MAKERERE UNIVERSITY

FACULTY OF TECHNOLOGY

PROGRAMME

FOR

MASTER OF SCIENCE

IN

RENEWABLE ENERGY

SEPTEMBER 2008

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1 PREAMBLE

Energy is essential to economic growth and poverty reduction in Uganda. The national drive to eradicate poverty and achieve the Millennium Development Goals (MDGs) requires trained manpower to handle energy development projects. This often requires advanced training which the undergraduate courses/degrees alone cannot provide. The Faculty of Technology is thus proposing to start a unique postgraduate programme in Renewable Energy to be run in collaboration with the following partner Universities: The Norwegian University of Science and Technology (Norway), University of Dar-es-Salaam (Tanzania), Addis Ababa University and Mekelle University (Ethiopia), Universidade Eduardo Mondlane (Mozambique) and University of Malawi (Malawi). It is aiming at addressing the shortage of appropriately trained people, to power the growth of renewable energy industry in the country and the region.

The purpose of this master programme is to provide state-of-the-art education in the field of renewable energy by means of economically and environmentally friendly systems and technologies. A strong emphasis is placed on dealing with renewable energy engineering tasks with due consideration of technical, environmental and socio-economic issues. Advanced methods are applied to identify, describe, quantify and find solutions to a diverse range of energy problems. Participants will gain proficiency in renewable energy project design and implementation, operation and maintenance, as well as in crucial phases of policy generation. Advanced training in a research-oriented perspective is also included.

The master programme has duration of two years with three semesters of taught courses and one semester of thesis project. During the first year, students will be taught general courses in renewable energy, project planning and management and entrepreneurship in line with energy development. During the first semester of the second year of study, students will specialize in one of the three specializations of Bioenergy, Hydropower and Solar energy. An individual thesis project in the area of specialization will be carried out in the second semester of the second year of study. Successful completion of the programme results in the award of the degree of Master of Science in Renewable Energy.

2 RATIONALE FOR CURRICULUM PROPOSAL

2.1 Rationale

Currently, engineers and other scientists are forced to go outside Uganda to attend Masters level postgraduate courses. While such courses upgrade technical knowledge, they are not appropriate in that the socio-industrial circumstances in the countries of training are very different from those in Uganda. This results in a mismatch between training acquired and the needs of Uganda. A locally run and well designed postgraduate programme will upgrade technical knowledge with emphasis on local needs and problems. The proposed Master Degree programme in Renewable Energy will meet the demand for appropriately trained people in the field of renewable energy technologies and applications.

The most important renewable energy options identified as mitigation measures to reduce the level of greenhouse gas emissions caused by over dependency on energy derived from fossil fuel include the development of bio-energy, hydropower, solar and wind energy, while energy intensity consumption reduction would also require the introduction of both energy efficiency and management measures, as well as the application of best design practices in the built environment.

The process of developing the curriculum for the course, writing of the proposal seeking for funds and many other related activities started way back in 2006. The workshops that were held in Kampala, Uganda and Trondheim, Norway for planning the project involved many participants from Tanzania, Mozambique, Malawi, Ethiopia and Norway who put in a lot of valuable time and resources to ensure the programme curriculum critically addressed the challenges facing the development of the renewable energy industry in Uganda and other East and Central African Nations. The allocation of funds by NORAD to support this master programme was as a result of its relevance in meeting the needs of the local society in Uganda and other East and Central African nations. This master program will run concurrently at both Makerere and University of Dar-es-salaam and movement of students between the two universities to carry out specialized courses and experiments/laboratories has been arranged.

It is envisaged that the programme will achieve effective training in renewable energy technologies, acquisition of advanced knowledge and understanding in the selected specialist areas of renewable energy and broadening the knowledge of engineers in areas of renewable energy specializations.

2.2 Market

Renewable energy specialists have a wide market in Uganda and beyond. The Government's Renewable Energy Technology policy calls for the increase of the contribution of Renewable Energy in the national energy mix. It also proposes to appoint energy officers in the districts. Graduate from the programme will be the ideal candidates.

It is envisaged that at the end of the training programme, graduates will work in the following areas of renewable energy.

(i) Bio-Energy,

(ii) Hydropower,

(iii) Solar Energy,

(iv) Wind Energy, and

(v) Energy Efficiency in Buildings.

2.2.1 Bio-Energy

The Master of Science in Renewable Energy degree programme with specialization in bio-energy has been designed in such a way that graduates will be provided with integrated technology and management skills required to compete internationally. The programme is designed to qualify students for occupations and careers in area of bio-energy production, fuels process equipment designs, pollution associated risk assessors as well as energy efficiency.

2.2.2 Hydropower

The Master of Science in Renewable Energy degree programme with specialization in hydropower has been designed in such a way that graduates will be provided with integrated technology and management skills in the area of hydropower development. The programme is multidisciplinary in nature and is designed to qualify students for occupations and careers in areas of integrated water management, land survey, dams and canals construction, hydroelectric power house design and construction, water turbines and control systems designs and installation, hydroelectric generators design and installation as well as electricity distribution networks design and monitoring.

2.2.3 Solar and Wind Energy

The Master of Science in Renewable Energy degree programme with specialization in solar and wind energy systems has been designed in order to introduce emerging technologies associated with solar and wind energies integrated with management skills. The programme is designed to qualify students for occupations and careers in solar energy systems design and installation, PV and wind energy systems design and installation, solar energy design in built environment as well as energy management.

2.2.4 Energy Efficiency in Buildings

The Master of Science in Renewable Energy degree programme with specialization in energy efficiency in buildings has been designed in such a way that graduates will be provided with a specialized knowledge in energy efficiency in built environment integrated with management skills. The programme is designed to qualify students for occupations and careers in residential and industrial energy efficiency and management field, building site planning and green buildings design and construction. The students will be able to carry out residential, commercial and industrial energy audits and recommend the best measures for energy conservation.

2.3 Aims

The programme aim is to train engineers and scientists in the area of renewable energy by providing them with core skills and knowledge needed in solving the practical challenges facing the energy industry and the community in general with regard to energy development, provision and utilization.

2.4 Mode of Teaching

The programme will be conducted by giving of lectures, laboratory exercises, assignments and project work.

2.4 Title

The title of the programme shall be Master of Science in Renewable Energy (MSc. RE)

2.5 Award Level

The degree Master of Science in Renewable Energy will be awarded to a student who fulfills all the requirements for the program or upon attaining total credits for graduation. The candidate who qualifies for admission to this programme must hold a bachelor's degree in any of the following fields: Mechanical, Electrical, Civil, Chemical and Environmental Engineering and Bachelor of Science in any of the three subjects: Physics, Chemistry and Mathematics.

3 PLANS (PATHWAYS)

Though the Master of Science in Renewable Energy is unique in its curriculum design, it however has similar core objectives and aims with other master programmes currently being offered by Faculty of Technology. It focuses on in-depth teaching of the theoretical work, practical work and field studies and research like the other degree programs being offered.

At the start, the courses will be taught by existing specialized lecturers within the faculty backed up by visiting professors from Norway and other collaborating partners in East Africa. The allowances and travel expenses will be catered for by the allocated project fund from NORAD up to end of 2010. The allocated fund will also offer ten scholarships to students per year for two consecutive intakes which will fully cover their tuition fees, stipend and all other learning related expenses.

It is planned that by 2011, the program should be sustainable both in terms of finances and human resource. Opportunities for training academic staff at PhD level in areas of specializations under this programme are being earmarked.

The faculty staff members coordinating this programme are working hard to get additional funding from other development partners to continue supporting the activities of this programme. So far GTZ has offered to fully sponsor four more students to study this master program. Also, because of the programme's unique structure/design and its relevant curriculum, it provides the faculty the opportunity of attracting a sizeable number of private students over time.

4 PROGRAMME OBJECTIVES

The general aims and objectives of the programme tally with those of Makerere University. The specific aims of this Programme are:

- To provide the country and the region with sufficient high level engineering human power in renewable energy as agents of development and change, thus contributing to the indigenous development of infrastructure, industry and trade.
- To conduct research in the interest of suitable exploitation of renewable energy resources in Uganda and the region, ultimately leading to innovation of technical products and production processes for renewable energy industry
- To provide expert professional services in the form of consultancy.

The specific objectives of this programme are:

- To instruct at least 10 students in the Renewable Energy field in each academic year
- Provide knowledge in analysis of Renewable Energy systems
- To develop capacity to evaluate and recommend effective Renewable Energy schemes
- To train students in appropriate research/project methodologies.

5 PROGRAMME STRUCTURE

The MSc.RE programme shall be run on semester system.

