TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING

COURSE OUTLINES

OF

M. SC. ENGINEERING
IN
ENERGY SYSTEMS PLANNING AND MANAGEMENT
(MS-ESPM)

January 2016

1. INTRODUCTION

The Institute of Engineering (IOE), Tribhuvan University has initiated a two years (4-semester) M.Sc. Engineering in Energy Systems Planning and Management (MS-ESPM) from November 2012 in collaboration with the Institute of Energy Systems and Thermodynamics, Vienna University Technology, Vienna, Austria. This master's program is offered under the Department of Mechanical Engineering, Central Campus, Institute of Engineering, Tribhuvan University. The Centre for Energy Studies (CES) of Institute of Engineering, Tribhuvan University was implementing agency in Nepal. The Austrian Partnership Program in Higher Education and Research for Development **"appear"** was the responsible agency and financier of this M.S. program and the Institute of Energy System and Thermodynamics, Vienna University Technology was responsible for coordination of this program. The Austrian funding was available from July 2011 to July 2013. From 2014, this master's program has been included under the regular program offered by the Central Campus, Institute of Engineering, Tribhuvan University.

The 2-year (4-semester) Master of Science program consists of a package of courses covering important areas for planning, policy making and managing energy systems. This master program is designed to give students a focused, relevant and utilizable body of knowledge in energy system planning and policy making suitable for people with an interest in starting and managing energy related projects. Graduates from the program will be prepared to work for government and non-governmental institutions, international organizations, corporations/industries and entrepreneurial firms in the knowledge economy with capabilities to plan, manage and formulate energy related policies.

2. ADMISSION REQUIREMENTS

2.1 Program entry requirements

In order to be eligible for admission for Master of Science Engineering in Energy System Planning and Management (MS-ESPM), a candidate must have:

- A Bachelors' Degree from a Four Year Engineering Program in Mechanical, Electrical, Electronics, Computer, Civil, Agriculture and Industrial Engineering or Five Year Program in Architecture from Tribhuvan University and other recognized universities as well as degree equivalent to any of the aforementioned branches of engineering.
- Secure at least a minimum score as prescribed by the Faculty Board in the admission test conducted by the Institute of Engineering.

2.2 Entrance Test

The nature of entrance test will be decided by the Entrance Examination Board of the Institute of Engineering, Tribhuvan University.

2.3 Selection

Candidate fulfilling the Program Entry requirements will be selected for admission on the basis of merit based on MS-ESPM Entrance Test.

2.4 Categories of Students

Four categories of students are envisaged in this course and they are:

1. Regular fee paying students
2. Full Fee paying students
3. Sponsored students.

2.5 Duration of Study

A regular student should complete the course within four years. Each student must take a minimum of 60 credits. Students may take more than 60 credits but the excess credit will not be counted for.

3. COURSE STRUCTURE/SYSTEM

This Master Course focuses on the planning, designing, policy making and management of energy systems and formulating strategies. The program is structured with an objective to produce graduates who will have in-depth knowledge of energy system planning, analysis and formulating strategies so that they have capability to accept both technical and management responsibilities. An important influence is real life problem based learning including case studies and problem solving with quantitative and qualitative models including commercial modeling software.

The course structure is based on the Semester system. The detailed course structure, examination scheme, marks, etc. are listed in detailed course structure sheet.

Each Year is divided in first and second Semester. In first year first semester, five core courses are offered and in second semester, four core courses related to energy planning, management and development are offered. Six different elective subjects are offered in second semester and students can opt for one of them. The second year, first semester consists of four compulsory subjects including one group projects. Six electives from different fields are offered in this semester and students can opt for one of them. The second year second semester is entirely allocated for dissertation work. The dissertation shall be individual's work and be extensive and normally field based. Students shall be encouraged to publish research papers in national and international journals as a outcome of their dissertation work.

