Master Program

Energy Systems Engineering

Program Specification

1.	**Awarding Institution**	Universitas Indonesia	
2.	**Teaching Institution**	Universitas Indonesia	
3.	**Faculty**	Engineering	
4.	**Program Title**	Master Program in Energy Systems Engineering	
5.	**Vision and Mission**	**Vision:** Becoming an excellent Master's Program in Energy Systems Engineering at an international level. **Mission:** To provide students with interdisciplinary knowledge in energy systems engineering that covers technical, economic, environmental, and policy aspects.	
6.	**Class type**	Special Class	
7.	**Final Award**	MT	
8.	**Accreditation Status**	BAN-PT (accredited Very Good or "Baik Sekali")	
9.	**Language of Instruction**	Indonesia	
10.	**Study Scheme (Full Time / Part-Time)**	Full Time	
11.	**Entry Requirements**	Pass the entrance selection test (SIMAK-UI), and Bachelor (S1) graduates from the field of Engineering, Natural Sciences, and Economy (including Business and Management)	
12.	**Study Duration**	Scheduled for two years	
	Semester Type	Number of semesters	Number of weeks/semesters
	Regular	4	16
13.	**Aims of the program:** The Master's Program in Energy Systems Engineering aims to produce graduates capable of designing, analyzing, and applying energy systems to solve problems in the energy sector by utilizing a or interdisciplinary approach.		
14.	**Profile of Graduates:** A Master in Energy System Engineering can design energy systems and formulate energy policy to support sustainable development at national and international levels.		

	Expected Learning Outcomes (ELO): Master's Program in Energy Systems Engineering has the following Expected Learning Outcomes: 1. Students can design technology and system on renewable and carbon-neutral energy. 2. Students can analyze energy economics and business model. 3. Students can formulate energy policy and planning. 4. Students can develop interdisciplinary research in energy systems engineering. 5. Students can understand professional and ethical responsibility.		
	Classification of Subjects		
	Types of Subjects	**Credits**	**Percentage**
	Compulsory courses at the study program level	26	62%
	Elective courses	16	38%
	Total	42	100%
	Total Credits for Graduation		**42 SKS**

Job Prospects

Graduates of this study program can work on:

1. Business Institutions / Professionals.
2. Government Institutions, such as Kementerian Energi dan Sumber Daya Mineral (ESDM), Kementerian Badan Usaha Milik Negara (BUMN) and Kementerian Keuangan.
3. State-Owned Enterprises, such as Pertamina, PLN, and PGN.
4. Educational and research institutions.

Expected Learning Outcomes (ELO)

GRADUATE PROFILE:

A Master in Energy System Engineering can design energy systems and analyze energy policy to support sustainable development at national and international levels.

1. Students can design technology and system on renewable and carbon-neutral energy.
2. Students can analyze energy economics and business model.
3. Students can formulate energy policy and planning.
4. Students can develop interdisciplinary research in energy systems engineering.
5. Students can understand professional and ethical responsibility.

Flowchart of courses to attain the expected learning outcomes in the Master's Program in Energy Systems Engineering

Expected Learning Outcomes	Courses			
	Semester 1	Semester 2	Semester 3	Semester 4
Students can analyze the design and optimization of energy technologies based on renewable energies.	Sustainable Energy Systems Energy Technology	Materials for Energy Smart Grid and Distributed Power Generation Renewable Energy	Energy Storage System	
Students can evaluate energy planning, policies, and business model.	Advanced Engineering Mathematics	Energy Systems Modelling and Policy Analysis	Energy Regulations and Markets Energy Transition Economics Energy Planning and Policy	
Students can create comprehensive interdisciplinary study/research in energy systems engineering.		Pre-Thesis	Carbon Capture Utilisation and Sequestration	Thesis Scientific Publication

