Savitribai Phule Pune University
Faculty of Science & Technology

Curriculum/Syllabus

For

Honors in "Energy Management in Utility Systems"

Bachelor of Engineering
(Choice Based Credit System)

Honors in Major Disciplines of Mechanical Engineering, Mechanical Engineering (Sandwich), Automobile Engineering and Electrical Engineering - (2019 Course)

Board of Studies – Mechanical and Automobile Engineering

(With Effect from Academic Year 2021-22)

Savitribai Phule Pune University

Board of Studies - Automobile and Mechanical Engineering

Undergraduate Program - Mechanical Engineering (2019 pattern)

Honors in "Energy Management in Utility Systems"

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-V														
302021MJ	Energy Management	4	-	-	30	70	-	-	-	100	4	-	-	4
302022MJ	Energy Modelling Lab	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VI														
302023MJ	Energy Efficiency of Thermal Utilities	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**4**	**-**	**-**	**4**
Semester-VII														
402024MJ	Electrical Energy Systems	4	-	-	30	70	-	-	-	100	4	-	-	4
402025MJ	Lab Practice	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VIII														
402026MJ	Sustainable Energy Conversion Systems	4	-	-	30	70	-	-	-	100	4	-	-	4
402027MJ	Energy audit Practice/Field Visit	-	-	2	-	-	50	-	-	50	-	-	2	2
	Total	**4**	**-**	**2**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**-**	**2**	**6**

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

1.Rules and Regulations for Honors / Minors Programs

R1.1 It is absolutely not mandatory to any student to opt for Honours or Minors Program. Choice is given to individual student to undertake Honors/Minors programs from the third year engineering (Fifth Semester) to fourth year engineering (Eighth Semester). Honors/Minors programs will be opted from offered programs by SPPU. Once selected he/she will not be permitted to change the Honors/Minors program in forthcoming semesters.

R1.2 The registration for Honors/Minors Programme will lead to gain additional credits to such students. The result of Honours/Minors Program will get reflected in ledgers to be maintained at University only. After the completion of the Honors/Minors program by concerned students, details of credits earned in Honors/Minors program be printed in the mark sheet of eighth semester. For those students, who will not be able to complete Honors/Minors program, details about the additional credits earned will not get printed.

R1.3 Credits earned through registration and successful completion of the Honors/Minors Programme will **not** be considered for the calculation of SGPA or CGPA.

As per the standard practice, SGPA and CGPA calculations will be done with common base only by considering mandatory credits assigned for the Bachelor programme as per the structure approved by the Academic Council.

R1.4 Students once registered for the programme need to complete all credits assigned for the specific Honors and Minors Programme in the period of 4 years from the Semester-V. Degree with Honors/Minors will be awarded only after the completion of Honors/Minors Programme along with respective UG program degree.
Student may opt to cancel the registration for Honors/Minors within this period of 4 years. After 4 years expire automatically Bachelor's degree will be awarded to such a student provided he/she has earned the credits needed for graduation.
R1.5 Backlog Honors/Minors courses will not contribute in the decision of A.T.K.T.

2. Examination Scheme:

R2.1 Examinations for Honors/Minors Program will get organized at the University Level. Question paper will be common for all students who had opted/registered for the specific Honors/Minors Program. Evaluation of answer books for Honors/Minors program will be done at the university level.
R.2.2 Additional examination fees as per prevailing rules and regulations will be charged from those students who had registered for Honors/Minors Program to match the expenses for paper setting and the assessment of answer books at the CAP Centre.

Instructions:

- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**

302021MJ: Energy Management					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses: Systems in Mechanical Engineering, Basic Electrical Engineering, Engineering Thermodynamics, Applied Thermodynamics

Course Objectives:

1. To familiarise Global and Indian energy scenario.
2. To make student conversant with energy policies.
3. To study energy audit methodology and energy economics.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. DEMONSTRATE general aspects of Energy management
CO2. ILLUSTRATE different energy policies.
CO3. SUMMARIZE and explain need of energy audit and energy management.
CO4. DEMONSTRATE energy audit instruments.
CO5. ILLUSTRATE basics of energy economics and financial analysis techniques
CO6. ILLUSTRATE environment impact of Energy systems and climate change.

