2-Course Specification of: Advanced Renewable Energy Systems
Course Code (PME539)

I. General Information About the Course:						
1.	**Course Title:**	Advanced Renewable Energy Systems				
2.	**Course Code and Number:**	PME539				
3.	**Credit Hours:**	**Credit Hours**			**Total**	
		Lecture	Practical	Seminar/Tutorial		
		3	-	-	3	
4.	**Study Level and Semester:**	First Semester				
5.	**Pre-requisites (if any):**	Introduction to Renewable Energy Systems/Renewable Energy Technologies				
6.	**Co-requisites (if any):**	-				
7.	**Program (s) in which the course is offered:**	MSc. in Electrical Power Engineering				
8.	**Language of teaching the course:**	English				
9.	**Study System:**	Courses & Thesis				
10.	**Prepared By:**	Prof. Dr. Eng. Omar H. Al-Sakaf				
11.	**Reviewed by:**	Dr. Adel Al-Shakiri				
12.	**Date of Approval:**					

II. Course Description:

Renewable energy is going to be an important source for large-scale power generation in the near future. The purpose of this course is to provide students with advanced knowledge and relevant skills for engineering designing and developing of solar and wind energy systems with focus on large-scale solar and wind energy-based power generation. Main topics include large-scale electricity generation from renewable energy sources, energy storage devices and technologies, grid-integration and economic aspects of renewable energy systems, and case studies.

III. Course Intended Learning Outcomes (CILOs):

Upon successful completion of Advanced Renewable Energy Systems Course, the graduates will be able to:

a1 - Describe in detail the main renewable energy-based technologies suitable for large-scale power generation and associated challenges.

a2 - Understand the rationale for and the drivers behind the world-wide expansion of renewable energy-based large-scale power generation.

b1 - Formulate engineering issues to solve problems in the field of large-scale renewable energy systems.

b2 - Develop new ideas to improve the sustainability of large-scale renewable energy systems.

c1 - Analyze large-scale renewable energy systems based on wind and solar energy that meet specific energy demands economically and environment-friendly.

c2 - Compare different renewable energy technologies to choose the most appropriate based on local conditions.

d1 - Demonstrate analytical and problem-solving skills appropriate to the energy sector in general and to the renewable energy sector in particular.

d2 - Function effectively in diverse teams and in multi-disciplinary settings to communicate and disseminate the benefits of and opportunities for large-scale renewable energy-based power generation.

IV. Alignment of Course Intended Learning Outcomes (CILOs) to Program Intended Learning Outcomes (PILOs)

CILOs		PILOs	
a. Knowledge and Understanding: Upon successful completion of **the Advanced Renewable Energy Systems Course**, the graduates will be able to:		**A. Knowledge and Understanding:** Upon successful completion of the **MSc. in Electrical Power Engineering Program**, the graduates will be able to:	
a1.	Describe in detail the main renewable energy-based technologies suitable for large-scale power generation and associated challenges.	**A1.**	Demonstrate in-depth understanding of the theory and practice of modern electrical power systems design and operation and system identification.
a2.	Understand the rationale for and the drivers behind the world-wide expansion of renewable energy-based large-scale power generation.	**A2.**	Recognize and comprehend the key role of sustainable energy for national and global sustainable development.
		A3.	Explain in detail the key considerations and challenges of sustainable design and development of modern electrical power system components.
b. Cognitive/ Intellectual Skills: Upon successful completion of the **Advanced Renewable Energy Systems Course,** the graduates will be able to:		**B. Cognitive/ Intellectual Skills:** Upon successful completion of the **MSc. in Electrical Power Engineering Program,** the graduates will be able to:	

