision of an ARE faculty. The project report should follow formal report format including an introduction, literature review, research methodology, collection and analysis of data, conclusions and recommendations, list of references and appendices of important information. The research project is presented and evaluated by a faculty committee.
5. Prerequisites	Graduate Standing and ARE 599 (or CEM 599)

1. Course Information	
Course Number:	ARE 610 (RE-4)
Course Title:	M.Sc. Thesis
2. Credit Hours:	0 Lecture/week (L=0, LAB=0, CR=6)
3. Designation	Required Course (RE, M.Sc.)
4. Course Description	An original study on an approved research topic in the field of Architectural Engineering focusing on (Sustainable Energy and Indoor Environment) carried out under the supervision of a specialized faculty member in Architectural Engineering. Fine
5. Prerequisites	Graduate Standing and ARE 599 (or CEM 599)



3.C Other KFUPM Elective Courses

This short section summarizes the programs and courses offered by KFUPM colleges and departments, and which may be judged as related to courses offered for the revised graduate program **ARE-SEIE**. A short analysis and assessment were made on the content of those courses with a presentation of the extent they might cross-link **ARE-SEIE** proposed courses.

Mechanical Engineering: Course **ME-547** seems to cover several learning aspects that are targeted in **ARE-SEIE** courses. However, the course addresses two various subjects, Solar Energy and HVAC Systems, that are not to be considered in a one homogeneous body as is the case for the **ARE-SEIE** courses. Students taking this course cannot be recognized as fulfilling the requirements of corresponding **ARE-SEIE** courses, as these latter go deeper separately into each of the addressed subjects. ME Courses can be considered as an alternative support to some of the courses in the ARE program, namely **ARE-539**, and **ARE-524**. **ME-564** course may cover some of the contents of the equivalent ARE courses but with an extra consideration of the vibration and noise-generation characteristics in machines.

Table 5 :LIST of OTHER KFUPM ELECTIVE Courses

#	No.	Free KFUPM Elective Courses	Status – Action(s)
1	ME 539	Solar Energy Utilization	Same, Kept
2	ME 524	Energy Management	Added to the Free Elective Course List
3	ME 564	Noise and Vibration Control	Same, Kept
4	ECON 525	Energy Economics	Added to the Free Elective Course List
5	CRP 514	Intro to Geographic Information Systems (GIS)	Same, Kept
6	XXX 5xx	Other Graduate Courses [OPEN Choice]	Same, Kept, Consult GPC