4. COURSE OVERVIEW

Semester 1	Semester 2	Semester 3	Semester 4
Research Methodology (4 Credit) *Core General course*	Energy Economics and Systems Planning (4 Credit) *Core Energy Planning Course*	Elective -III (4 Credit)	Dissertation / Thesis Work (16 Credit)
Operation Research/ Management Science (4 Credit) *Core Management Course*	Energy Financial Management (4 Credit) *Core Management Course*	Elective -IV (4 Credit)	
Thermo-fluid (4 Credit) *Core Technology Course*	Elective -I (4 Credit)	Group Projects (4 Credit)	
Energy Resources (4 Credit) *Core Energy Course*	Elective –II (4 Credit)		

Note:

1. Total Credit = 60 Credits.
2. Course work , directed study and projects = 44 Credits
3. Dissertation = 16 Credits
4. Depending on the interest of students only 2 electives are offered in each term. Minimum number of students in each elective should be 6.

4.1 Core and Elective Courses

The course consists of two types of courses: the Core Courses which deal with the fundamental theory and the Elective Courses which deal with the specific details of the course.

Similarly, conferences and seminars are organized time to time to make students abreast with the current happenings in energy world. Also students are encouraged to participate in various national and international conferences.

The core courses of the Energy System Planning and Management program focuses on the fundamentals of energy systems planning, analysis, modeling and management. Elective courses chosen will enable students to focus their courses to their technical interests and to specific topics in power plant technology, energy generation, transmission, distribution, control systems, energy economics and management. In addition, required project works will provide hands-on real world experience.

4.2 Group Project Work

The purpose of the group project in second year, second semester is to provide an opportunity for the group of students to investigate, analyze and to provide possible solution to an existing energy related problems. The group project must be completed in the allocated term. The group project may be done in small group normally two to three students per group.

4.3 Dissertation /Master's Thesis

The main objective of Master's Degree Dissertation is to carry out original research work concerning energy related problems and solve those problems. Students are encouraged to publish articles in national and international journals.

5. CREDIT SYSTEM

The course curriculum is organized in the overall framework of Credit System. Each course has a certain number of credits which indicates the weightage. The number of credits depends on the contact hours for the course and its work load. Course with one credit weightage will have 15 lecture hours in a semester. The tutorial consulting and assessment hours will vary depending on the nature of the course. The total Credit for the master's program is 60 credits.

6. EVALUATION SYSTEM

The evaluation system is based on the continuous assessment by the course teacher and the final examination. The students have to pass individually in the assessment as well as the final examination. The minimum pass marks for the assessment and final examination is 50%.

The percentage is calculated from the following criterion:

$$Total\ Percentage = \frac{\sum Credit \times Mark\ Obtained}{\sum Credits}$$

Depending upon the total percentage of the marks obtained, the following division shall be awarded:

Percentage	Division
>= 50 %	Pass
50 - < 65%	II
65-< 80%	I
80 and above	Distinction

7. COURSE CODE

Each course is identified by a code. Each course will have a three digit number with a prefix set of two capital letters. The prefix letters stands for the department offering the course (for example, ME signifies Department of Mechanical Engineering). In the three number central digits, the first digit denotes the level in which the course is offered. For example, the digit 8 and 9 indicate the first and second year respectively of the Master's level course. The second digit is used to designate the semester. The second digits from 1 to 50 are used for the course offered in the first and third semesters and 51 to 100 for the courses offered in the second and fourth semesters respectively.

8. INSTRUCTIONAL METHODS

Conventional lectures and seminars in the taught course components (core and elective courses) of the program are reinforced by other approaches to teaching and learning process:

- the use of case studies (video and text -based) to highlight key issues and management practices
- training by using electronic sources
- training in team work, group work, presentations and project management.

Each course is coordinated by a member of the faculty or the visiting faculty from outside who is expert in a given subject. The course faculty has the full responsibility for the conduction of the particular course. The courses comprise of lectures tutorials, laboratory works, group discussions and project works if applicable. The course contents are designed in such a way that considerable self-learning efforts should be used by the students.