b1.	Formulate engineering issues to solve problems in the field of large-scale renewable energy systems.	**B1.**	Identify, formulate, and solve complex power engineering problems by selecting and applying appropriate tools and techniques.
b2.	Develop new ideas to improve the sustainability of large-scale renewable energy systems.	**B2.**	Critically review the scientific literature for effective justification and support of results and decisions.
		B3.	Select appropriate techniques and tools for successful problem solving.
c. Professional and Practical Skills: Upon successful completion of the **Advanced Renewable Energy Systems Course,** the graduates will be able to:		**C. Professional and Practical Skills:** Upon successful completion of the **MSc. in Electrical Power Engineering Program,** the graduates will be able to:	
c1.	Analyze large-scale renewable energy systems based on wind and solar energy that meet specific energy demands, are economically feasible and have a minimal impact on the environment.	**C1.**	Apply modern tools for research, computation, simulation, analysis, and design of modern power systems.
c2.	Compare different renewable energy technologies and choose the most appropriate based on local conditions.	**C2.**	Recognize the interdisciplinary nature of technical problems and apply other areas of knowledge to the solution, and work with other professions to arrive at a solution for complex engineering problems.
		C3.	Employ design standards and safety codes as an integral part of the design and building process for machine parts and systems.
d. Transferable Skills: Upon successful completion of the **Advanced Renewable Energy Systems Course,** the graduates will be able to:		**D. Transferable Skills:** Upon successful completion of the **MSc. in Electrical Power Engineering Program,** the graduates will be able to:	
d1.	Demonstrate analytical and problem-solving skills appropriate to the energy sector in general and to the renewable energy sector in particular.	**D1.**	Demonstrate leadership skills in the workplace, to function professionally in a globally competitive world, and to communicate engineering results effectively.
d2.	Function effectively in diverse teams and in multi-disciplinary settings to communicate and disseminate the benefits of and opportunities for large-scale renewable energy-based power generation.	**D2.**	Realize the relevance of economics, ethics and teamwork to the profession.
		D3.	Pursue advanced graduate studies and lifelong learning.

V. Alignment of CILOs to Teaching and Assessment Strategies

a. Alignment of Knowledge and Understanding CILOs:

Knowledge and Understanding CILOs		Teaching Strategies	Assessment Strategies
a1.	Describe in detail the main renewable energy-based technologies suitable for large-scale power generation and associated challenges.	▪ Lectures ▪ Demonstrations ▪ Interactive class discussions	▪ Group work ▪ Assignments ▪ Oral Presentations ▪ Written Exams
a2.	Understand the rationale for and the drivers behind the world-wide expansion of renewable energy-based large-scale power generation.		

b. Alignment of Intellectual Skills CILOs:

Intellectual Skills CILOs		Teaching Strategies	Assessment Strategies
b1.	Formulate engineering issues to solve problems in the field of large-scale renewable energy systems.	▪ Lectures ▪ Demonstrations ▪ Interactive class discussion	▪ Assignments ▪ Oral Presentations ▪ Exams
b2.	Develop new ideas to improve the sustainability of large-scale renewable energy systems.		

c. Alignment of Professional and Practical Skills CILOs:

Professional and Practical Skills CILOs		Teaching Strategies	Assessment Strategies
c1.	Analyze large-scale renewable energy systems based on wind and solar energy that meet specific energy demands, are economically feasible and have a minimal impact on the environment.	▪ Lectures ▪ Demonstrations ▪ Interactive class discussion	▪ Assignments ▪ Oral Presentations ▪ Exams
c2.	Compare different renewable energy technologies and choose the most appropriate based on local conditions.		

d. Alignment of Transferable (General) Skills CILOs:

Transferable (General) Skills CILOs		Teaching Strategies	Assessment Strategies
d1.	Demonstrate analytical and problem-solving skills appropriate to the energy sector in general and to the renewable energy sector in particular.	▪ Demonstrations ▪ Interactive class discussion	▪ Assignments ▪ Oral Presentations.
d2.	Function effectively in diverse teams and in multi-disciplinary settings to communicate and disseminate the benefits of and opportunities for large-scale renewable energy-based power generation.		