Semester I	Code	Course name	CU	LH	PH	CH	New/Current
All Core Courses	RET7101	Electrical Energy Systems	3	40	10	45	New
	RET7102	Hydropower	3	40	10	45	New
	RET7103	Bioenergy	3	40	10	45	New
	RET7104	Solar Energy	3	40	10	45	New
	RET7105	Statistics and Research Methods	3	40	10	45	New
Total CU			**15**				

Semester II	Code	Course name	CU	LH	PH	CH	New/Current
All Core Courses	RET7201	Other Forms of Renewable Energy	3	40	10	45	New
	RET7202	Entrepreneurship Development	3	45	0	45	New
	RET7203	Project Management	3	45	0	45	New
	RET7204	Energy Policy, Planning and sustainable Development	3	45	0	45	New
	RET7205	Optimization of Energy Systems	3	40	10	45	New
Total CU			**15**				

Semester III	Code	Course name	CU	LH	PH	CH	New/Current
Bioenergy Specialisation (All core courses)	RET8101	Thermochemical conversion Processes and Application	3	40	10	45	New
	RET8102	Biochemical Conversion Processes and Applications	3	40	10	45	New
	RET8103	Design and Modeling of Thermal Power Systems	3	40	10	45	New
Total CU			**9**				
Solar Energy Specialisation (All core courses)	RET8104	Solar Cell Technology	3	40	10	45	New
	RET8105	Electrical Energy Conversion in PV systems	3	40	10	45	New
	RET8106	Solar Thermal Technology	3	40	10	45	New
Total CU			**9**				
Hydropower Specialization (All core courses)	RET8107	Design and Maintenance of Hydropower Electro-Mechanical Equipment	3	40	10	45	New
	RET8108	Hydraulic Structures in Hydropower	3	40	10	45	New
	RET8109	Development of small Hydropower	3	40	10	45	New
Total CU			**9**				
Energy Efficiency in Buildings (All core Courses)	RET8110	Heat Transfer and Thermal Insulation in Buildings	3	40	10	45	New
	RET8111	Low Energy Architeture	3	40	10	45	New
	RET8112	Energy comfort in Buildings	3	40	10	45	New
Total CU			**9**				

Semester IV	Code	Course name	CU	LH	PH	CH	New/Current
Thesis Proposal and Dissertation	RET8201	Thesis	10	0	300	150	New
Total CU			**10**				

Total Credit Units for a student to graduate in this program are **49**

6 RESOURCES

6.1 Space

Although the existing lecture rooms in the faculty can serve the students who will be admitted to this program, a special arrangement for these students has been made. A class specifically for these master's students has been organized with power point presentation facilities. Therefore the faculty is ready to offer a good learning environment to the students. The offices for this program will be located in the state-of-the-art facilities of the Centre for Research in Energy and Energy Conservation (CREEC) in the faculty though the program is under the Department of Electrical Engineering.

The master's program will fully sponsor ten (10) students for each academic year 2007/2008 and 2008/2009 intake. Six (6) of the ten (10) students will be Ugandans and the rest will come from the eligible countries. We may have a very limited number of private students enrolling for this programme, and therefore this will not greatly affect the facilities/space arranged.

6.2 Computer Labs

The faculty has put in place a suitable computer lab for the students. A total of ten (10) additional computers dedicated to the programme will be bought using the fund from NOMA to cater for the first intake. The student/computer ratio is estimated to be 1:1.

6.3 Research Labs/Facilities

The faculty has a well equipped facility for Bioenergy experiments/practical including the gasifier. The fund from NOMA also provides for purchase of some laboratory equipment and consumables. Where the faculty lacks test equipment, students will take the courses or experiments from the partner institution

(University of Dar-es-salaam) and then transfer the credits. There are plans to apply for addition funding to purchase more laboratory equipment. There are 3 specializations for this Master program, namely Hydropower, PV Systems and Bio-energy. Those doing the first two specializations shall be allocated to the University of Dar-es-Salaam where laboratory facilities are better than ours.

6.4 Field Attachments

Fieldwork will be part of the module work and will form part of the theoretical degree programme as part and parcel of teaching in each module. Field trips to industries dealing in energy production as well as those with intensive energy consumption processes will be visited and also students will be attached to do typical energy projects with them. This proposal emphasizes collaboration with partners Universities in the region on the conduction of the field work.

6.5 Human Resource

The faculty has enough lecturers who will be taking part in teaching different courses in this program as shown in Table 6.1. The available staff members will be boosted by over six (6) visiting professors from Norway who will take on modules in various courses.

All the lecturers involved in this program have qualifications of PhD and above. The faculty also currently has three PhD students in energy who will conduct tutorials for the master's students.

The list of lecturers above will increase since the project emphasizes that the other cooperating Universities other than Makerere, Dar-es-Salaam and NTNU should also take part in teaching and supervision of students. Furthermore, some teaching assistance in areas of relevancy has been promised by Faculty of Science particularly Departments of Mathematics and Physics and Faculty of Economics and Management at Makerere University.

To ensure sustainability of staff, the project has applied for additional funding to educate more lecturers from the host institution at PhD level in areas relevant to this master programme and the funding is yet to be approved by the relevant NORAD/NOMA committees in Norway.

Table 6.1: Academic Staff with confirmed Participation

S.N			SEMESTER I					SEMESTER II				
	RESOURCE PERSON	STATUS	CURRENT TEACHING LOAD		PROPOSED TEACHING LOAD		TOTAL LOAD	CURRENT TEACHING LOAD		PROPOSED TEACHING LOAD		TOTAL LOAD
			COURSES	CU	COURSES	CU		COURSES	CU	COURSES	CU	
1	Dr. I.P. Da Silva	Permanent	ELE3104 ELE7104	4 4	RET7101	3	11 CU	ELE2201 ELE7201	4 3	RET7204	3	10 CU
2	Dr. M. Okure	Permanent	MEC3105 MEC4102	4 4	RET7103	3	11 CU	MEC3205 TEC7302	4 3	RET7205	3	10 CU
3	Dr. A. Sebbit	permanent	MEC2101 MEC4105	4 4	RET8101	3	11 CU	MEC4206 MEC7201	4 4	RET7201	3	11 CU
4	Assoc. Prof. J. Byaruhanga	Permanent								RET7202	3	
5	Dr. S.B. Kucel	Permanent	MEC7101 MEC3104	3 4	RET7102	3	10 CU	MEC7202 MEC4205	3 4	RET7203	3	10 CU
6	Assoc. Prof. T. Togboa S.	permanent	EMT 3101 EMT7103	4 4	RET7105 RET8109	3 3	14 CU	ELE7214 ELE4202	4 3	RET7202	3	10 CU
7	Prof. Tom Otiti	Permanent (Phy. Dept)	Unknown		RET7104 RET8105	3 3	6 CU	Unknown		None		
8	Dr. Sengonzi JB	Part-time	Unknown		RET8102	3	3 CU	Unknown		None		
9	Prof. Torbjorn N.	Visiting	Unknown		RET8109	3	2 CU	Unknown		None		
10	Prof. Annund K.	Visiting	Unknown		RET8108	3	2 CU	Unknown		None		
11	Dr. Oyvind S.	Visiting	Unknown		RET8103	3	2 CU	Unknown		None		
12	Prof. Ivar W.	Visiting	Unknown		RET8108	3	2 CU	Unknown		None		
13	Prof. Lars Norum	Visiting	Unknown		RET8107	3	2 CU	Unknown		None		
14	Dr. Gaute S.	Visiting	Unknown		RET8106	3	2 CU	Unknown		None		

The current teaching load for permanent lecturers who will take part in teaching this program is 8 hours per week. If the above full time lecturers are to add on an average of 4 hours per week to teach a course unit in the proposed master program, this will bring the total hours to 12 hours, which is above the minimum of 10 hours recommended by Makerere University. This implies that the faculty can provide the quality of teaching needed since the participating lecturers have enough time to teach this programme.

The visiting lecturer will share the course unit with the full time lecturer and his/her contact hours taught will be arranged in form of modules which will last for a period of not more than two weeks. This will be arranged to allow the visiting lecturer to cover the assigned syllabus in a short stay.

KEY to courses currently being taught by permanent Lecturers

ELE3104	Energy Conversion
ELE7104	Energy Sources and the Environment
ELE2201	Power Systems Theory
ELE7201	Power Generation and Power Stations
MEC3105	Dynamic Systems Engineering
MEC4102	Applied Thermodynamics
MEC3205	Control Systems Engineering
TEC7302	Research Methods
MEC2101	Fluid Mechanics for Mechanical Engineers I
MEC4105	Renewable Energy Systems
MEC4206	Fluid Power Systems
MEC7201	Energy Planning and Management
MEC7202	Renewable Energy Technology
MEC4205	Air Conditioning and Refrigeration
MEC7101	Maintenance Engineering
MEC3104	Design of Machine Elements
EMT3101	Engineering Mathematics IV
EMT7103	Computer Applications and Programming
ELE7214	Computer Technology
ELE4202	Computer Systems Engineering

6.6 Student Support

The students will have an induction ceremony in the first week of the programme start intended to create awareness amongst them and will be given details on how the program will run. International students will constantly get assistance and guidance from the project coordinator. Arrangements for their visas and accommodation while in Uganda will be coordinated well by the concerned faculty staff members responsible for this programme. Initially, the students will receive scholarships which will make their welfare perfect. Generally, the students will receive support equal to what the current students enjoy or better.

6.7 Funding

The tuition fees will be UShs.3, 000,000 per annum for Ugandan students and Ushs 5,000,000 (or US $ 3125) per annum for international students. All other charges for postgraduate students at Makerere University will apply.

The project will cater for tuition fees of 10 students registered at Makerere and the rest of the students who wish to enroll will be privately sponsored. The project will however be able to take care of any increments in tuition fees or other students' charges for the sponsored students. The tuition fees will be utilized as indicated in the budget at the end of this document (Appendix).

The project is financially sustainable in terms of students' support, payment of visiting professors, acquisition of learning materials and equipment and other related expenses. The funds have been released by NOMA (NORAD's Programme for Master Studies) through NTNU (Norwegian University of Science and Technology), Norway and part of these funds have been transferred to Makerere University account.

7 TARGET GROUP

The programme is targeted at fresh graduates, Tutorial fellows, Assistant Lecturers and practicing engineers who wish to upgrade their knowledge and also develop their research capacities. It is envisaged that the development shall involve a combination of the following three elements:

i) Training in research methods and pedagogic skills
ii) Acquisition of higher levels of knowledge and understanding in selected areas.
iii) Broadening the knowledge of engineers in areas other than their specialties.

8 ADMISSION REQUIREMENTS

To qualify for admission, the candidate must hold a Bachelor's degree in either Engineering or Science of second class lower division and above in a relevant field (Mechanical Engineering, Electrical Engineering, Chemical Engineering, Civil Engineering, Environmental Engineering, Physics, Chemistry and Mathematics) from a recognized institution. All other requirements and regulations by Makerere University shall apply.

9 EXAMINATION REGULATIONS

Makerere University regulations shall apply.

