BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam - 501 510, Hyderabad

DEPARTMENT OF MECHANICAL ENGINEEIRNG

COURSE OUTCOMES (COs)

B.TECH – MECHANICAL ENGINEEIRNG

JNTUH: R13 REGULATIONS

Course Code	Course Title	Course Outcomes
		1st YEAR
A10001	ENGLISH	**At the end of this course, each student should be able to:** CO1. Understand the value of English as an international language, as a Lingua-Franca and try to improve their knowledge regarding language skills and elements to be perfect in their usage. CO2. Usage of English Language, written and spoken. CO3. Enrichment of comprehension and fluency CO4. Gaining confidence in using language in verbal situations. CO5. Develop the ability to analyze the language used in descriptions and narrations.
A10002	MATHEMATICS - I	**At the end of this course, each student should be able to:** CO1. After learning the contents of this unit the student is able to write the matrix representation of a set of linear equations and to analyze solutions of system of equations. CO2. The student will be able to understand the methods of differential calculus to optimize single and multivariable functions. CO3. The student is able to evaluate the multiple integrals and can apply the concepts to find the areas, volumes, moment of inertia etc., of regions on a plane or in space. CO4. The student is able to identify the type of differential equation and uses the right method to solve the differential equation. Also able to apply the theory of differential equations to the real world problems. CO5. The student is able to solve certain differential equations using Laplace transform. Also able to transform functions on time domain to frequency domain using Laplace transforms.
A10302	ENGINEERING MECHANICS	**At the end of this course, each student should be able to:** CO1. Classify basic engineering mechanics concepts required for predicting behavior static structures. CO2. Identify an appropriate structural system to study a given problem and isolate it from its environment. CO3. Model the problem using free-body diagrams and accurate equilibrium equations. CO4. Identify and choose various types of loading and support conditions that act on structural systems. CO5. Communicate the solution to all problems in an organized and coherent manner and elucidate the meaning of the solution in the context of the problem. CO6. Develop concepts of rigid body kinematics and dynamics with an emphasis on the modeling, analysis, and simulation of how forces produce motion of rigid body systems. CO7. Determine simple dynamic variables and solve simple dynamic problems involving kinematics, energy and momentum.

A10004	ENGINEERING PHYSICS	**At the end of this course, each student should be able to:** CO.1 The student would be able to learn the fundamental concepts on behavior of crystalline solids. CO.2 The knowledge on fundamentals of Quantum Mechanics, Statistical Mechanics enables the student to apply to various systems like Communications Solar Cells, Photo Cells and so on. CO.3 Design, Characterization and study of properties of materials help the student to prepare new materials for various Engineering applications. CO.4 This course also helps the student exposed to non-destructive testing methods. CO.5 Finally, engineering physics course helps the student to develop problem solving skills and analytical skills.
A10005	ENGINEERING CHEMISTRY	**At the end of this course, each student should be able to:** CO1. Extrapolate the knowledge of cell, electrode, cathode, anode, electrolysis, electromotive force and reference electrode. CO2. Explore the engineering applications of polymeric materials. CO3. Develop awareness about the usage of conducting polymers as an engineering material. CO4. Justify the immense importance of basic constructional material, Portland cement in Civil Engineering works. CO5. Summarize the application of phase rule to one and two component systems.
A10501	COMPUTER PROGRAMMING	**At the end of this course, each student should be able to:** CO1. Identify and understand the working of key components of a computer system. CO2. Develop algorithms and flowcharts for solving mathematical and engineering problems. CO3. Design programs involving decision structures, loops and functions. CO4. Use structured data types and the concept of arrays in simple data processing applications. CO5. Understand the concept of recursion and describe its implementation using a stack. CO6. Understand simple data structures, use of pointers, memory allocation and data handling through files in C.
A10301	ENGINEERING DRAWING	**At the end of this course, each student should be able to:** CO1. Identify the basic concepts of Engineering Drawing. CO2. Construct various conic sections, cycloids and scales. CO3. Apply the principles of orthographic projections to projections of points and lines. CO4. Sketch different sections and sectional views of solids. CO5. Show the orthographic projection of the isometric views. CO6. Design the perspective projections of various points, lines, plane figures and simple solids.
A10083	English Language Communication Skills Lab	**At the end of this course, each student should be able to:** CO1. Better Understanding of nuances of language through audio-visual experience and group activities. CO2. Neutralization of accent for intelligibility. CO3. Speaking with clarity and confidence thereby enhancing employability skills of the student. CO4. student able to know the speech sounds and phonetic transcription and phonemic symbols of English.