Course Contents

Unit 1	**Global Energy scenario**

Various Energy Sources, Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and Projected future demands. Depletion of energy sources and impact of exponential rise in energy consumption on economies of countries, Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics.

Unit 2	**Indian Energy scenario**

Energy resources & Consumption: Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy Consumption, Energy need of Growing economy, Status of Nuclear and Renewable Energy: Present Status and future promise, Need for use of new and renewable energy sources. Electricity pricing in India, Energy security, Energy conservation and its importance.

Unit 3	**Energy Policy**

Energy Conservation act-2001 & its features, Schemes of BEE under Energy Conservation Act-2001-ECBC, Green Building, Net Zero Energy Building (NZEB), Building as an Energy System, Energy Saving Approaches for Building, Passive Designs, S&L, DSM, BLY, SME's, Designated consumers, certification of Energy auditors and managers, PAT scheme, Electricity Act-2003, Integrated Energy policy, National Action Plan on Climate Change (NAPCC).

Unit 4	**Energy Audit**

Energy Management: Definition of Energy management and objectives, ISO 50001 to Manage Energy Effectively, Energy Performance Approach, Relationship between Energy Performance and

the EnMS, Plan-Do-Check-Act (PDCA) cycle, Benefits of Implementing ISO 50001, New ISO 50001 Version, Requirements of ISO 50001:2018 Clauses (S.No. 1 to 10) correspond with clause numbers of the Standard)

Energy audit- definition and need, Types of Energy audit, Energy audit methodology, Energy audit instruments, Energy audit reporting, Analysis and recommendations of energy audit, Benchmarking of Sectorial Energy Efficiency, Energy audit software.

Unit 5	**Energy Economics**

Need of Investment, Costing of Utilities - Determination of cost of steam, natural gas, compressed air and electricity, Financial Analysis Techniques - Simple payback period, Time value of money, Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis.

Unit 6	**Environmental Impact and climate change**

Energy and Environment, Global environmental issues- Acid rain, Ozone layer depletion, Global Warming and climate change, Loss of biodiversity. International agreements: United Nations Framework convention on climate change (UNFCCC), Conference of Parties (COP), The Kyoto Protocol, Clean Development Mechanism (CDM).

Books and other resources

Text Books:

1. Energy Management Principles, C.B.Smith, Pergamon Press
2. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press

References Books:

1. TEDDY Year Book Published by Tata Energy Research Institute (TERI).
2. World Energy Resources: Charles E. Brown, Springer2002.
3. 'International Energy Outlook' -IEA annual Publication
4. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc., 5th Edition, Georgia.
5. BEE Reference book: no.1/2/3/4.

Web References:

1. www.aipnpc.org
2. www.beeindia.gov.in

302022MJ: Energy Modelling Lab					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Engineering Graphics, Solid Modelling & Drafting, Engineering Thermodynamics

Course Objectives:

1. To aware about energy scenario of commercial buildings.
2. To understand energy performance of buildings.
3. To develop the essential skills for energy modeling of buildings through software like e-Quest.

Course Outcomes:

On completion of the course, learner will be able to

CO1. DEVLOPE Energy model of building
CO2. EXPLAIN factors involved in energy efficient buildings
CO3. ASSESS energy performance of building

Guidelines for Laboratory Conduction

Link to download e-Quest open source software

https://www.doe2.com/equest

Term Work

The learner shall complete following activities as a Term-Work:

Basic Energy modeling of minimum two floor building with Schematic Design (SD) Wizard in e-Quest software/Design builder and preparation of detailed report. Following methodology shall be followed for energy modeling and simulation.

1. Modeling of minimum two floor building.
2. Apply Building Envelope Construction.
3. Apply Exterior openings and features.
4. Apply for activity and schedule.
5. Apply internal loads like lighting, HVAC, etc.
6. Complete the simulation

302023MJ: Energy Efficiency of Thermal Utilities					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses: Systems in Mechanical Engineering, Engineering Thermodynamics, Applied Thermodynamics.

Course Objectives:

1. To provide detailed understanding of energy efficiency of Thermal utilities.
2. To assess the energy performance of Thermal utilities.
3. To make student conversant with energy conservation opportunities in Thermal Utilities.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. EXPLAIN thermal utilities and their function.
CO2. DEMONSTRATE energy efficiency of thermal utilities.
CO3. ASSESS energy efficiency of thermal Utilities
CO4. ILLUSTRATE energy conservation opportunities in thermal utilities.
CO5. DEMONSTRAE best practices in Thermal Utilities.