Assessment of Courses

a) Each course shall be assessed on the basis of 100 total marks with proportions as follows

Course work	- 40%
Written Examination	-60%

b) Course work assessment shall consist of practical work (laboratory work, Workshop practice and field work) and progressive assessment (assignments and tests) and shall be assessed as follows:

(i) For a course without practical work:

Assignments	15%
Tests	25%

(ii) For a course with practical work:

Assignments	5%
Tests	10%
Practical Work	25%

c) A minimum of two course work assignment/tests shall be required per course

Grading of Courses

a) Each course shall be graded out of a maximum of 100 marks and assigned appropriate letter grades and grade points as follows:

Marks%	***Letter Grade***	***Grade points***
80-100	A	5.0
75-79.9	B^+	4.5
70-74.9	B	4.0
65-69.9	B^-	3.5
60-64.9	C^+	3.0
55-59.9	C	2.5
50-54.9	C^-	2.0
45-49.9	D^+	1.5
40-44.9	D	1.0
35-39.9	D^-	0.5
Below 35	E	0

b) These additional letters shall be used where appropriate

W – Withdraw from course

I- Incomplete

AUD- Audited courses only

c) The Pass grade point is 2.0

d) No credit unit shall be awarded for any course in which a student fails.

Progression

Progression through the course shall be assessed in three ways:

Normal Progress

This occurs when a student passes all courses taken.

Probationary

This is a warning stage and occurs if:-

a) A student fails a core/ compulsory course or

b) A student obtains GPA or CGPA of less than 2.0

Probation is removed when either of the conditions (a) and (b) no longer holds.

Discontinuation

A student shall be discontinued from the programme if one of the following conditions obtains:-

a) Receiving two probations on the same core/compulsory course
b) Receiving two consecutive probations based on CGPA

Repeating a Course

There shall be no supplementary in any course of the programme. However, a student may repeat any course when it is offered again in order to:

a) Pass if the student had failed it before.

b) Improve the grade if the first pass grade was low.

A student, who does not wish to repeat a failed elective course, shall be allowed to take a substitute elective.

Dissertation

The dissertations shall conform to the standing guidelines and regulations of the University on higher degrees. In addition, the following shall also apply:

a) A candidate shall not be allowed to formally start on research work unless he/she has passed at least 10 courses.

b) A candidate shall submit a research proposal to the Faculty Higher Degrees Committee before the end of first semester of year two of study.

c) The candidate shall conduct research during the second semester of the second year of study.

d) The candidate shall hand in three hard copies and one soft copy of the dissertation by the end of the second year.

Passing Dissertation

To pass a dissertation, the candidate shall satisfy the examiners in both the written report and viva voce.

Revised Dissertation

A candidate who fails to satisfy examiners shall resubmit a revised dissertation within six months after notification.

Graduation Requirements

The degree of MSc (Renewable Energy) shall be awarded to a candidate who fulfils both conditions below:-

a) Accumulated a minimum of 49 credit units.
b) Passed the dissertation.

10 PROGRESSION

The program has yet to start and no tracer studies have been carried out. However monitoring of the performance of the graduated students and receiving feedback from them will be conducted in future. Consulting the target employers for our graduates before the review of curriculum in 2010 will also be carried out.

11 QUALITY ASSURANCE

The quality assurance practices in the other programmes in the faculty of Technology in particular and Makerere University in general shall apply. A student will be required to attend at least 70% of the lecturers given in a course, do and pass all the coursework assignments, tests and laboratory exercises before he/she can sit for a written examination. Also the performance of the assigned lecturers to teach these students shall be monitored closely to ensure they comply with the curriculum requirements. This will be partly achieved through giving the students assessment forms to assess their lecturers on the content taught, mode of delivery, self explanation and appearing for lectures.

12 DETAILED DESCRIPTION OF COURSES

RET 7101 Electrical Energy Systems

Short Description

This course presents a recap of the principles of electrical energy systems. It covers circuits, power calculations, electrical power machinery and power systems analysis.

Aims

The aims of this course are to:

- Bring the students with non electrical background to the same level with those having electrical engineering bachelor's degree
- Cover the material required to understand existing electrical energy systems and design new ones
- The course will introduce methods and techniques for modeling and analysis of components and systems for conversion and distribution of electrical energy.

Learning Outcomes

At the end of this course, a student should be able to:

- Identify and explain the functions of the various components that make electrical power circuits
- Model different types of electrical power circuits and systems
- Carry out analysis of electrical power circuits

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. The course is divided into 13 topics, each one meant to last 3 hours. These are: 1. Introduction to electrical engineering 2. Fundamentals of Electrical Circuits 3. AC network Power Calculation 4. Phasor for Steady State Studies 5. State Space Modeling 6. Transfer Functions 7. AC Power 8. Three Phases Systems 9. Electro-magnetism 10. Electro-mechanical machines 11. Power Electronics 12. Power System Analysis/Load Flow 13. Power System Instrumentation (substation and switch-yard layout). Laboratory Demonstrations (8 hours): AC Power measurements, Experiments with simple Electromechanical Energy Conversion Systems and simple Power Electronics

References

<ins>Core Reading</ins>

1. **Mohamed E. El-Hawary, "**Electrical Power Systems: Design and Analysis, IEEE Press Series on Power Engineering), 1995
2. **Frederick C. Trutt & Syed A. Nasar**, "Electric Power Systems", CRC Press, 1999.
3. **Surya Santoso, H. Wayne Beaty, Roger C. Dugan, and Mark F. McGranaghan,** "Electrical Power Systems Quality", 2002
4. **Allan Greenwood**, "Electrical Transients in Power Systems", 1991

Optional Reading

Birron M. Weedy, “Electric Power Systems”, John Wiley and Sons, 1972

Background Reading

Material on undergraduate Electric Energy Course

RET 7102 Hydropower

Short Description

This course introduces the concepts and methods of analysis of hydropower systems with a bias to micro and mini plants. It covers types of schemes, planning, background measurements, economic analysis, impacts and the design of hydropower plants.

Aims

The aims of this course are to:

- Ensure that students appreciate the role of hydropower in today’s energy mix
- Guide students through the procedures and requirements for design and analysis of power plants
- Instruct students on the tools used in the analysis and design of hydropower schemes with emphasis on mini and micro plants

Learning Outcomes

At the end of this course, a student should be able to:

- Distinguish between the different hydropower schemes
- Explain how the various tools and procedures are used in the designa d analysis of power plants
- Compute key characteristics of a small hydropower scheme given basic data

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. Energy, different forms of energy (2 hrs). Optimization of combined Hydro and thermal systems (3 hrs). General features of water power, Potential and developed hydropower sources (world and regional) (1 hr). Categorization of hydropower plants, hydropower planning (3 hrs). Hydrologic cycle, Data acquisition, rainfall and discharge measurements, flow duration curves, power duration curves (6 hrs) firm power, Annual Energy production, power markets, regional power pools (4 hrs). Economic and Financial analysis (3 hrs), Production and operating strategy (6 hrs). Environmental, Ecological and Social impacts (3 hrs). Software and preliminary design (6 hrs)

Practical: Turbine – pump efficiency determination, Impulse of a jet on surfaces, Surge tank transients (8 hrs)

References

Core reading

1. **Annund Killingtveit: Nils R. Saalthum (1998)**, Hydrology for Hydropower Development Series No. 7, NTNU Hydraulic Engineering division
2. **Peter L. Payne**, The Hydro, Aberdeen University Press (ISBN 0-08-036584-1)
3. **J.S. Gulliver and R.E.A Arndt.**, Hydropower Engineering Handbook, McGraw Hill Inc. 1991 ISBN. 0-07-025193-2

Optional Reading

Linsley R.K. et-al Hydrology for Engineers, McGraw Hill Co.

Background Reading

Godfrey Boyle, 2004: Renewable Energy "Power for a Sustainable Future" Second Edition, Oxford University Press. ISBN-0-19-926178-4

RET 7103 Bioenergy

Short Description

The course gives an overview of relevant aspects connected to the utilization of biomass and the biomass fractions of waste streams for energy purposes. This includes biomass resources with special focus on developing countries, the conversion process and the economics of these methods.

Aims

- The student will be able to grasp fundamental principles of bioenergy
- To introduce the students to basic concepts of bioenergy resource utilization
- To equip students with skills for designing equipment and system integrations for bioenergy conversion.

Learning Outcomes

- Students should be able to distinguish between different forms of biomass
- Students should be able to describe the processes for converting raw biomass into ready to use Biofuel.

- Students are able to make basic designs and analysis of biomass combustion equipment.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. The course gives an overview of relevant aspects connected to the utilisation of biomass and the biomass fractions of waste streams for energy purposes. This includes biomass resources with special focus on developing countries; biomass characterization, production and pretreatment; refined biomass fuels (9 hrs); overview of thermo chemical conversion processes including combustion, gasification, pyrolysis and liquefaction (6 hrs); overview of biochemical conversion processes for production of 1st and 2nd generation biofuels (9 hrs); anaerobic digestion and landfill gas (3 hrs). Economics, efficiencies, environmental (6 hrs), social and gender aspects (3 hrs). Overview of system and system optimization aspects (4 hrs).

Practicals: Experiments on gasification of different biofuels, determination of caloric value and moisture content of biofuels and biodiesel production.

<u>Field Visits</u>: Sugar mills, Tea Factories.

References

<u>Core reading</u>

1. **Lee, S.**, Alternative Fuels, Tylor & Francis Books, London, 1996.
2. **ECOFYS**, Planning and Installing Bioenergy Systems: A Guide to Installers, Earthscan, 2005, ISBN 184471324.
3. **Semida Silveira**, Bioenergy,- Realizing the Potential, Elservier, 2005
4. Graham Houghton, Bioenergy, Gareth Stevens Inc., 1991

<u>Optional Reading</u>

Janos Pasztor & Lars A. Kristoferson, Bioenergy and the Environment, Westview Press, 1990

<u>Background reading</u>

Godfrey Boyle, 2004: Renewable Energy "Power for a Sustainable Future" Second Edition, Oxford University Press. ISBN-0-19-926178-4

RET 7104 Solar Energy

Short Description

This course presents a recap of the principles of both solar photovoltaic and solar thermal technology. It presents the solar resource and basic techniques for harnessing the power of the sun for various applications. Economic analysis of integrated solar systems will be covered.