VI. Course Content

1. Theoretical Aspect

Order	Topic List / Units	Sub -Topics List	Number of Weeks	Contact Hours	Course ILOs
1	Yemen Renewable Energy Potential	• Yemen's renewable energy strategies, policies and plans ▪ Renewable energy applications in Yemen; past-present-future	1	3	a.2, b.2, c.1, c.2, d.1, d.2
2	Large-Scale Electricity Generation from Renewable Energy Sources	• Solar Photovoltaic PV Farms - System Configurations - Design and implementation aspects - Modeling and simulation	2	6	a.1, a.2, b.1, b.2, c.1, c.2, d.1
		▪ Concentrating Solar Power CSP Plants - Types of solar thermal power plants - Principle of operation - Applications world-wide - Operation and maintenance challenges	2	6	
		• Wind Farms - System Configurations - Design and implementation aspects - Modeling and simulation	2	6	
3	Midterm Exam		1	3	a.1, a.2, b.1, b.2, c.1, c.2, d.1
4	Energy Storage Devices and Technologies	▪ Limitations of renewable energy systems ▪ Energy storage challenges and solutions ▪ Emerging energy storage devices and technologies ▪ Hydrogen economy	1	3	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2
5	Grid-Integration Aspects of Renewable Energy Systems	• Technical requirements • Standards and codes • Power-Quality Requirements for Grid-Connected Wind Turbines • Advanced technology development	2	6	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2
6	Economic Aspects of Renewable Energy Systems	• Eight principles for successful investment in renewable energy projects • Financing Large-scale Projects • Renewable energy systems cost analysis • The life-cycle cost approach	1	3	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2

7	Case Studies	• Solar farms – World projects • Wind farms – Selected countries • Real time wind power generation • Grid interconnection case studies	3	9	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2
8	Final Exam		1	3	a.1, a.2, b.1, b.2, c.1, c.2, d.1
Number of Weeks /and Contact Hours Per Semester			**16**	**48**	

2. Practical Aspect	**NA**			
Order	**Practical / Tutorials topics**	**Number of Weeks**	**Contact Hours**	**Course ILOs**
1	▪			
2	▪ ▪			
3	▪ ▪			
Number of Weeks /and Contact Hours Per Semester				

3. Tutorial Aspect: NA				
No.	**Tutorial**	**Number of Weeks**	**Contact Hours**	**Learning Outcomes (CILOs)**
1				
2				
3				
Number of Weeks /and Units Per Semester		**15**	**30**	

VII. Teaching Strategies:

- Formal lectures
- Interactive discussions
- Presentations

VIII. Assessment Methods of the Course:

- Group work
- Assignments
- Oral Presentations
- Written Exams

IX. Tasks and Assignments:

No	Assignments/ Tasks	Individual/ Group	Mark	Week Due	CILOs (symbols)
1	Group work; groups will: • Have reading assignments to investigate and discuss up-to-date topics related to the course content. • Prepare a report based on a survey of sample large-scale projects implemented in other countries highlighting challenges, success stories and lessons learnt. • Discuss in detail applicability of similar projects in Yemen in near future. • Get acquainted with and use dedicated renewable energy systems simulation programs. • By the end of the semester (Week 14), Student Groups will submit their Final Reports and deliver a PowerPoint presentation within a plenary session.	Group	20	3-14	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2
	Total Score		**20**	**-**	**-**

X. Learning Assessment:

No.	Assessment Tasks	Week due	Mark	Proportion of Final Assessment	CILOs
1	Assignments	3-14	20	20%	a.1, a.2, b.1, b.2, c.1, c.2, d.1, d.2
2	Mid-Term Exam	8	20	20%	a.1, a.2, b.1, b.2, c.1, c.2, d.1
3	Final Exam	16	60	60%	
Total			**100**	**100%**	-

XI. Learning Resources :

4. Required Textbook(s) :

- Pengwei Du, Ross Baldick, Aidan Tuohy, ' Integration of Large-Scale Renewable Energy into Bulk Power Systems - From Planning to Operation', Springer, 2017.
- Leon Freris, David Infield, 'Renewable Energy in Power Systems', John Wiley & Sons, 2008.