Course Contents

Unit 1	**Fuels and Combustion**

Introduction of fuels, Properties of solid, liquid and Gaseous fuels, Properties of Agro residues, combustion, Combustion of oil, coal and gas, Draft system and combustion control.

Unit 2	**Boilers and FBC**

Boilers: Types, Combustion in boilers, Performance's evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities.

FBC: Introduction, Mechanism of fluidized bed combustion, Advantages, Types of FBC boilers, Operational features, Retrofitting FBC system to conventional boilers, Saving potential.

Unit 3	**Steam Distribution and Utilization**

Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings.

Case study related to steam distribution and utilization

Unit 4	**Furnaces**

Types and classification, Performance evaluation, Various losses in furnace, Instruments required to monitor the furnace, General fuel economy measures in Furnace.

Insulation and Refractories: Purpose, Types of Application, Calculation of Insulation Thickness and simplified formula for heat loss, Economics Thickness of Insulation, Refractories classification, its properties, Typical refractories in Industrial Use, Selection of refractories, and Heat losses from Furnace walls.

Unit 5	**Cogeneration**

Need of cogeneration, principle of cogeneration, Steam turbine cogeneration systems, Gas turbine cogeneration systems, reciprocating engine cogeneration systems, Classification of Cogeneration

Systems, Factors Influencing Cogeneration Choice, Important Technical Parameters for Cogeneration, Quality of thermal energy needed, Prime Movers for Cogeneration, Typical Cogeneration Performance Parameters, Merits of Cogeneration Systems, Case Study related to cogeneration in sugar industry. Tri-generation

Unit 6	**Waste Heat Recovery**

Waste heat recovery-Sources of waste heat and its potential applications, Waste heat survey and measurements, Data collection, Limitations and affecting factors, Heat recovery equipment and systems, Heat Exchangers, Incinerators, Regenerators and Recuperates, Waste Heat boilers, System Integration.

Books and other resources

Text Books:

1. Boilers – Types, Characteristics and functions – Carl D. Shields (Mc-Graw Hill book)
2. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)
3. Refractories and their Uses – Kenneth Shaw, (Applied Science Publishers Ltd.)

References Books:

1. Handbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, Press, New Delhi, 2006
2. Boiler Operator‘s Guide Fourth Edition, Anthony L Kohan, McGraw Hill
3. BEE Reference book: no.1/2/3/4.

Web References:

1. www.aipnpc.org
2. www.beeindia.gov.in

402024MJ : Electrical Energy Systems					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**04 Hrs/Week**	**Theory**	**04**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses

Basic Electrical Engineering, Systems in Mechanical Engineering, Engineering Thermodynamics, Applied Thermodynamics

Course Objectives

1. To familiarise with Electrical utilities.
2. To make student conversant with Electrical energy management.
3. To assess energy efficiency of electrical utilities

Course Outcomes

On completion of the course, learner will be able to

CO1. DEMONSTRATE energy efficiency of electrical utilities.
CO2. DEMONSTRATE energy saving opportunities in electrical utility systems
CO3. EXPLAIN assessment of T&D losses in power systems.
CO4. SUMMARIZE energy efficient lighting.
CO5. DEMONSTRATE electricity bill.

Course Content

Unit 1	**Electrical Systems**

Introduction to Electrical power supply system, Cascade efficiency, Transformers types, Transformer losses and efficiency, Energy efficient transformers, Standard and labelling programme of distribution transformer. Electricity bill: kWh and kVAh billing.

Power Factor Improvement: methods of power factor improvement and its benefits, selection and location of capacitor, performance assessment of power factor capacitor, automatic power factor correction, distribution and transformer losses calculations.

Case study of electricity bill calculation and remedies to reduce electricity bills.

Unit 2	**Electric Motors**

Electric Motors- Types, Losses in Induction motors, Motor efficiency, Factors affecting motor performance, motor characteristics, Rewinding verses replacement of motor, Energy saving opportunities, Energy efficient motors, variable speed drives.