Aims

- To introduce the students to solar energy resources, characteristics and measuring techniques;
- To give a broad introduction into the principles, conversion technologies and applications solar photovoltaics and solar thermal.
- To prepare the students for the advanced courses in solar specialization branch.

Learning Outcomes

- Students should be able to characterize solar potential of various regions.
- Students should be able to describe the working principles of the systems used to convert the solar energy of the sun to desirable form.
- Students are able to determine the capacity of solar modules/panels required for a given facility for instance need for lighting or other applications.
- Students should be ale to design simple equipment for harnessing solar power.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

General: Origin of solar energy, solar radiation principles, solar geometry, global energy flows, types of radiation, insolation, solar radiation measuring techniques and data, Solar Energy Mapping, current and future potential of solar energy (6 hrs).

Photovoltaics: Working principle of solar cells; types of solar cells; cell, module and array; production of wafers, cells and modules; PV Systems Components (modules, controllers, inverters, batteries, appliances and balance of system); PV systems sizing; installation; commissioning; maintenance; troubleshooting; PV applications (grid connected systems, solar home systems, communication systems, water pumping systems, consumer products, and rural electrification systems); future technologies - solar chemical applications (12 hrs)

Solar Thermal: Solar thermal conversion principles; Solar collectors (flat plate collectors, concentrators, evacuated tubes); solar thermal applications (water heating, drying, cooking, cooling, electricity - solar tower, trough and lenses systems); solar thermal engineering (sizing, installation, commissioning, maintenance, troubleshooting);

Future technologies: Potential for solar hydrogen production and storage (6 hrs).

Social issues associated with using solar heaters and cookers and mitigation of negative tendency (3 hours).

Practicals

Solar energy resource: Solar energy/radiation measurements, solar geometry, interactions on solar energy, thermal radiation; radiation temperature; air temperature; air temperature; humidity; evaporation (3 hrs).

Solar PV: Measurement of PV module output characteristics, Installation of a solar PV system, measurements on a PV system (3 hrs).

Solar thermal: Testing of solar thermal devices, collectors, driers and cookers (3 hrs)

References

<u>Core reading</u>

1. **Stuart R. Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish**, "Applied Photovoltaics", Centre for Photovoltaic Engineering – Australia 2006

2. **Martin A. Green**, "Solar Cells: Operating Principles, Technology and System Application" - University of New South Wales - Kensington, Australia – 1998
3. **Tomas Markvart** - Solar Electricity - John Wiley & Sons, Ltd - Chichester, New York, Weinheim, Brisbane, Toronto, Singapore - Second Edition, 1994
4. **France Lasnier and Tony Gan Ang**, "Photovoltaic Engineering Handbook" - Adam Hilger Bristol - New York,1990
5. **Sorensen, Bent**, "Renewable Energy", Elservier, 2004
6. **Dunn, P. D.**, "Renewable Energies: Sources, Conversion and Application", Peter Peregrunus Ltd.
7. **Kivaisi, R. and Kawambwa, S. (Eds.)**, (2002), "Training of Trainers Workshop on Solar PV Systems for Decentralized Rural Electrification", Training Manual, Jan 28 – Feb 3, 2002, Bagamoyo, Tanzania UNESCO, Dar es Salaam, Tanzania.

Optional Reading

1. Steven J. Strong and William G. Scheller, "The Solar Electric House: Energy for the Environmentally-Responsive, Energy-Independent House", Chelsea Green Pub. Co., 288 pages, 1994, ISBN: 0963738321.

2. Harkins, M., "Small Solar Electric Systems for Africa", Commonwealth Science Council and Motif Creative Arts Ltd, May 1991.

3. Mshana, R. R., and Ischebeck, O. (Eds.), "Sustainable Development through Renewable Energies in Tanzania", Akademischer Verlag München, 1999.

Background Reading

1 Godfrey Boyle, 2004: Renewable Energy "Power for a Sustainable Future" Second Edition, Oxford University Press. ISBN-0-19-926178-4

2 Karekezi, S. and Ranja, T., "Renewable Energy Technologies in Africa", Zed Books Ltd., London in association with African Energy Policy Research Network (AFREPREN) and the Stockholm Environment Institute (SEI), 1997. – Available in Department Library.

RET 7105 Statistics and Research Methods

Short Description

This course presents the fundamentals, concepts and methods used in the analysis of data. It covers definitions, methods of computation of the various measures of data summarization. It also introduces stochastic analysis of events and the test used to assess whether a given set of data fits into some general pattern. The course will also cover advanced engineering research skills, focusing on research design, design of data collection instruments, implementation of data collection plans, and principles of research report writing and dissemination.

Aims

The aims of this course are to:

- Provide students with a strong knowledge base for mathematical analysis of energy systems.
- Equip students with background and fundamental knowledge behind the techniques for analyzing a vast amount of data for different scenarios with ease
- Equip students with the skills to use the tools for handling large amounts of data Explain to students the role of research in knowledge creation
- Instruct students on how research is conducted practically and in academic circles

Learning Outcomes

At the end of this course, a student should be able to:

- Explain the mathematical concepts of data occurrence and analysis
- Apply the different methods of displaying and reporting data
- Compute the various quantities used to summarize data
- Distinguish among the different scenarios of occurrence of events
- To test different data sets to find which models best describe them
- Explain the various terminology used in research methods
- Describe the various research designs applied in research
- Develop a research proposal including identification of a research problem, formulation of research objectives, description of the methodology and the data analysis techniques
- Identify shortcoming in research proposals, designs and reports

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical/project Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

***Statistics*:**

Definition of elementary statistical concepts (1.5 hrs). Measures of location: arithmetic mean, median, midpoint/midrange (1.5 hrs). Measures of dispersion: range, variance, standard deviation, coefficient of variation, standard error (3 hrs). Presentation and summarization of data; frequency, histograms/bar charts, Probability, probability distributions and expectations (2 hrs). Cases of probability distribution curves: poisson and binomial distributions, normal (Gaussian), exponential, gamma, beta and other distributions (3 hrs). Samples and populations (1.5 hrs). Tolerance and quality control (6 hrs). Confidence limits (1.5 hrs). The chi-squared test. Inference, comparison of means. Method of least squares and regression (3 hrs). Correlation (1.5 hrs).

***Research methods*:**

Foundations: Language, philosophy, and ethics in research (1.5 hrs);

Phases of Management Inquiry: Abduction, deduction and induction logic. Types of inquiry, the pyramid principle. Management inquiry and the method of science (3 hrs).

Layout of arguments: Data and warrants, backing our warrants (1.5 hrs).

Sampling: External validity; Terminology; Statistical terms in sampling; Probability and non-probability sampling (1.5 hrs).

Survey Research: Types of survey; selecting the survey method; Constructing the survey – type of questions, question content, response format, question wording and placement (3 hrs).

Scaling: General issues in scaling; Thurstone scaling; Likert scaling; Guttman scaling (1.5 hrs).

Qualitative Measures: The qualitative debate; Data; Approaches; Methods and Validity (1.5 hrs).

Experimental Design: Two-group experimental designs; Factorial designs; Randomized block designs; Covariance designs; Hybrid designs (3 hrs).

Report Writing: Key elements; Formatting; Sample Paper (1.5 hrs).

References

Core reading

1. **Jay L. Devore**, *“Probability and Statistics for Engineering and the Sciences”*, Cole Publishing Company, Latest edition
    2. **Patrick Neil & Steve Chapman,** *“Research Methods”, 3rd Edition*, Poutledge Taylor & Francis Group, 1985
    3. **Brenda Laurel (ed.)**, *“Design Research; Methods and Perspecitves”*, MIT Press, 2004

Background Reading

Handbook of Mathematics for Engineers and Scientists ***Andrei Polyanin, Alexander Manzhirov***

RET 7201 Other Forms of Renewable Energy

Brief Description

This course gives an overview of geothermal, wind, wave and tidal energy. It addresses the potential for these resources towards contributing to energy mix within Uganda and the region. The technologies for tapping the power from the above resources and their respective applications will be clearly demonstrated.

Aims

- To equip students with advanced knowledge in all the other types of renewable energy not covered by the three mainstream specializations.
- To present the state-of-the-art technologies for tapping power from these resources.
- To address the feasibility of harnessing power from any of the above resource types for Uganda’s applications.

Learning Outcomes

- Students should be able to describe the mechanisms or processes used in obtaining the usable energy from wind, geothermal, tidal and wave energy.
- Students should be able to estimate the power from wind and geothermal using basic techniques and tools.

- Students should have the skills on how to make integrated designs for harnessing energy from the above resources

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. Geothermal: Geophysics , Regional Geothermal Potential; Geothermal energy applications; Harnessing geothermal recourses; Dry Rock and Aquifer Analysis; Technology for Geothermal Resources; Applications: low and high temperature applications; Electricity generation (9 hrs). Wind Energy: Regional wind resources; energy from the wind; characteristics of wind; wind measurement and analysis (The Betz model and Raleigh wind distribution) (6 hrs). Electricity generation; Water pumping, the Design Parameters, cost and environment (9 hrs). Tidal Energy: The cause of tides; enhancement of tides; tidal flow power; tidal power range (6 hrs). Wave Energy: Wane motion; wave energy and power; wave patterns; devises (6 hrs).

References

<u>Core Reading</u>

1. **W.J. Minkowycz and E.M. Sparrow**, Advances in numerical heat transfer, Taylor & Francis Books, 2001.
2 **Leon Douglas Smoot & Philip J. Smith,** Coal Combustion and Gasification, Springer, 1985
3 **Prabir Basu**, Combustion and gasification in Fluidized Bed, CRC Press, London, 2000.