5. Essential References:

- Nikolai V. Khartchenko, Vadym M. Kharchenko, 'Advanced Energy Systems', 2nd Edition, CRC Press, 2014.
- Keith Lovegrove, Wes Stein, 'Concentrating Solar Power Technology - Principles, Developments and Applications', Woodhead Publishing Ltd., 2012.
- Paul Breeze, Aldo Vieira da Rosa, Mukesh Doble, et al., 'Renewable Energy Focus Handbook', 1st Edition 2009, Elsevier Inc.

6. Electronic Materials and Web Sites *etc.*

- Course Power Point
- Video clips
- Links to information resources.

• الضوابط والسياسات المتبعة في المقرر Course Policies

بعد الرجوع للوائح الجامعة يتم كتابة السياسة العامة للمقرر فيما يتعلق بالآتي:

1	**سياسة حضور الفعاليات التعليمية Class Attendance:** - يلتزم الطالب بحضور 75% من المحاضرات ويحرم في حال عدم الوفاء بذلك. - يقدم أستاذ المقرر تقريرا بحضور وغياب الطلاب للقسم ويحرم الطالب من دخول الامتحان في حال تجاوز الغياب 25% ويتم اقرار الحرمان من مجلس القسم.
2	**الحضور المتأخر Tardy:** - يسمح للطالب حضور المحاضرة إذا تأخر لمدة ربع ساعة لثلاث مرات في الفصل الدراسي، وإذا تأخر زيادة عن ثلاث مرات يحذر شفويا من أستاذ المقرر، وعند عدم الالتزام يمنع من دخول المحاضرة.
3	**ضوابط الامتحان Exam Attendance/Punctuality:** - لا يسمح للطالب دخول الامتحان النهائي إذا تأخر مقدار (20) دقيقة من بدء الامتحان - إذا تغيب الطالب عن الامتحان النهائي تطبق اللوائح الخاصة بنظام الامتحان في الكلية.
4	**التعيينات والمشاريع Assignments & Projects:** - يحدد أستاذ المقرر نوع التعيينات في بداية الفصل ويحدد مواعيد تسليمها وضوابط تنفيذ التكليفات وتسليمها.

	- إذا تأخر الطالب في تسليم التكليفات عن الموعد المحدد يحرم من درجة التكليف الذي تأخر في تسليمه.
5	**الغش Cheating:** - في حال ثبوت قيام الطالب بالغش في الامتحان النصفي أو النهائي تطبق عليه لائحة شؤون الطلاب. - في حال ثبوت قيام الطالب بالغش او النقل في التكليفات والمشاريع يحرم من الدرجة المخصصة للتكليف.
6	**الانتحال Plagiarism:** – في حالة وجود شخص ينتحل شخصية طالب لأداء الامتحان نيابة عنه تطبق اللائحة الخاصة بذلك
7	**سياسات أخرى Other policies:** - أي سياسات أخرى مثل استخدام الموبايل أو مواعيد تسليم التكليفات ..... الخ

Academic Year: ……....

Course Plan (Syllabus): Advanced Renewable Energy Systems

I. Information about Faculty Member Responsible for the Course:

Name	**Prof. Dr. Eng. Omar H. Al-Sakaf**	**Office Hours**					
Location &Telephone No.	Faculty of Engineering Mobile: 733772328/773332328	**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail	oalsakaf@gmail.com oalsakaf@yahoo.com		08:00 - 12:00				

II. General information about the course:

1.	**Course Title**	**Advanced Renewable Energy Systems**			
2.	**Course Code and Number**	**PME539**			
3.	**Credit Hours**	**Credit Hours**			**Total**
		Lecture	**Practical**	**Seminar/Tutorial**	
		3	-	-	**3**
4.	**Study Level and Semester**	**First Semester**			
5.	**Pre-requisites**	Introduction to Renewable Energy Systems/Renewable Energy Technologies			
6.	**Co –requisite**	-			
7.	**Program (s) in which the course is offered**	MSc. in Electrical Power Engineering			
8.	**Language of teaching the course**	English			
9.	**Location of teaching the course**	**Faculty of Engineering**			

II. Course Description:

Renewable energy is going to be an important source for large-scale power generation in the near future. The purpose of this course is to provide students with advanced knowledge and relevant skills for engineering designing and developing of solar and wind energy systems with focus on large-scale solar and wind energy-based power generation. Main topics include large-scale electricity generation from renewable energy sources, energy storage devices and technologies, grid-integration and economic aspects of renewable energy systems, and case studies.