Core courses

Elective courses

New Course

Course Structure Master Program in Energy Systems Engineering

Core Courses

Code	Subject	SKS
	1st Semester	
ENES801001	Advanced Engineering Mathematics	4
ENES801002	Sustainable Energy Systems	4
ENES801003	Energy Technology	4
	Sub Total	**12**
	2nd Semester	
ENES802004	Pre-Thesis	2
	Elective 1	4
	Elective 2	4
	Sub Total	**10**
	3rd Semester	
ENES803005	Energy Planning and Policy	4
	Elective 3	4
	Elective 4	4
	Sub Total	**12**
	4th Semester	
ENES804006	Master Thesis	6
ENES804007	Scientific Publication	2
	Sub Total	**8**
	Total	**42**

Elective Courses

Code	Subject	SKS
ENES802008	Energy Systems Modelling and Policy Analysis	4
ENES803017	Energy Transition Economics	4
ENES802012	Materials for Energy	4
ENES803020	Energy Storage System	4
ENES802013	Smart Grid and Distributed Power Generation	4
ENES802014	Renewable Energy	4
ENES803015	Energy Regulations and Markets	4
	Carbon Capture Utilisation and Sequestration	4

Students may take elective courses across departments within or outside the Faculty of Engineering. Taking these cross courses must be by following the Faculty of Engineering, Universitas Indonesia rules.

Syllabus Master Program in Energy System Engineering

Core Courses

Advanced Mathematics

ENES801001

4 CREDITS

Expected Learning Outcomes:

Students can design technology and system on renewable and carbon-neutral energy.

Course Learning Outcomes:

This course aims to provide students with mathematical-based analysis and modeling skills so that students are expected to be able to use various analytical tools (modeling) to perform calculations, analyses, and simulations related to energy.

Syllabus:

The Advanced Engineering Mathematics course provides analytical or modeling tools to support policymaking, generally based on mathematical equations and can be used to perform data analysis or simulations that are typically related to energy. The scope of the material taught includes Probability, Dynamic and Optimization Model.

Prerequisite: -

Textbooks:

1. Meershcaert, Mark M. Mathematical Modeling Fourth Edition. Elsevier. Michigan; 2013.

Sustainable Energy Systems

ENES801002

4 CREDITS

Expected Learning Outcomes:

Students can analyze energy economics and business model.

Course Learning Outcomes:

This course provides an overview of current energy status and the transition to future energy systems, especially energy resources (fossil and renewables), conversion, transportation, storage and end-used technologies as well as its linkage to other systems (economic, social and environment).

Syllabus:

This course includes Concept of energy system, sustainability and sustainable energy; Global climate change, mitigation and cleaner fossil energy systems; Energy System Transition; Bioenergy; Hydropower system; Geothermal Energy; Variable Renewable Energy (VRE) wind and solar energy; Hydrogen Fuel and fuel cell nuclear energy; Energy storages and power flexibility; Energy demand systems, energy efficiency and conservation; Sustainable energy policy and Energy Economic.

Prerequisite: -

Textbooks:

1. Jefferson W. Tester, et al., Sustainable Energy: Choosing Among Options, MIT Press, 2005.
2. Godfrey Boyle, et al. Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2003.
3. Mac Kay, D.J.C., Sustainable Energy –without hot air, UIT Cambridge, 2008, free online
4. Dincer, Ibrahim**,** Zamfirescu**,** Calin, Sustainable Energy Systems and Applications, Springer, 2012.
5. Hendrik Lund, Renewable Energy Systems. A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions, 2nd Edition, Elsevier, 2014.

Energy Technology

ENES801003

4 CREDITS

Expected Learning Outcomes:

Students can analyze the design and optimization of energy technologies based on renewable energies.

Course Learning Outcomes:

The learning outcome of this subject is that students can explain the resources, processes, applications, and technologies related to energy conversion.

Syllabus:

The scope or syllabus taught in this course includes Power Generation; Engine Heat and Heat Exchangers; Fossil Energy; Geothermal Energy; Solar energy; Wind energy; hydro energy, nuclear energy, and Biomass energy.

Prerequisite: -

Textbooks:

1. Fanchi JR. Energy Technology and Directions for the Future. Academic Press; 2004.

2. Sulaiman SA (editor). Clean Energy Opportunities in Tropical Countries [Internet]. 1st ed. 2021. 2021.

<u>Pre-Thesis</u>

ENES802004

2 CREDITS

Expected Learning Outcomes:

Students can develop interdisciplinary research in energy systems engineering.