Each student will be assigned a counselor. The main function of the counselor will be to guide the students throughout the
2- Year program.

9. QUALIFYING CRITERIA

To qualify for the Master of Science in Energy System Planning and Management, the student must satisfactorily complete the program consisting of course work, directed study, group projects of 44 credits and an individual thesis of 16 credits.

10. REGISTRATION

Students must register for their course every semester. They must seriously attempt to complete the masters' program in 2 years. In all the four semesters, a total of 44 credits will be offered which will consist of core and elective courses. The credits for the thesis will be 16. The total credit for the complete program is 60.

11. MARK DISTRIBUTION IN EACH COURSE PER SEMESTER

Year I Part A

Teaching Schedule				Examination Scheme			Total	Remark
				Theory				
					Final			
S. N.	Course Code	Course Title	Credit	Assessment Marks	Duration hours	Marks		
1	EG 821 ME	Research Methodology	4	40	3	60	100	
2	EG 822 ME	Operation Research /Management Science	4	40	3	60	100	
3	EG 823 ME	Thermo-fluid Engineering	4	40	3	60	100	
4	EG 824 ME	Energy Resources	4	40	3	60	100	
		Total	**16**	**160**	**12**	**240**	**400**	

Year I Part B

Teaching Schedule				Examination Scheme			Total	Remark
				Theory				
					Final			
S. N.	Course Code	Course Title	Credit	Assessment Marks	Duration hours	Marks		
1	EG 871 ME	Energy Economics and Systems Planning	4	40	3	60	100	
2	EG 872 ME	Energy Financial Management	4	40	3	60	100	
3	EG 873 ME	Elective I	4	40	3	60	100	
4	EG 874 ME	Elective II	4	40	3	60	100	
		Total	**16**	**160**	**12**	**240**	**400**	

Eletive I Hydropower Development and Maintenance
Climate Change and its Impact on Energy Sector

Eletive II Power Plant Technology (Thermal, Hydro & Renewable)
Power Transmission & Distribution
Power Systems Dynamics & Stability
Power System Control & Operations
Renewable Energy Technology

Year II Part A

Teaching Schedule				Examination Scheme			Total	Remark
				Theory				
S. N.	Course Code	Course Title	Credit	Assessment Marks	Final			
					Duration hours	Marks		
1	EG 922 ME	Elective III	4	40	3	60	100	
2	EG 923 ME	Elective IV	4	40	3	60	100	
3	EG 921 ME	Group Project	4	100	-	-	100	
		Total	**12**	**180**	**6**	**120**	**300**	

Elective III Energy Systems Modelling and Analysis
Energy Strategy, Energy Policy & Regulations
Energy Project Development and Social Sector Management

Elettive IV Human Resources Management and Communication Skills
Electricity Economics and Planning
Energy Efficiency and Audit
Reliability & Risk Analysis
Environment Impact Assessment

Year II Part B

Teaching Schedule				Examination Scheme			Total	Remark
				Theory				
					Final			
S. N.	Course Code	Course Title	Credit	Assessment Marks	Duration hours	Marks		
1	EG 971 ME	Thesis	16	100	-	-	100	
		Total	**16**	**100**	**0**	**0**	**100**	

12. COURSE OUTLINE

12.1 EG822ME: Operation Research /Management Science

Introduction to Modeling for Decision; data management and analysis; regression analysis ; forecasting models for time-series; introduction to optimization; linear and multi-objective optimization models; interpreting solver results and sensitivity analysis; decision and risk analysis; expected value decision-making; Monte Carlo simulation; optimization and simulation; system modeling and simulations; modeling and simulating dynamic inventory models.

12.2 EG823ME: Thermo-Fluid Engineering

Fluid mechanics and Machines: Basic equations of fluid for incompressible and compressible fluid with their applications, Basic flow field, streamlines, velocity potential, stream function, flow net, Open and close conduct flow. Turbine (impulse and reaction) principles, components, force calculation. Pumps and related theories.