<u>Optional Reading</u>

Karekezi, S. and Ranja, T., "Renewable Energy Technologies in Africa", Zed Books Ltd., London in association with African Energy Policy Research Network (AFREPREN) and the Stockholm Environment Institute (SEI), 1997. – Available in Department Library.

<u>Background Reading</u>

Godfrey Boyle, 2004: Renewable Energy "Power for a Sustainable Future" Second Edition, Oxford University Press. ISBN-0-19-926178-4

RET 7202 Entrepreneurship Development

Short Description

This course covers the development of entrepreneurship. It covers characteristics of entrepreneurs, business planning, financial planning and control, controlling operations and resources. It also covers the practical aspects of forming, running and nurturing a business enterprise.

Aims

The aims of this course are to:

- Give students an appreciation of the role of entrepreneurship in the economy
- Develop an understanding of the requirements and challenges of entrepreneurs and entrepreneurship development
- Explore the options for establishment, operating and managing an enterprise
- Give students the ability to evaluate the success and failure of enterprises

Learning Outcomes

At the end of this course, a student should be able to:

- Identify the key characteristics of entrepreneurs and how they can be developed
- Explain the major functions normally undertaken by entrepreneurs and the options available
- Explain methods used in starting and managing businesses
- Describe strategies for evaluating and nurturing and/or reviving an enterprise

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Case studies of energy services companies will be used. Students will also be required to undertake a business plan or establish a mock enterprise as a team project

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and team project Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

Framework of Entrepreneurship: Definition of entrepreneurship; general enterprising tendencies; unlocking of enterprising tendencies; sources of business ideas; techniques for generating innovative business ideas; evaluation and selection of business ideas; establishing a new business; growing an existing business (12 hrs).

Business Environment*:* Relevant laws and policies in Uganda; business development services; business support organizations; business growth programmes; sources of capital; character of micro, small, medium and large enterprises; local and international competition; the role of technology (12 hrs).

Business plan preparation: Objectives of business plans; main components of business plans(Marketing plan, operations plan, organization and management plan; financial plan); Characteristics of bankable business plans; Negotiation techniques (8 hrs). Activities, decisions and responsibilities to manage the design, production and delivery of renewable energy products and services (2 hours). Critical Review of financial reporting documents, an intial financial assessment of an energy project/investment, and treatment of renewable energy cost/investments in a financial system of a company (5 hours). Project on Business plan preparation by students.

References

Core Reading

G.G. Meredith, R.E. Nelson, P.A. Neck. *The Practice of Entrepreneurship*. ILO, Geneva, 1987.

K. Loucks. ILO, *Training Entrepreneurs For Small Business Creation: Lessons From Experience*. Geneva, 1992.

Optional Reading

P.A. Neck, R.E. Nelson. *Small Enterprise Development: Policies and Procedures*. ILO, 1992.

Background Reading

Jack Gido and James P. Clements *Successful Project Management*
An International Thompson Publishing Company ISBM 0-538-88152-6

RET 7203 Project Management

Short Description

This course covers aspects of project management as applied to engineering, construction and developmental undertaking of a limited duration often called projects. It include the project cycle, project costs, project planning, network techniques, project monitoring and control, and project organisation

Aims

The aims of this course are to:

- Enable students appreciate the role of projects in energy provision
- Give students and understanding of the conduct of projects in all its various aspects such as project planning and management, tendering and procurement.

Learning Outcomes

At the end of this course, a student should be able to:

- Distinguish between a project and a normal operation
- Develop project plans
- Calculate project schedules
- Develop project requirements especially human and financial
- Explain the various project monitoring and control techniques

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques. Case studies of energy project such as dams, energy efficiency improvements and geothermal plants, shall be used.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and team project Work 25%.

Detailed Content

The course will be taught for 14 weeks in a semester.

- **Integration management: T**he Overview to the key (Adaptability) (3 hrs).
- **Scope management:** Project Initiation and Project Planning (3hrs).
- **Time management:** Estimating, time tracking, and performance and progress measurement (project administration) (3 hrs).
- **Cost management:** Estimating performance and progress measurement, Project Initiation stage through business case analysis (3 hrs);
- **Contract management:** This shall include legal aspects of contracts and discussion of standard contracts for procurement of professional services, goods and works (3 hrs)
- **Human resources management**: definition of roles and responsibilities, joint reviews, performance evaluations and project reviews (3 hrs);
- **Communications management**: Project Planning and executed both in Project Execution and Project Wrap-up (the reviews and performance improvement activities in wrap-up represent additional means of communicating project status, success, and process improvement ideas) (3 hrs);

- **Risk management** addressed in Project Initiation, Project Planning, and Project Execution. It is also specifically identified within the Project Approval Process (3 hrs); and
- **Procurement Strategies and Management** is discussed within the Project Initiation Stage (under the business case - options analysis section) (6 hrs).
- **Project Evaluation** will be presented from the project managers' point of view and also from an independent reviewer's point of view (3 hrs);
- **Management of Project Teams;** provision of the skills required to successfully manage project teams successful team culture, assess team members' abilities and make appropriate assignments, then define authorities and accountabilities, including rewards and consequences (3 hrs).

References

Core References

Jack Gido and James P. Clements *Successful Project Management*
An International Thompson Publishing Company ISBM 0-538-88152-6

Frederick L. Harrison, Dennis Lock, Advanced Project Management: A Structured Approach, Gower Publishing, Ltd., ISBN 0566078228, 2003

Scott Berkun, The Art of Project Management, O'Reilly, ISBN 0596007868, 2005.

Optional Reading

Eric Verzuh, The Portable MBA in Project Management, John Wiley and Sons, SBN 0471268992, 2003.

Background Reading

James P Lewis, Fundamentals of Project Management: developing core competencies to help outperform the competition **AMACOM Div American Mgmt Assn, 2007.**

RET 7204 Energy Policy, Planning and Sustainable Development

Short Description

This course covers scope for policy input, Issues, resources, development, Clarifications, Issues and Preferences (consultation), Drafting and discussions, Institutional Framework, Legal framework, Policy implementation. Monitoring, Policy Strategies for Implementation, Energy policy content

Aims

- To provide students with an understanding of the political and institutional aspects of energy.
- To equip students with knowledge on government policy initiatives regarding energy issues.
- To enlighten the students on how energy technology design and concerns can drive policy formulation and implementation

Learning Outcomes

- Students should be able to interpret energy policy issues and understand the possible driving factors to its formulation
- Students will have capacity to relate the purely academic designs with the institutional arrangements with regard to implementation of such designs
- Students can help government in the formulation of new energy policies or revision of the existing ones.
- Students can describe the process for policy formulation from its generation to enforcement.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical/project work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. Introduction (2 hrs), Issues and scope for policy input (3 hrs), Issues, resources, development (3 hrs), Clarifications, Issues and Preferences (consultation) (2 hrs), Drafting and discussions (3 hrs), Institutional Framework (2 hrs), Legal framework (3 hrs), Policy implementation (3 hrs). Monitoring, Policy Strategies for Implementation, Energy policy content (5 hrs). Other policies affecting energy development including the National Environment Management Policy, Gender policy (6 hours). Issues of sustainable development (3 hours), Environmental impact Assessment (EIA) and Environmental Audits (4 hours).

References

<u>All Core References</u>

1. **Winter, G.**, *Blueprint For Green Management,* McGraw-Hill Book Company, London, 1994.
2. **David R. Cope**, *Energy Policy and Land-Use Planning: An International Perspective (International Series in Experimental Social Psychology)*, Pergamon, **ISBN-13:** 978-0080313238
3. **Sam Moyo & Mike Sill,** Energy Policy and Planning in Southern Africa, African Books Collective, Oxford, 1999

RET 7205 Optimization of Energy Systems

Short Description

The course will give an introduction to Optimization of Energy Systems. It presents problems related to balancing energy supply and demand, utilization of different types of resources and conversion processes with due consideration to both investment and running costs as well as the stochastic nature of the behaviour of systems. The course also covers use of tools such as Monte Carlo Simulation.

Aims

The aims of this course are to:

- Explain how complex systems like energy systems can be handled to meet different criteria or objectives
- Expose students to the techniques used by professionals to match energy requirement to available resources
- Describe how investment and running costs affect the cost of energy and how these affect efficiency
- Provide students wit an introduction to advanced techniques of modeling and optimizing energy systems

Learning Outcomes

At the end of this course, a student should be able to:

- Develop energy system models
- Manipulate energy systems models to arrive at optional approaches to their implementation
- Compute the cost of energy from different options
- Use simple simulation tools for energy system specification

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques. Most of the exercise will be of the project type and students will be required to work in teams.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Project Work 25%.

Detailed Course Content

The course will give an introduction to Optimization of Energy Systems. The student shall be empowered to understand problems related to energy supply and demand. An overview of the different types of resources and processes shall be presented with emphasis on electricity generation. The subject shall include planning and coordination of different resources to supply a given market. Investment and running costs of the different options are meant to be taken into account. The student has to be able to calculate the cost of a unit of energy for each case. The advantages of different types of tariff and its relevance on interconnected and not-interconnected system shall be discussed. Introductory description of some stochastic processes such as Monte Carlo Simulation as tools for optimization will be covered.