Course Learning Outcomes:

The learning outcome of this subject is that students can study a topic scientifically and write a research proposal.

Syllabus:

This course includes an introduction, techniques to identify problems and arrange hypotheses, logical thinking, scientific writing methods, technical writing of research proposals, designing research techniques, presentation techniques, and techniques to collect, analyze, and present data.

Prerequisite: -

Textbooks:

1. Pedoman Teknis Penulisan Tugas Akhir Mahasiswa Universitas Indonesia, Keputusan Rektor Universitas Indonesia Nomor 2143/SK/R/UI/2017.

<u>Energy Planning and Policy</u>

ENES803005

4 CREDITS

Expected Learning Outcomes:

Students can formulate energy policy and planning.

Course Learning Outcomes:

This course provides the concept of Energy Planning and Policy in solving energy system problems based on technical, economic, environmental and political aspects.

Syllabus:

This course covers the following topics: Introduction, Statistical Review on Energy Modelling, Model Use in Decision Making, Method for Model Evaluation, Communication Problem in Energy Policy Analysis, Modelling Energy Demand in Short and Middle Term, Energy Model and Technology Review, Electricity Development in the Future, Production Modelling, Price Production Decision, Analysis and Energy Demand Modelling, Using Energy Modelling for Business Decision, Model Comparison for Policy and Energy Planning, Validation Problem and Energy Model Assessment.

Prerequisite: -

Textbooks:

1. Energy Policy Planning · Editors: B. A. Bayraktar, E. A. Cherniavsky, M. A. · Series Title: Nato Conference Series · Springer New York, NY

2. Purwanto W, Nugroho Y, Dalimi R, Soepardjo AH, Wahid A, Supramono D, et al. Indonesia Energy Outlook and Statistics 2006. 2006.

Master Thesis

ENES804006

6 CREDITS

Expected Learning Outcomes:

Students can develop interdisciplinary research in energy systems engineering.

Learning Objectives:

Students can design and conduct research in energy systems engineering and present research results in oral and writing.

Syllabus:

Material based on the research topic

Prerequisite: -

Based on regulation

Textbooks:

1. Pedoman Teknis Penulisan Tugas Akhir Mahasiswa Universitas Indonesia, Keputusan Rektor Universitas Indonesia Nomor 2143/SK/R/UI/2017.

Scientific Publication

ENES804007

2 CREDITS

Expected Learning Outcomes:

Students can develop interdisciplinary research in energy systems engineering.

Course Learning Outcomes:

Students will be able to produce scientific writing on the results of studies or the research with a decent quality to be published in national or international dissemination forums.

Syllabus:

The rules of scientific writing; various modes of scientific writing; the argument formulation strategy in a scientific paper that clearly shows the position on existing knowledge; publication procedures in national/ international seminars/conferences; publication procedures in internationally reputable journals; article review in internationally reputable journals.

Prerequisite: Master Thesis

Textbooks: Relevant references to the research topic of the Master Thesis

Elective Courses

Energy Modelling and Policy Analysis

ENES802008

4 CREDITS

Expected Learning Outcomes:

Students can formulate energy policy and planning.

Course Learning Outcomes:

The learning outcome of this subject is to provide a skill energy system modeling using well known models/software to support sustainable energy system design, energy planning and policy as well as decision-making.

Syllabus:

This course includes a study on Energy System Modelling and Reference Energy System; Energy Demand Model; Energy Supply and Technology Model; Type of Energy Model and Software Tools; Integrated Supply-Demand model & Optimization; Economic and Environmental Model; System Dynamics Modelling; Decision Making Process and Model Based Policy Making; Scenario Planning Development.

Prerequisite: -

Textbooks:

1. A. Integration of Large-Scale Renewable Energy into Bulk Power Systems: From Planning to Operation, Du, P., Baldick, R., & Tuohy, Springer International Publishing, 2017.