Thermal Engineering**:** Revision of properties of substances, control mass and control volume formulation of First Law of Thermodynamics, Steady state and unsteady state analysis and applications, Reversible and Irreversible process, entropy and enthalpy generation, Control mass and Control Volume formulation of Second Law of Thermodynamics, Combined Analysis, availability and irreversibility. Thermodynamic cycles, Revision of heat transfer models and Heat exchangers. Application of thermo-fluid engineering.

12.3 EG824ME: Energy Resources

Introduction to energy resources; Energy – the engine of development; estimation and evaluation of energy resources; Combustion fundamentals and theory, Environmental effects of energy; biomass energy resources; fossil fuels and fossil energy; nuclear energy; renewable energy resources; geothermal energy; hydropower energy; Solar energy; wind energy; ocean waves, tide, and thermal energy conversion; energy systems and sustainability metrics, Application of energy resources.

12.4 EG871ME: Energy Economics and Systems Planning

Basics of energy economics; theory of consumer and producers; theory of market equilibrium; economics of energy supply; energy system; technical, economic, social and environmental aspects of energy systems; energy balance; energy demand and supply; energy system analysis; a framework for national energy planning; energy planning procedures; energy systems planning tools; familiarization with econometric models, optimization models, input -output models; energy systems planning models.

12.5 EG872ME: Energy Financial Management

Types of firms, raising capital, financial markets, dividend policy and cost of capital; understanding financial statements and their analysis; financial and cost accounting; financial forecasting; financial strategic planning and management control; time value of money and capital budgeting techniques; overview of financial management; understanding financial risk management such as futures, options and real options; knowledge about mergers, acquisitions and restructuring

12.6 EG873ME (Elective-1):

873.1: Hydropower Development and Maintenance

Power situation; Types and classification; Power Regulation: Definition and meaning of terms like firm power, secondary power, mean & peak load, utilization and factors, power variation, power grids; Planning & layout of hydropower projects: Site selection of hydropower, requirement of hydropower projects, reservoir regulation, layout of hydropower projects; Water retaining structure: dams, choice of dams, design of dam, foundation principle; Regulatory structure: intake, design of intake structure, hydraulic tunnels, design of settling basin, forebay and surge tank, design of forebay, penstock; Spillway: function of spillway, cavitation and erosion, design of silting basin; Hydro-electric machine: hydro mechanical installation, types of turbines, performance characteristics of hydraulic turbines, selection of turbine and specification, introduction of bulb turbine, draft tube, pumps, generators and type, governers; Power Development Policy and Rules: survey licenses, power purchase agreement. Introduction to maintenance engineering, Types of maintenance, Maintenance tools (fault tree analysis and failure mode, effects and criticality analysis etc.), Condition based maintenance, Reliability- centered maintenance, Total productive maintenance. Maintenance practices in power plants in Nepal.

873.2: Climate Change and Its Impact on Energy Sector

Climate change science: introduction to climate change, key indicators of global climate change and evidence, climate change models and scenarios. Climate change impacts, adaptation measures and risk analysis: climate change impacts, adaption measures and risk analysis in agriculture and food security, water resources and energy, climate induced disasters, forest and biodiversity, public health, urban settlement and infrastructure, cross-cutting sectors. Climate change mitigation: technological options for mitigating climate change such as carbon capture and storage, switching to more renewable energy and greater energy efficiency, cost effectiveness analysis of mitigation measures. Climate change policy: global and national policy on climate change, regulatory instruments and human behavior and social change.