IV. Course Intended Learning Outcomes (CILOs):

Upon successful completion of Advanced Renewable Energy Systems Course, the graduates will be able to:

a1 - Describe in detail the main renewable energy-based technologies suitable for large-scale power generation and associated challenges.

a2 - Understand the rationale for and the drivers behind the world-wide expansion of renewable energy-based large-scale power generation.

b1 - Formulate engineering issues to solve problems in the field of large-scale renewable energy systems.

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d1 - Demonstrate analytical and problem-solving skills appropriate to the energy sector in general and to the renewable energy sector in particular.

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I. Course Contents

A – Theoretical Aspects

Order	Topics List	Week Due	Contact Hours
1	Yemen Renewable Energy Potential	Week 1	3
2	Large-Scale Electricity Generation from Renewable Energy Sources		
	• Solar Photovoltaic PV Farms	Week 2 - 3	6
	• Concentrating Solar Power CSP Plants	Week 4 - 5	6
	• Wind Farms	Week 6 - 7	6
3	Midterm Exam	Week 8	3
4	Energy Storage Devices and Technologies	Week 9	3
5	Grid-Integration Aspects of Renewable Energy Systems	Week 10 - 11	6
6	Economic Aspects of Renewable Energy Systems	Week 12	3
7	Case Studies	Week 13 - 15	9
8	Final Exam	Week 16	3
Number of Weeks and Units Per Semester		**16**	**48**

1. Practical Aspect NA

Order	Practical / Tutorials topics	Number of Weeks	Contact Hours	Course ILOs
1	▪			
2	▪ ▪			
Number of Weeks /and Contact Hours Per Semester				

2. Training/ Tutorials/ Exercises Aspects: NA			
Order	**Tutorials/ Exercises**	**Week Due**	**Contact Hours**
1	▪		
2	▪		
Number of Weeks /and Contact Hours Per Semester			

V. Teaching Strategies:

- Formal lectures
- Interactive discussions
- Presentations

VI. Assessment Methods of the Course:

- Group work
- Assignments
- Oral Presentations
- Written Exams

No	Assignments/ Tasks	Individual/ Group	Mark	Week Due
1	Group work; groups will: • Have reading assignments to investigate and discuss up-to-date topics related to the course content. • Prepare a report based on a survey of sample large-scale projects implemented in other countries highlighting challenges, success stories and lessons learnt. • Discuss in detail applicability of similar projects in Yemen in near future. • Get acquainted with and use dedicated renewable energy systems simulation programs. • By the end of the semester (Week 14), Student Groups will submit their Final Reports and deliver a PowerPoint presentation within a plenary session.	Group	20	3-14
	Total Score		**20**	**-**

XI. Learning Assessment:

No.	Assessment Tasks	Week due	Mark	Proportion of Final Assessment
1	Assignments	3-14	20	20%
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3	Final Exam	16	60	60%
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- Video clips
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2	**الحضور المتأخر Tardy:** **- يسمح للطالب حضور المحاضرة إذا تأخر لمدة ربع ساعة لثلاث مرات في الفصل الدراسي، وإذا تأخر زيادة عن ثلاث مرات يحذر شفويا من أستاذ المقرر، وعند عدم الالتزام يمنع من دخول المحاضرة.**
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7	**سياسات أخرى Other policies:** **- أي سياسات أخرى مثل استخدام الموبايل أو مواعيد تسليم التكليفات ..... الخ**