The course will be taught for 14 weeks in a semester. The course is divided into 10 topics.

a) Introduction to Optimization of energy systems (3 hrs)

b) Fundamentals of supply and demand (3 hrs)
c) Characterization of load demand curves (3 hrs)
d) Investment capital and running costs related to the cost of energy for different sources (6 hrs)
e) Different types of tariffs (3 hrs)
f) Overview of optimization tools and associated solutions (6 hrs)
g) Interconnection and Power exchange - Power Pools (3 hrs)
h) Optimization of small scale power plants (6 hrs)
i) Open Market and deregulation of Power systems (3 hrs)
j) The African Electricity Market from an optimal view point (3 hrs)

References

All Core Reading

1. **Richard E. Putman** (2004), Industrial Energy Systems: Analysis, Optimization, and Control, ASME Press, ISBN 0791802086
2. **Katarina Nilsson** (1990), Mind: Optimization Method for Industrial Energy Systems Institute of Technology, Department of Mechanical engineering, ISBN 9178705991
3. **Albert Thumann, D. Paul Mehta** (2002), Handbook of Energy Engineering, The Fairmont Press, Inc. ISBN 0881733474

RET 8101 Thermochemical conversion Processes and Application

Short Description

The course builds on the 1st year "Bioenergy" course and gives a further in-depth knowledge of relevant fundamental aspects connected to the utilisation of biomass and the biomass fractions of waste streams for energy purposes in thermochemical conversion processes. The major areas are combustion, gasification, paralysis and liquefaction of biofuels. The economic and environmental aspects of thermo chemical processes will be analyzed.

Aims

The aims of this course are to:

- Give students a background for understanding thermo chemical processes to strengthen the first year bioenergy course.
- Provide students with in-depth knowledge of the relevant fundamental aspects connected to the utilisation of biomass.
- Expose the students to practical application of bioenergy conversion systems

Learning Outcomes

- The students have gained core knowledge on advanced thermo-thermal processes
- The students are in position to carry out advanced analysis of real problems in thermal applications

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. Utilization of biomass and the biomass fractions of waste streams for energy purposes in thermochemical conversion processes including combustion, gasification, pyrolysis and liquefaction (12 hrs). Fundamentals, equipment/components, products and applications/systems (9 hrs) and environmental and economic aspects are treated (6 hrs). Case study and project.

Practicals on gasification of Biomass: Estimation of Heating values, optimization of gasification conditions and real plant operations (12 hrs).

References

All Core References

1. **Hugo Karl Messerle** (1969), Energy Conversion statics, Academic Press, University of Michigan, USA
2. **Glenn, Barbara H. Milne, Thomas A. and Brennan, A.H.** (1990), Sourcebook for Methods of Analysis for Biomass and Biomass Conversion Processes, Springer, ISBN 1851665277
3. **Winebrake, James J.** (2004), Alternate Energy: Assessment and Implementation Reference Book, Marcel

Background Reading

Godfrey Boyle, 2004: Renewable Energy "Power for a Sustainable Future" Second Edition, Oxford University Press. ISBN-0-19-926178-4

RET 8102 Biochemical Conversion Processes and Applications

Short Description

The course builds on the 1st year "Bioenergy" course and gives a further in-depth knowledge of relevant fundamental aspects connected to the utilisation of biomass and the biomass fractions of waste streams for energy purposes in biochemical conversion processes for production of 1st and 2nd generation biofuels.

Aims

The aims of this course are to:

- As a specialization unit, this course will empower the student with in-depth knowledge of how to obtain bioenergy by means of biochemical processes using different resources.

Learning Outcomes

- Students will have gained knowledge on Uganda’s potential for ethanol biodiesel production and able to apply advanced approaches/techniques to its production.
- Students can be able to design systems for harnessing ethanol, biodiesel and biogas in the most appropriate way.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students’ understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. The course builds on the 1st year "Bioenergy" course and gives a further in-depth knowledge of relevant fundamental aspects connected to the utilisation of biomass and the biomass fractions of waste streams for energy purposes in biochemical conversion processes for production of 1st and 2nd generation biofuels (6 hrs). This includes biodiesel production (6 hrs), ethanol and other biofuels production (9 hrs). Production processes, equipment/components, applications/systems (9 hrs) and environmental and economic aspects are treated (6 hrs). Case study and project

Practical: Chemical analysis of biomass (6 hrs)

References

All Core Reading

1) **Wang, Lawrence K. and Pereira, Norman C.** (1980), Handbook of Environmental Engineering, Hamana Press, ISBN 0896030083
2) **Sims, Ralph E.H.** (2002), The Brilliance of Bioenergy: In Business and in Practice, James & James/Earth scan, ISBN 1902916
3) **Winebrake, James J.** (2004), Alternate Energy: Assessment and Implementation Reference Book, Marcel
4) **Glenn, Barbara H. Milne, Thomas A. and Brennan, A.H.** (1990), Sourcebook for Methods of Analysis for Biomass and Biomass Conversion Processes, Springer, ISBN 1851665277
5) **Blauch, Harvey W. and Clark, Douglas S.** (1997), Biochemical Engineering, CRS Press, ISBN 0824700996

Background Reading

Godfrey Boyle, 2004: Renewable Energy “Power for a Sustainable Future” Second Edition, Oxford University Press. ISBN-0-19-926178-4

RET 8103 Design and Modeling of Thermal Power Systems

Short Description

The course deals with theoretical and practical aspects connected to plant design for different types of bioenergy plants for power generation and combined heat and power (CHP) generation. Modeling of plant subcomponents and complete plants will be carried out using engineering modeling tools. The plant (energy) models will be coupled to cost analysis, GHG analysis and sensitivity and risk analysis, providing a clean energy awareness, decision-support and capacity building tool.

Aims

The aims of this course are to:

- Equip students with knowledge on different types of energy production plant design, including combined heat and power, their models and the analysis required to completely characterize them.
- Provide students with the capacity to do energy models of complex thermal power plants.
- Give students a thorough understanding of system functions and integration that can be used to improve the plant performance and quality by analyzing the plant functions and performance and optimize the processes.

Learning Outcomes

At the end of this course, a student should be able:

- Describe different type of thermal power plants
- Formulate appropriate models to define the characteristics and performance of thermal power plants
- Determine unknown characteristics and performance parameters from known values
- Use different models for power plant modeling and design

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques. In addition, visits shall be arranged to thermal power plants around the country.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. Detailed course content consists of the following topics;

- Plant design and modification concepts (2 hrs),
- Plant design phases;
    - Conceptual or system analysis phase,
    - Detailed design phase - produces the final design product, and
    - Design implementation phase - detailed design package (6 hrs)

- Design audits (6 hrs),
- Analysis Verification (3 hrs),
- Design Review (3 hrs)
- Plant simulations

    - Computer support tools like computer aided design (CAD) groups,
    - Hardware support for designing structures and systems,

- o Web layouts and graphic design,
- o Evaluation of network layout and propose optimum plant solutions (6 hrs).

- Financial analysis (3 hrs)
- Environmental aspects and economics of power generation from Renewable energy (3 hrs).
- Recent developments, future trends, and societal issues in power industry (3 hrs). Case study and Project

Practical: Exercise on Plant Design and Simulation using standard tools (Simulations software) (6 hrs)

References

<u>All Core Reading</u>

1) **Timmerhaus, Klaus D.** (2003), Plant Design and Economics for Chemical Engineers, McGraw Hill, ISBN 0072392665
2) **Bassel, William D.** (1990), Preliminary Chemical Engineering Plant Design, Springer, ISBN 04422344406
3) **Bequette, B. Wayne** (2002), Process Control: Modeling, Design and Simulation, Prentice Hall, ISBN 1001335366408
4) **Bumble, Stan** (2000), Compouter Simulated Plant Design for Waste Minimization/Pollution Prevention, CRC Press, ISBN 1566703522

RET 8104 Solar Cell Technology

Short Description

The course will cover advanced semiconductor physics, Solar cell principles, Silicon solar cell technology, Module production, Production, Economics/lifetime and other cells technologies. The course will focus strongly on the recent and most promising technologies for cell production and the performance analysis of such cells.

Aims

- To provide students with knowledge in the fundamentals of the photovoltaic generator and the physics and chemistry of the production processes.
- To equip students with a deep understanding of how solar cells operate and which factors determine the efficiency of a system.
- To make the students understand the different phases of the production process and be able to communicate with experts in the entire PV value chain.
- To provide students with knowledge in characterization techniques and skills to demonstrate them.

Learning Outcomes

- Students are in position to explain the fundamentals of the photovoltaic generator and the physics and chemistry of the production processes.
- The students are able to determine efficiency of solar cells and can explain the factors that lead to such efficiency values.
- Students can critically analyze different phases of the production process of solar cells.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

General: Properties of light, Wave and Particle duality (3 hrs), Semiconductor physics: Crystal structure, Band model, Direct and indirect band gap, Electrons and holes, Fermi level, Doping (6 hrs). Solar cell principles: Absorption of light, Generation and recombination of carriers, Effect of impurities and defects, Carrier transport, PN Junction, Dar characteristics, Illuminated characteristics, Solar cell output parameters (I-V Curve), Efficiency limits (6 hrs). Silicon solar cell technology: Production of metallurgical grade silicon, Production of electronic grade and solar grade silicon, Crystallization, Czochralski, Multi-crystalline, Float zone, Ribbons, Wafering, Solar cell production, PN Junction formation, Texturisation, Anti-reflective coating, Surface passivation, Metal contact formation and Advanced cell structures (8 hrs). Module production: Interconnection, Bypass and blocking diodes, Lamination, Module lifetime and Recycling (4 hrs). Amorphous silicon technology: Structure, Hydrogenetion, Staebler-Wronski effect, Production, Economics and lifetime (6hrs). Other cells technologies: CIGS (Copper Indium Gallium Salenide), CdTe (Cadmium Telleride), Concentrator, Organic / Dye sensitized and Plastics (3 hrs). Case study and project.

Practical: There will be no laboratory exercises. The course will be complemented by video shows demonstrating solar cell production processes (4 hrs).