12.7 EG873ME (Elective-2): 4 Credits

873.1 Power Plant Technology

Compression Ignition and Steam turbine based thermal power plants: Boilers and steam cycle, type of boilers, boiler mountings and accessories, boiler operation, feed water treatment, fuel handling, air path and energy conservation, stack gas path and clean up, handling of products of combustion. Types and principles of operation: Steam nozzles, types of steam turbines and the operation and field of application of gas turbines. Operation and selection of different types of turbines for hydro power plants Current and future trend of technologies: for different types of solar thermal power plants, and solar thermal refrigeration and air conditioning

873.2 Power Transmission and Distribution

This subject is offered from as inter disciplinary electives from Masters of Science in Power Systems offered by Department of Electrical Engineering.

873.3Power System Dynamics and Stability

Introduction to power system dynamics & stability in the operation and design of system Synchronous machine, Exciter and voltage regulators; Function of speed governing systems, Transient Stability; State equation for multi-machine system with one axis model and simulation , Dynamic stability.

873.4 Power System Control and Operation

Introduction to power system control and operation; Real Power -Frequency Control, Basics of speed governing mechanism and modeling; Integration of economic dispatch control with LFC; Reactive Power -Voltage Control; Commitment and Economic Dispatch; Computer control of power system; Network topology – state estimation – security analysis and control.

873.5Renewable Energy System Technology

Solar Thermal System**:** Solar radiation and its characteristics, basic principles and performance of flat plate and solar concentrators, application of active and passive solar thermal systems, Solar PV System: Fundamentals of solar cells, types of solar cells and their fabrication. Application of photovoltaic systems, Micro Hydro: micro hydro power system, site selection, transmission and installation. Wind Energy: Principle of wind energy generation, resource assessment, types of systems and applications. Geothermal Energy: Geophysics, available technology, harnessing geothermal resource. Others: Hydrogen energy, fuel-cells, energy generation from waste, hybrid energy generation systems. Energy Supply and Demand side Management, Environmental Impact Assessment of Renewable Energy Technologies, Carbon trading.

12.8 EG922ME (Elective-3): 4 Credits

992.1: Energy Systems Modeling and Analysis

Top down and bottom up approaches in energy systems modeling; scenario analysis in energy systems modeling; different energy modeling frameworks; LEAP; MARKAL; MAED; MESSAGE; TIMES etc; development of energy systems modeling framework and energy analysis.

922.1: Energy Strategy, Energy Policy & Regulations

Defining strategy, levels at which strategy operates, Strategic Decision Making and Approaches to Strategic Decision making, Mission and Purpose, Objectives and Goals, Strategic Business Units, Corporate Planning Process, Strategy Formulation and Choice of Alternatives: Strategies — Modernization, Diversification, Integration, Merger, Take-over and Joint Venture strategies, Turnaround-divestment and Liquidation strategies, of Strategic Choice — Industry, competitor and SWOT analysis; Importance of Energy policy, Energy Resource tradeoff; Oil markets and fuel switching; Energy sector economics; Relevant policy mechanism for energy policy, Existing energy policy, Policy drivers and actors, Policy analysis: Establishing evaluative criteria: efficiency, effectiveness, equity, political acceptability, ease of implementation, process values, legal challenges, adaptability, robustness, Regulatory Impact Analysis: Assumption in policy formulation, Evaluating analytical tools , Renewable Fuel Standard; Sensitivity and scenario analysis; Policy design for implementation; Renewable and carbon regulation: Planning Implications from the Interactions between Renewable, Energy Policies and Carbon Regulation.

922.3: Energy Project Development and Social Sector Management

Definition and scopes of project, Technical design, Financing, Contracting, Implementation and performance monitoring; Implementation plan for top management, Planning budget, Procurement procedures, Construction, Measurement and Verifications, Conflict Management; Social Management. The course will also cover emerging methods, principles and practices in energy/power project procurement, including Public-Private-Partnerships, carbon project management, and Clean Development Mechanism, etc.