2. Energy System Analysis for Developing Countries, Meier, P., Springer-Verlag, 1984.

3. Energy Policy Analysis and Modeling, Munasinghe, M., & Meier, P, Cambridge University Press, 1993.

4. Optimization of Energy Supply Systems: Modelling, Programming and Analysis, Nagel, J., Springer International Publishing, 2018.

Renewable Energy

ENES802014

4 CREDITS

Expected Learning Outcomes:

Students can analyze the design and optimization of energy technologies based on renewable energies.

Course Learning Outcomes:

This course provides knowledge to design of various renewable energy sources, the technology of renewable energy conversion, and the use of renewable energy in Indonesia and the world, and the economics of renewable energy.

Syllabus:

Various renewable energy and the infrastructure relevant to each renewable energy. This course also discusses design renewable energy systems and its application in Indonesia and the world, and evaluate the economics of renewable energy.

Prerequisite: -

Textbooks:

1. Tester, Jefferson W., et al. Sustainable Energy. Choosing Among Options, The MIT Press, 2012.

2. Charles F. Kutscher, Jana B. Milford, Frank Kreith. Principles of Sustainable Energy Systems, CRC Press, Taylor & Francis Group, 2019.

Materials for Energy

ENES802012

4 CREDITS

Expected Learning Outcomes:

Students can analyze the design and optimization of energy technologies based on renewable energies.

Course Learning Outcomes:

This course includes overview of the latest developments in materials chemistry, various synthesis approaches, and properties of energy materials for energy storage and energy conversion for efficient and sustainable energy applications.

Syllabus:

This course includes the following topics: Fundamental and latest advances in energy materials, the electrical characteristic of a material, material for electrochemical energy, material for solar energy, material for wind energy, materials for energy storage, advanced material for energy harvesting, and future perspective.

Prerequisite: -

Textbooks:

1. Zhang, S. Materials for Energy 1st edition, CRC Press, Taylor & Francis Group, 2021.

2. Dhoble, S.J., et al. Energy Materials Fundamentals to Application 1st edition. Elsevier. 2021.

3. Gupta, R. Handbook of Energy Materials**.** Springer Singapore. 2022.

Smart Grid and Distributed Power Generation

ENES802013

4 CREDITS

Expected Learning Outcomes:

Students can analyze the design and optimization of energy technologies based on renewable energies.

Course Learning Outcomes:

This course provides a complete evaluation of programming and protection of smart grid and distributed power generation, the concept of distribution, stability, and quality of generating networks.

Syllabus:

This course covers these topics: Introduction, What, Why, How, If and When is Smart Grid, Smart Grid more than Technology, From Smart Grid to Smart Energy Uses, Equity Implications of Smart Grid, Renewable Energy Prospects, Vision dan Mission of Smart Grid, Manifestation Potential Renewable and Distributed Power Plants, Rules of Microgrids, Renewable Energy Integration, Software Infrastructure and Smart Grid, Smart Pricing, Success in the Smart Grid, Effects of Smart EVs.

Prerequisite: -

Textbooks:

1. Sioshansi F. (editor) Smart Grid Integrating Renewable, Distributed and Efficient Energy. Academic Press; 2011.

Energy Regulations and Markets

ENES803015

4 CREDITS

Expected Learning Outcomes:

Students can formulate energy policy and planning.

Course Learning Outcomes:

The learning outcome of this subject are: the electric power system from an interdisciplinary point of view, which deals with policy, regulation, markets, and the economy.

Syllabus:

This course includes the following topics: Introduction, Understanding of the Electric Industry, Energy Competition, Regulation Levels for Transmission and Distribution, Competition Support, Load Balancing and Power Delivery, Ensuring Reliability in Superior Markets, Role of Countries in Electricity Regulation and Markets, Standard Cost Coverage, Rebuilding and Environmental Safety, Programs for Public Communities in Competitive Markets, Prospects of Restructuring.

Prerequisite: -

Textbooks:

1. Brennan TJ, Palmer KL, Martinez SA. Alternating Currents Electricity Markets and Public Policy. Routledge; 2002.

Energy Transition Economics

ENES803017

4 CREDITS

Expected Learning Outcomes:

Students can analyze energy economics and business model.