Unit 3	**Compressed air systems**

Compressed air Systems: Types and classification, Compressor Performance, Compressed air system components, Capacity and leakage assessment, Factors affecting the performance and efficiency, Types of driers and their operating principal, Energy conservation opportunities.

Unit 4	**HVAC and Refrigeration System and Cooling Towers**

HVAC and Refrigeration System: Psycrometrics and air-conditioning processes, Types and applications of HVAC and Refrigeration systems in Industry, Performance assessment of Refrigeration plants, Factors affecting performance and energy efficiency of refrigeration plants, Performance assessment of split and package air conditioning unit, Heat pump and their application, Energy conservation opportunities.

Cooling Tower: Types and performance evaluation, Efficient system operation, Flow control strategies and energy saving opportunities, Assessment of cooling towers.

Unit 5	Fans and Blowers and Pumping systems
Fans and Blowers: Fan types and applications, Fan characteristics and performance curves, Fan laws, Factors affecting efficiency, Design and selection criteria, Pressure drop and system resistance, flow control strategies, performance assessment, Energy conservation opportunities. **Pump and Pumping systems:** Types, Performance evaluation, Efficient system operation, Flow control strategies, Boiler feed water pump, pumping system for Municipal drinking water, Sewage water pumps, Agricultural pump sets, Energy conservation opportunities.	
Unit 6	**Lighting System and DG Set System**
Lighting Systems: Light Sources and Types of lamps, Terminology used in Lighting systems, recommended illuminance standard, Method of calculating illuminance, Energy efficient lighting controls, Energy saving opportunities in lighting systems. **Diesel Generating system**: Factors affecting selection, Energy performance assessment of diesel conservation avenues	

Reference Books:

1. Handbook of Electrical Installation Practice- Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, by Anil Valia, Lighting System
3. Analysis and design of Energy Systems - Hogde b.K. (Prentice hall 1988)
4. Energy management and control system –Vol-I, II –M.C.Macedo (John Willy)
5. BEE Reference book: no.1/2/3/4.
6. www.aipnpc.org
7. www.beeindia.gov.in

402025MJ: Lab Practice					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**01**	**Term Work**	**50 Marks**

Prerequisites: Engineering Graphics, Solid Modelling & Drafting, Engineering Thermodynamics

Course Objectives: This course aims to

1. Recognize energy management opportunities in electrical equipment and systems.
2. Aware recent trends in electricity billing

Course Outcomes:

On completion of the course, learner will be able to

CO1: ANALYSIS of electricity bill of commercial and industrial load.

CO2: DESIGN size and location capacitor for power factor correction.

CO3: DISCUSS case study related to energy management in electrical utilities.

CO4: WRITE a report on case studies & industrial visit including opportunities of energy saving.

Guidelines for Laboratory Conduction

Instruction: Any five lab practices from 01 to 06 the following. Lab practice 07 is compulsory.

Term Work

1. Analysis and interpretation of commercial electricity bills. (Take electricity bill of any commercial project and verify it with manual calculation. Same will be verified on online calculator)
2. Analysis and interpretation of industrial electricity bills. (Take electricity bill of any industrial project and verify it with manual calculation. Same will be verified on online calculator)
3. Assessment of illumination system at workplace by using LUX meter.
4. Design size and location capacitor for power factor correction in any industrial/commercial project. (such as pumping system, flour mills etc.)
5. Calculation of energy saving in illumination, air conditioning system, lift and elevators etc.
6. Use of temperature, pressure and flow measurement in any industrial or commercial process.
7. Case study on any of the following: (Must include details of case along with calculation, energy saving opportunities, benefits) (Any one of the following)
   a. Replacing drive system with adjustable speed drive.
   b. Impact of capacitor on energy bill
   c. Impact of demand controller on energy bill
   d. Energy saving opportunities in air conditioner.

402026MJ: Sustainable energy Conversion Systems					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses:
Basic Electrical Engineering, Systems in Mechanical Engineering, Engineering Thermodynamics, Applied Thermodynamics

Course Objectives

1. To familiarise sustainable practices in electrical and thermal utilities.
2. To make student conversant with renewable energy systems.
3. To make student conversant with energy efficient buildings.