References

<u>All Core Reading</u>

1. **Martin A. Green** - Solar Cells: Operating Principles, Technology and System Application - University of New South Wales - Kensington, Australia – 1998

2. **Jenny Nelson** - The Physics of Solar Cells - Imperial College Press - London, United Kingdom – 2003
3. **Tomas Markvart** - Solar Electricity - John Wiley & Sons, Ltd - Chichester, New York, Weinheim, Brisbane, Toronto, Singapore - Second Edition, 1994
4. **Martin A. Green** Silicon Solar Cells: Advanced Principles & Practice Centre for Photovoltaic Devices and Systems University of New South Wales, Kensington, Australia1995

RET 8105 Electrical Energy Conversion in Photovoltaic systems

Short Description

The course *PV* encompasses complete engineering studies for real-life applications (both stand alone and grid connected).The course presents advanced concepts of photovoltaic system integration and their accessories and auxiliary units. It addresses the electrical characteristics and modeling of solar cells and modules. Solar panels, converters and module design are addressed in depth.

Aims

- Provide students with skills on specifying and designing system components and to build power supplies with energy optimal interface between the PV panel and load.
- To provide students with knowledge necessary in building PV modules

Learning Outcomes

- Students should be able to distinguish between various PV types and estimate their efficiency using the knowledge obtained.
- Students should be able to design PV modules for different applications
- Students should be able to carry out tasks of designing modules

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

Photovoltaic system description (3 hrs), Electrical characteristics and mathematical modeling of solar cells and modules, Maximum Power Point Tracking – MPPT (3 hrs), Power electronics converters, Power switches, Power transistor and power diodes, Switched Mode (DC-DC) Converters, Design of feedback controllers for switched mode power supply, DC-AC Converters (Inverters) (8 hrs), Energy storage, Batteries, Super capacitors, Hydrogen (6 hrs), Applications: Stand alone systems, Hybrid systems, Grid connected systems, Micro grid systems, Water pumping systems (6 hrs), Economics of photovoltaic systems (3 hrs), Integration of photovoltaics in future energy systems (2 hrs), a Case study on sizing of photovoltaic systems (3 hrs). Case study and project.

Laboratory Demonstrations: The laboratory work will demonstrate practical use of photovoltaic systems. Spice, a Circuit Analyser Programme, HOMER a Hybrid Off Grid system analyser programme and Lab View Software will be used during desk top laboratory works. AC Power measurements, Experiments with simple

Electromechanical Energy Conversion Systems and simple Power Electronics Experiments (8 hrs).

References

<u>All Core Reading</u>

1. **Stuart R. Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish** - Applied Photovoltaics - Centre for Photovoltaic Engineering – Australia 2006
2. **Martin A. Green** - Solar Cells: Operating Principles, Technology and System Application - University of New South Wales - Kensington, Australia – 1998
3. **Jenny Nelson** - The Physics of Solar Cells - Imperial College Press - London, United Kingdom – 2003
4. **Tomas Markvart** - Solar Electricity - John Wiley & Sons, Ltd - Chichester, New York, Weinheim, Brisbane, Toronto, Singapore - Second Edition, 1994
5. **France Lasnier and Tony Gan Ang** - Photovoltaic Engineering Handbook - Adam Hilger Bristol - New York,1990
6. **Martin A. Green**, "Silicon Solar Cells: Advanced Principles & Practice", Centre for Photovoltaic Devices and Systems University of New South Wales, Kensington, Australia1995

RET 8106 Solar Thermal Technology

Short Description

The course focuses on the advanced techniques of concentrating solar energy for thermal applications. Combined heat and power generation from the sun is also studied, including understanding different types of systems and general design concepts, the components required in them and economic analysis of the systems.

Aims

- To give students a broad introduction to photovoltaic solar electricity production and solar thermal energy.

- To equip students with knowledge in utilization of solar energy using various systems,
- To provide students with practical knowledge of how solar energy works, and so that they are able to put it into practical applications in the places they come from.

Learning Outcomes

- Students are able to explain various technologies used in tapping solar thermal power.
- Students can analyze and design equipment for solar power production

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester. The course is divided into 14 topics each lasting 3 hours.

1. Introduction to solar thermal systems.
2. Heat transfer analysis of flat plate collectors
3. Tracking
3. Concentrating collector

4. Evacuated tube collectors
5. Design concepts for solar collectors
6. Energy storage in solar thermal systems
7. Solar process loads
8. Measurement and data analysis
9. Materials for solar thermal systems and their properties (heat transfer materials, absorber surfaces, glazing and insulating materials)
10. Performance characteristics of solar collectors
11. Measurement and data analysis
12. Modelling of solar thermal systems
13. Solar thermal applications: Solar thermal power plants (concentrating systems, lenses, solar towers), water heating systems, drying, cooking, cooling/refrigeration and solar thermal applications in building, hybrid systems
14. Economic analysis of solar thermal systems
15. Case study and Project

Practicals

Solar collector heat loss measurements; testing of various solar thermal devices and systems (driers, water heaters, cookers); simulation and modeling exercises (10 hrs)

References

<u>All core Reading</u>

1. **Goswami, Y.D., Brown, R.C.,** Principles of Solar Engineering, Taylor & Francis Books, London, 2000.
2. **Lee, S.,** Alternative Fuels, Tylor & Francis Books, London, 1996.
3. **Larson m, Ronal & Ronald E. West, Ronald E.** Implementation of Solar Thermal Technology (Solar Heat Technologies) ISBN: 0262121875
4. **Lunde, P. J.**, "Solar Thermal Engineering: Space Heating and Hot Water Systems", John Wiley & Sons, New York, 1980.

5. **John A. Duffie, John A. & Beckman, Wiiliam A.**, Solar Engineering of Thermal Processes, 3rd Edition, 2006

RET 8107 Design and Maintenance of Hydropower Electro-Mechanical Equipment

Short Description

The course provides a recap of the machinery used in converting the water power to electrical power. It includes analysis of turbines, system support equipment, generators, and transformers. Aspects of running and maintenance of equipment will be addressed.

Aims

- Present all aspects of hydropower mechanical equipment from reservoirs to the power house
- Present basic designs and selection knowledge for hydro turbines
- Present basic and applied knowledge on dynamic system behavior and governor stability.
- Introduction on electrical equipment to be given.
- Give the student a deeper understanding and competence on mechanical and electrical equipment on hydropower production.

Learning Outcomes

- Students are able to explain the processes of converting potential Energy of the water to Electric power in large power plants.
- Students are able to specify turbines, generators and other auxiliary equipment.
- Students are equipped with an understanding of basic and applied knowledge on dynamic system behavior and governor stability.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

Fluid energy and hydraulic turbines, turbine capacities, categories – low and high head turbines, impulse and reaction turbines, turbine theory and applications, selection of turbines (6 hrs). Dimensioning of Francis turbines, dynamic behavior, surges water hammer, governor stability, wicket gates, dimensioning of spiral casing (6 hrs). Dimensioning of pelton turbines, jets and pump-turbines (3 hrs). Performance curves of turbines, turbine specific speed, cavitations, Thoma coefficient, and peripheral velocity coefficient Rotational speed of turbine (6 hrs). Propeller turbines, bulb turbines (2 hrs). valves, types of gates, Draft tube, tailrace (3 hrs) Generators, transformers, excitation (6 hrs). Case study and project.

Practical: Efficiency of turbines on a turbine rig and Turbine – Pump Performance and Impulse of a jet on surfaces (10 hrs)

References

<u>All Core Reading</u>

1. **Thanikechalam, V**, Hydraulic and Hydraulic Machinery, Tata McGraw Hill Publishing Company Ltd – New Delhi, ISBN -0-07-4604434-1
2. **Bansal, R.K.**, Fluid Mechanics and Hydraulic Machines, Laxmi Publications 2005

3. **J.S. Gulliver, R.E.A Arndt**. Hydropower Engineering Handbook, McGraw Hill Inc. 1991 ISBN. 0-07-025193-2
4. **David Japikse, Nicholas C. Baines**, Introduction to Turbo machinery, Oxford University Press 1994. ISBN 0-19-856525-9
5. **F. de Sievuo, A. Lugaresi,** Modern Trends in selecting and designing Pelton turbines, Water Power and Dam Construction, December 1978.
6. **Calvin C. Warnick**, Hydroelectric Power Plants Design and Construction, 1984, ISBN 0134484983.
7. **Clifford Matthews**, Engineers' Guide to Rotating Equipment: Pocket Reference, John Wiley and Sons, 2002.

RE 7108 Hydraulic Structures in Hydropower

Short Description

This course covers the civil structures in large hydropower development. Development of dams is discussed in detail. The design methodology of constructing the physical structures for housing the power house and all the flow pathways are discussed with due consideration of the standards required.

Aims

- To provide students with the knowledge and skills to design and construct the hydraulic structures required in hydropower plants.
- To provide students with the capacity to design and select the appurtenant structures on dams.
- To equip students with a thorough understanding of reservoir operations and problems.

Learning Outcomes

- Students should be able to design hydraulic structures required in hydropower plants.
- Students should be able to participate in the construction of dams and reservoirs.

- Students are presented with the design and selection methods for the appurtenant structures on dams
- Students grasped the reservoir operations and problems

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

Dams and barrages, classification of dams, design concepts and criteria, data topographical, geological, hydrological (6 hrs). Reservoirs data, reservoir problems, sedimentation in reservoirs, planning of dams, mass curve analysis, seepage through embankment dams, slope stability, Concrete Dams, types of concrete dams, spillways, classification, types of spillways, weirs, side channel, siphon, shaft types, design concepts and criteria, energy dissipation, terminal structures, stilling basins, bucket dissipaters (12 hrs). Diversion and intake works, trash racks, water conveyance structures, canals, pressure tunnels penstocks, water hammer surge chambers (8 hrs). Power house layout options and components – machine hall, generators, exciters, transformer, synchronization, switch room, battery room, and control room (9 hrs). Draft tube and tailrace (3 hrs). Case study and project

Practical: Specific energy experiments in open channels, Surge tank experiments (10 hrs)

References

All Core Reading

1. **Thanikacham, V.**, Hydraulics and Hydraulic Machinery, Tata McGraw Hill Publishing Co. Ltd. 1994
2. **Sherard, Wordwand Gizienski and Clavenger**, Earth and Earth rock dams
3. **Massey, B.S.**, Mechanics of Fluids, -Van Natrand Reinhold
4. **Dandekan, M.M. sharma K.N.**, Waterpower Engineering, Vikas Publishing House – India (1991)
5. **Arved J. Raudkivi A.A. Balkema**, Sedimentation Exclusion and Removal of Sediment from diverted water, Rotterdam – 1993
6. **Maurice Albertson, Rahim KIA, A.A. Balkema**, Design of Hydraulic Structures 89, Rotterdam – 1989
7. **U.S. Department of Interior** – Bureau for Reclamation, Design of Small Dams, Oxford, IBH Publishing Co. Pvt. Ltd – 1984

RET 8109 Development of small Hydropower

Short Description

This course addresses the aspects for developing small hydropower for rural/remote applications. It presents the techniques for estimating the resource potential, the various turbines used, and all the auxiliary equipment that is required. Challenges for small scale hydropower development will be looked at.