Course Learning Outcomes:

The learning outcomes of this subject are: theory of energy economics; market and pricing of energy; emerging issues raised by the transition to a low carbon economy; the basics of the energy transition and the technologies and innovations need to achieve it; the economics of renewable energy sources and compare alternative energy systems that require vastly different capital expenditures and operating costs and how governments support them; energy transition impact on jobs inequality finance trade mobility and infrastructure or citizens societies and nations; decarbonisation and carbon pricing policies and how the country will become climate-neutral; the role of public policy instruments including taxes, regulations, and incentives in accelerating the transition away from traditional fossil fuels.

Syllabus:

This course includes the following topics: The theory of energy economics; Transition, Regulation and Energy Market; Energy Pricing; Economic principles of the Energy transition; Impact energy transition on energy markets and societies; Financing energy transition; Carbon markets.

Prerequisite: -

Textbooks:

1. Alessandro Rubino, Alessandro Sapio, Massimo La Scala. Handbook of Energy Economics and Policy. Fundamentals and Applications for Engineers and

Energy Planners, Elsevier, 2021

2. Subhes C. Bhattacharyya, Energy Economics. Concepts, Issues, Markets and Governance, Springer, 2011
3. Zweifel, Peter, Praktiknjo, Aaron, Erdmann, Georg, Energy Economics. Theory and Applications, Springer, 2017
4. Joanne Evans, Lester C. Hunt. International Handbook on the Economics of Energy, Edward Elgar Publishing Limited, 2009
5. Petit, Vincent. The Energy Transition. An Overview of the True Challenge of the 21st Century., Springer 2017

Energy Storage System

ENES803020

4 CREDITS

Expected Learning Outcomes:

Students can analyze the design and optimization of energy technologies based on renewable energies.

Course Learning Outcomes:

The learning outcomes of this subject are: Principles of Energy Storage System (ESS) and Energy storage application on different renewable energy system.

Syllabus:

This course includes the following topics: Introduction of energy storage system, Battery ESS, Hydrogen based ESS, Capacitor and Super Capacitor, Flywheel ESS, Pumped hydro ESS, Compressed Air ESS, Thermal ESS, Electromagnetic ESS, and micro scale ESS.

Prerequisite: -

Textbooks:

1. Bresser D, Passerini S. Handbook of Battery Materials. Second Edition; Edited by Claus Daniel and Jürgen O. Besenhard. Energy Technology. 2013 Oct 1;1(10):617–8.
2. Kiehne HA. Battery Technology Handbook. CRC Press; 2003.
3. Gulbinska MK. Lithium-ion Battery Materials and Engineering: Current Topics and Problems from the Manufacturing Perspective. Springer-Verlag London; 2014.
4. Warner J. The Handbook of Lithium-Ion Battery Pack Design. Elsevier Science; 2015.

Carbon Capture Utilisation and Sequestration

4 CREDITS

Expected Learning Outcomes:

Students can develop interdisciplinary research in energy systems engineering.

Course Learning Outcomes:

The purpose of this course is to provide an overview of Carbon Capture and Sequestration (CCS), with a focus on the latest technology for reducing CO_2 emissions from the atmosphere, the different methods of capturing and storing carbon dioxide with advanced capture and sequestration technologies also Carbon Capture Utilisation (CCU) for fuels, chemicals, or other commodities.

Syllabus:

This course includes the following topics: Introduction to Carbon Capture Utilisation and Sequestration (CCUS); Pre-combustion, oxyfuel and post combustion CO_2 Capture technology; CO_2 sequestration in subsurface and its application; Carbon Capture and Utilisation (CCU) to fuel and chemical; Negative Emission Technology (NET); Political economy of carbon capture utilisation and sequestration.

Prerequisite: -

Textbooks:

1. Bui, Mai., Dowell, N.M., Carbon Capture and Storage, Royal Society of Chemistry, Cambridge, 2019.
2. Ballerat-Busserolles, K., et al. Cutting-Edge Technology for Carbon Capture, Utilization, and Storage, Wiley, Beverly, 2018.