12.9 EG923ME (Elective-4): 4 Credits

923.1 Human Resources Management and Communication Skills

Introduction to human resource management; Environmental context: New economic policy, technological, socio-economic and political, legal environment structural reforms, their implication for HRM in Nepal; Introduction to strategy and strategic management-The Paradigm shifts in people Management, Emergence of Human Resource Management as a distinct model of people management, Human Resource Planning: recruitment , selection , training & development ; Human Resource Development; HRD Development in Nepal; Labor Performance management and appraisal: Compensation/rewards system; Labor management- Industrial relations, law on industrial relations, characteristic features of industrial relations in Nepal, collective bargaining; Trade unions and trade unionism: Theories of trade unions, trade union law, trade unionism in Nepal, issues and problems, employees associations, managerial unionism.

923.2 Electricity Economics and Planning

Nature of Planning in Electricity Sector and the Hierarchy of Electricity Planning Models, Electricity Demand Forecasting: Electric Load Representation, Different Approaches for Forecasting, Short Term Demand Forecasting Models, Long Term Demand Forecasting Models, Electricity Demand Side Management: Economic Operation of Power System, Short-term Economic Dispatch, Unit Commitment, Mid-term Scheduling, Hydro-Thermal Scheduling, Generation Planning Techniques: Electricity Generation Technologies, Levelized bus-bar cost analysis, Screening Curve Analysis: Thermal and Hydropower Plants, Key Indices of Power System Reliability and their Calculations, Linear, Mix Integer and Dynamic Programming approach to Planning, Traditional Generation Expansion Planning Models, Integrated Resource Planning Models, Dealing with Uncertainties in Capacity Expansion Planning, Electricity Pricing Theory and Approaches: Objective of Electricity Pricing, Marginal Cost Pricing, Theory of Peak Load Pricing, Buyback rates of

Electricity Produced by Independent Power Producers, Deregulation of Electric Utilities**:** Issues and Approaches, Performance Evaluation of Electric Utilities using DEA.

923.2 Energy Efficiency and Audit

Energy management: need for energy management and energy conservation, energy management process, principles of energy management, Energy auditing: auditing techniques, preliminary and detail energy audit, energy audit tools & instruments, preparation of audit format, energy audit report writing, Boilers energy audit: fuels and combustion process, factors affecting combustion efficiency, combustion equation, boiler efficiency measurement, energy saving opportunities in boiler, Building Energy Audit: building heat gain, types of heating, ventilating and air-conditioning, chilled water storage, thermal insulation, and solar passive architecture; Electrical system audit: understanding utility bill, tariffs, demand charges, ordinary a.c. motors, energy efficient motors, load cycling of motors, power factor improvement, demand management, energy efficient lighting system, energy saving opportunities, Furnaces: types of furnaces, performance evaluation of furnace, fuel economy measures; Compressor**:** types of compressor, compressor selection, monitoring performance, energy saving opportunities in compressed air network.

923.4 Reliability & Risk Analysis

Reliability concept: reliability function, failure rate, mean time between failures, mean time to failure , a priori and a posteriori concept; mortality curve; useful life availability, maintainability; system effectiveness; Reliability data analysis: time to failure distributions, exponential ,normal gamma, Weibull, ranking of data, probability plotting techniques, hazard plotting; Reliability prediction models : series and parallel models, reliability based design approach, standby systems , application of Baye's theorem, cut and tie set method , Markov analysis , fault tree analysis , limitations. Reliability management: reliability testing, reliability growth monitoring, non parametric methods, reliability and life cycle costs, reliability allocation, replacement mode, reliability methods. Risk assessment: definition and measurement of risks, element of risk assessment, analysis techniques, risk reduction resources, industrial safety and risk assessment.

923.5 Environment Impact Assessment

Purpose and aims of EIA; EIA administration and practice; concept of associated assessment processes; key elements of the EIA process; undertaking an EIA; role of public participation; stages that follow EIA; the costs and benefits of undertaking EIA; and understanding of the strengths and limitations of EIA.

12.10 EG971ME Dissertation /Thesis work