Aims

The aims of this course are to:

- Ensure that students appreciate the role of hydropower in today's energy mix
- Guide students through the procedures and requirements for design and analysis of power plants
- Instruct students on the tools used in the analysis and design of hydropower schemes with emphasis on mini and micro plants

Learning Outcomes

At the end of this course, a student should be able to:

- Distinguish between the different hydropower schemes
- Explain how the various tools and procedures are used in the design and analysis of power plants
- Compute key characteristics of a small hydropower scheme given detailed data

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment Method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical Work 25%.

Detailed Course Content

The course will be taught for 14 weeks in a semester.

Energy for Rural development (3 hrs) Measurements – discharge and head (2 hrs). Estimation of a flow duration curve, design flow Determination of power and energy potential (4 hrs). Site selection and layout, water diversions civil works, fore bay, water conveying structures, penstocks, gates, valves, tailrace (6 hrs). Sediment problems, settling tanks (3 hrs). Turbine specifications, cross flow turbines, pelton, turgo Francis, Kaplan runners, options for coupling (5 hrs). Generators – synchronous and asynchronous, voltage, phase frequency, switch gear and protection equipment (6 hrs). Mechanical versus Electrical Energy options AC versus DC generation (6 hrs). Governing, phase control, power transmission, inverters (3 hrs).

Economic considerations – cost benefit approach for socio-economic selection (3 hrs). Case study and project.

Design Exercises Students will be allocated real field conditions for case study designing and submission of full project report **(8 hrs).**

References

<u>All Core Reading</u>

1. **US Bureau of Reclamation**, Design of Small Dams, Oxford and IBH Publishing Co. Pvt Ltd – 1984
2. **Allen R. Inversion**, Micro hydropower Sourcebook, NRECA International Foundation – Washington DC - 1990
3. **R. Holland**, Energy for Rural Development, International Water Power and Dam Construction Vol. 34 NR. 12 December 1982
4. **Juan Mala**, Design Criteria for Typical Civil Works for Mini hydropower plants projects, Small Hydropower Plants"NRECA 1980
5. **Uli-Meir,** Local Experience with Micro-hydro Technology , SKAT – ATOL, St. Gallen, 1985
6. **Uli Meir, Eisenring M, Chapallaz J.M.**, Civil Enginering in Micro hydro projects, SKAT, 1986

RET 8110 HEAT TRANSFER AND THERMAL INSULATION IN BUILDINGS

Objectives: This cause is envisaged to provide the learners with theories and techniques which will allow house designers or architect design and construct houses that consume minimum energy. At the end of the course, the candidates will be able to use advanced design techniques which uses natural phenomenon more than the artificial conditions.

Delivery:
Lectures: Tutorials, seminars and laboratory demonstrations and practicals.

Course Content: The following topics will be covered:

- Heat and mass transfer in buildings – Heat transfer, measurements of fluid flow, the role of fluid flow on heat transfer,
- Building insulation – Air tight envelop, insulation materials, insulation sizing and characterization,
- Low energy buildings
- Passive house – Standard space heating requirements, passive solar design, super-insulation, window technology, ventilation, space heating, air tightness, lighting and electrical appliances. Case study and project

Assessment: Coursework 40% & Written University Examination 60%

Reference Books:

1. **Francis A. Govan, David M. Greason, John D. McAllister** (1983). ASTM Committee C-16 on Thermal Insulation, Oak Ridge National Laboratory, ASTM International, United States Dept. of Energy ISBN 0803102305
2. **R. P. Tye** (1979). Thermal Transmission Measurements of Insulation, ASTM International, ISBN 0803105894

3. European Passive Solar Handbook, preliminary edition. Edited by P Achard and R Gicquel. Commission of the European Communities, 1986.
4. **M Santamouris and D. Asimakoloulos.** Passive Cooling of Buildings. James and James, London, 1996.
5. **F. Allard,** editor. Natural ventilation in Buildings. James and James, 1999.
6. **E. Maldonado, editor**. Efficient Ventilation Techniques for Buildings. DG TREN, THERMIE report, University of Porto, 2000.
7. Chapter 1 Low Energy Architecture TAREB Integration with Building Service Sandberg, M. "What is Ventilation Efficiency?" Building and Environment, vol.16 (1981), pp.123- 135.
8. Review of Low Energy Cooling Technologies", Annex 28 of the International Energy

RET 8111 LOW ENERGY BUILDINGS DESIGN

Objectives

- To equip students with an understanding of the design principals and techniques used to create energy efficient buildings and enable them to make informed critical evaluations of low energy architectural proposals.
- To enable students understand how low energy buildings affect the design decisions
- Introduce students to the interdependence of design, cultural, technological and scientific factors in producing low energy buildings.

Course Outline

- Renewable energy concept in the heating and cooling systems in buildings, landforms, building envelope, elements, and building forms as relates to energy, thermal mass, building energy management system, smart energy systems, innovative materials for low energy buildings. Energy in urban environment. Case study and project

Assessment: Coursework 40% & Written University Examination 60%

References:

1. European Passive Solar Handbook, preliminary edition. **Edited by P Achard and R Gicquel**. Commission of the European Communities, 1986.
2. **M Santamouris and D. Asimakoloulos.** Passive Cooling of Buildings. James and James, London, 1996.
3. **F. Allard, editor**. Natural ventilation in Buildings. James and James, 1999.
4. **E. Maldonado, editor**. Efficient Ventilation Techniques for Buildings. DG TREN, THERMIE report, University of Porto, 2000.
5. Chapter 1 Low Energy Architecture TAREB Integration with Building Service **Sandberg, M**. "What is Ventilation Efficiency?" Building and Environment, vol.16 (1981), pp.123- 135.
6. Review of Low Energy Cooling Technologies", Annex 28 of the International Energy Agency, Energy Conservation in Buildings and Community Systems Programme**. Natural Resources Canada**, December de 1995.
7. **Mark Zimmermann e Johnny Andersson.** "Case Study Buildings, Low Energy Cooling", Annex 28 of the International Energy Agency, Energy Conservation in Buildings and Community Systems Programme. EMPA, Switzerland, 1998.

RET 8112 ENERGY COMFORT IN BUILDINGS

Objectives

- To develop an understanding of the concept of low energy buildings in the context of renewable energy without sacrificing occupant comfort in buildings
- To appreciate the techniques and design principles for energy efficient buildings.
- To equip students with an understanding of the design principals and techniques used to create energy efficient buildings

Course Outline: Energy, Environment and climate: Looks at climatic zones and climatic factors, effect of climate in buildings, measurement of energy in buildings, thermal balance, heating and cooling, buildings and environment, integration of renewable energies in buildings. Energy Consumption for human comfort, related standards, adaptive approach, Energy balances, lighting and visual comfort, indoor day lighting improvement. Case study and project.

Practical: Light distribution measurements in buildings, Temperature distribution measurements in buildings

Assessment: Coursework 40% & Written University Examination 60%

References:

1. **Yeang, K.** Bioclimatic Skyscrapers Artemis, London, Zürich, München, 1994
2. **Koenigsberger, Ingersoll, Mayhew, Szokolay** Manual of Tropical Housing and Building Longman, London, 1974
3. **Recknagel, H., Sprenger, E., Schramek, E.R.** Taschenbuch für Heizung + Klima Technik R. Oldenbourg Verlag, München, Wien, 1995
4. **Daniels, Klaus** Advanced Building Systems; A Technical Guide for Architects and Engineers Birkhäuser Verlag, Basel, 2003

Assessment: Coursework 40% & Written University Examination 60%

RET 8201 Thesis Project

Brief Description

After completing all coursework, each student commences with a thesis project on which he/she typically works over a period of 5-6 months (10 CU)). The thesis project should deal with a clearly defined topic from the domain of renewable energy and under the condition that competent guidance/supervision is available to the student throughout the thesis project period. The project may be carried out either in an academic environment (university, research institute, or equivalent) or in an industrial setting (power plant, energy consulting agency, or other industry/business).

13 BUDGET

Appendix: Programme Costing (2007/2008)

Master of Science in Renewable Energy

A.	**Income**			**Amount(Ushs)**
	Students x Tuition Fees		6 x 3,000,000 + 4 x 5,000,000	38,000,000
	Total			**38,000,000**
B.	**Expenses**			
a)	University Council	25%		9,500,000
b)	Teaching Expenses	41%		15580000
c)	Administrative Expenses	5%		1900000
d)	Office Expenses	3%		1140000
e)	Laboratory Materials	2%		760000
f)	Library Materials	2%		760000
g)	Utilities/Furniture	1%		380000
h)	Faculty Levy	5%		1900000
i)	Staff Development	2%		760000
j)	Computer Laboratory	4%		1520000
k	Air ticket for visiting professors	10%		3800000
	Total	100%		**38,000,000**

Note: **Teaching Expenses:**

Lecturers at 40,000/= per contact hour

Note: Fees are Ushs. 3,000,000 for Ugandans and Ushs. 5,000,000 for international students.