Course Outcomes

On completion of the course, learner will be able to

CO1. DEMONSTRATE best practices in electrical and thermal utilities.
CO2. EVALUATE performance of solar thermal systems.
CO3. DESIGN Solar photovoltaic system.
CO4. ILLUSTRATE different components and working of wind mill.
CO5. DEMONSTRATE biomass gasifier for energy conversion.
CO6. ILLUSTRATE Energy efficient building and building codes.

Course Content

Unit 1	**Solar Thermal Systems**

Sustainable energy, Solar water heating systems (Active and passive), Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Performance evaluation of solar thermal systems, Solar industrial process heating systems.

Unit 2	**Solar Photovoltaic Energy Conversion**

Photovoltaic Principal, Solar photovoltaic system design, Shadow analysis, Performance evaluation of SPV systems, Economics of SPV system.

Unit 3	**Wind Energy**

Wind Energy Basics, Power Content, Wind turbine types- Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator, Hybrid wind energy systems - wind + diesel power, wind + conventional grid, wind + Photovoltaic system etc., offshore wind power.

Unit 4	**Waste to Energy Conversion**

Types: Biochemical Conversion: Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Types of biogas plants, Community biogas plants; Thermo-chemical conversion: Sources of energy generation, Gasification; Types of gasifiers; Industrial applications of gasifiers; Environment benefits of biochemical and thermo-chemical conversion, Briquetting; Utilization and advantages of briquetting.

Unit 5	**Energy storage systems**

Need and importance of Energy storage in Conventional and Nonconventional Energy Systems, Various forms of Energy Storage: Thermal, Chemical, Mechanical, Electrical and Nuclear, Techno Commercial Analysis (Economical aspects)

Unit 6	Best Practices in Energy Efficient Technology
Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, IOT application for chiller system, Energy saving potential of each technology. Case study related to energy efficient technologies.	

Reference Books:

1. Solar Engineering of Thermal Process- J.A. Duffie & W.A. Beckman
2. Solar Energy Engineering- S.A.Kalogirou
3. Wind Energy Data for India- Anna Mani
4. Wind Energy- Sathyajith Mathew
5. Non-Conventional Energy Sources- B.H.Khan
6. Biomass Renegerable Energy – D.O.hall and R.P. Overeed (John Wiley and Sons, New york, 1987)
7. Biomass Gasification Principles and Technology, Energy technology review No. 67, - T.B. Read (Noyes Data Corp., 1981)
8. BEE Reference book: no.1/2/3/4.
9. www.aipnpc.org
10. www.beeindia.gov.in

402027MJ:Energy audit Practice/ Field Visit					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**01**	**Term Work**	**50 Marks**

Course Content

The student shall complete one of the following activities as a Term Work

1. **Conduct detailed energy audit of any Industry/Hotel/Commercial building and prepare detailed energy audit report in the prescribed format.**
   Format for preparation of Energy Audit Report:
   1. Acknowledgement
   2. Executive Summary
   3. Energy audit details
      a. Introduction about the plant
      b. General plant details and description
      c. Energy audit team
      d. Component of production cost (raw materials, energy, chemicals, manpower, overhead and others
      e. Major energy use and areas
      f. Production process description
      g. Process flow diagram
      h. Historical energy consumption data analysis
      i. Measurement and analysis
      j. Energy conservation opportunities with economic analysis
      - The report shall be prepared using Latex preferably (default font throughout) with double spacing throughout on A4 page.

Page	Left Margin	Right Margin	Top Margin	Bottom margin
A-4 (8.5'' * 11'')	1.5''	1''	1''	1''

      - Section titles should be bold typed in all capital letters and should be left aligned.
      - Sub-Section headings should be aligning at the left, bold and Title Case (the first letter of each word is to be capitalized).
      - Figure No. and Title at bottom with 10 pt; Legends below the title in 10 pt
      - Use SI system of units only.]
2. **Field visit to any one of the following Renewable/Sustainable energy plant/Energy efficient Plant and write a detailed industry visit report and present during evaluation.**
   a. Solar thermal system/Solar PV Plant/Solar roof top
   b. Wind data centre/Wind Farm
   c. Biomass gasification plant/Biomass briquette manufacturing plant/Bio-gas Plant
   d. Energy efficient building/ECBC complied building/ NZEB
   e. Waste heat recovery plant/Co-generation/Tri-generation Plant.