A10581	Computer Programming Lab	**At the end of this course, each student should be able to:** CO1. Identify and understand the working of key components of a computer system. CO2. Develop algorithms and flowcharts for solving mathematical and engineering problems. CO3. Design programs involving decision structures, loops and functions. CO4. Use structured data types and the concept of arrays in simple data processing applications. CO5. Understand the concept of recursion and describe its implementation using a stack. CO6. Understand simple data structures, use of pointers, memory allocation and data handling through files in C
A10081	Engineering Physics/Engineering Chemistry Lab	**At the end of this course, each student should be able to:** CO1. From a given discrete data, one will be able to predict the value of the data at an intermediate point and by curve fitting, can find the most appropriate formula for a guessed relation of the data variables. This method of analysis data helps engineers to understand the system for better interpretation decision making. CO2. After studying this unit one will be able to find a root of a given equation and will be able to find a numerical solution for a given differential equation. CO3. Helps in describing the system by an ODE, if possible. Also, suggests to find the solution as a first approximation. CO4. One will be able to find the expansion of a given function by Fourier series and Fourier transform of the function. CO5. Helps in phase transformation, phase change and attenuation coefficients in acoustics CO6. After studying this unit, one will be able to find a corresponding partial differential equation for an unknown function with many independent variables and to find their solution
A10082	IT Workshop/ Engineering Workshop	**At the end of this course, each student should be able to:** CO1. Apply knowledge for computer assembling and software installation. CO2. Identified opportunities for coordinated policy responses, capacity building and implementation of best practices. CO3. Apply the tools for preparation of PPT, Documentation and budget sheet etc. CO4. Identified instruments for improved decentralization to the local level. CO5. Identified strategies for overcoming constraints to effective decentralization and sustainable management at different levels.
2ND YEAR I SEM		
A30009	ENVIRONMENTAL STUDIES	**At the end of this course, each student should be able to:** CO1. Students will be able to realize the significance of Green development and Wild life protection. CO2. Students will be able to apply fundamentals of cleanliness and importance of natural resources. CO3. Students will be able to adopt, grasp and absorb knowledge across disciplines CO4. Students will be able ability to integrate within research areas of Environmental protection. CO5. Students will be able evaluate the developing technologies in the

		ecological systems CO6. Students will be able to understand the environmental policy, legislation and protection acts.
A30008	PROBABILITY AND STATISTICS	**At the end of this course, each student should be able to:** CO.1 Able to understand a random variable that describes randomness or an uncertainty in certain realistic situation. It can be of either discrete or continuous type. CO.2 In the discrete case, study of the binomial and the Poisson random variables and the Normal random variable for the continuous case predominantly describe important probability distributions. Important statistical properties for these random variables provide very good insight and are essential for industrial applications. CO.3 Most of the random situations are described as functions of many single random variables. In this unit, the objective is to learn functions of many random variables through joint distributions. CO.4 The types of sampling, Sampling distribution of means ,Sampling distribution of variance, Estimations of statistical parameters, Testing of hypothesis of few unknown statistical parameters. CO.5 The mechanism of queuing system ,The characteristics of queue, The mean arrival and service rates. CO.6 The expected queue length, The waiting line.
A30203	ELECTRICAL AND ELECTRONICS ENGINEERING	**At the end of this course, each student should be able to:** CO1. Understand the concept of electrical circuits and its components CO2. Learn the basic principles of diode and transistors CO3. Analyze and solve problems of electrical circuits using network laws and theorems CO4. Identify and characterize diodes and various types of transistors
A30104	MECHANICS OF SOLIDS	**At the end of this course, each student should be able to:** CO.1 Able to analyze the given designed member is enough to resist the forces which it is subjected. CO.2 Able to identify the serviceability requirements of designed structure member. CO.3 able to determine the properties of given materials is acceptable to make sure that the design structure will remain serviceable and will not fail under applied loads with a suitable factor of safety. CO.4 It also teaches us how to make effective and economical use of engineering materials.
A30306	THERMODYNAMICS	**At the end of this course, each student should be able to:** CO1. able to understand the basic concepts which are useful in calculation of energy interactions CO2. able to understand principle of thermometry and different thermometers CO3. able to apply simple energy balance equations for closed and open system by understanding I st law of thermodynamics CO4. Able to formulate true efficiency of a cyclic heat engines and heat pumps. CO5. Understand the properties of pure substance with phase change which are useful in power plants. CO6. Able to apply the simple principles of psychometric to evaluate the air conditioning principles.
A31803	METALLURGY & MATERIALS SCIENCE	**At the end of this course, each student should be able to:** CO1. Application of knowledge relating the composition, structure and processing of materials to their uses. The field encompasses the

		spectrum of materials that covers metals, ceramics, polymers, semiconductors, and combinations of materials or composites. CO2. Able to investigates the relationship between structure of materials and their properties. It also includes elements of applied physics and chemistry, as well as chemical, mechanical, civil and electrical engineering CO3. Able to understand the new developments such as nano-science and nanotechnology continue to propel materials science and engineering to the forefront of the studies (at many universities) around the world.
A30281	Electrical and Electronics Engineering Lab	**At the end of this course, each student should be able to:** CO.1 Understand the concept of electrical circuits and its components. CO.2 Learn the basic principles of diode and transistors. CO.3 Analyze and solve problems of electrical circuits using network laws and theorems. CO.4 Identify and characterize diodes and various types of transistors
A30085	Metallurgy & Mechanics of Solids Lab	**At the end of this course, each student should be able to:** CO.1 Analyze the behavior of the solid bodies subjected to various types of loading. CO.2 Apply knowledge of materials and structural elements to the analysis of simple structures. CO.3 Analyze and interpret laboratory data relating to behavior of structures and the materials they are made of, and undertake associated laboratory work individually and in teams. CO.4 Undertake problem identification, formulation and solution using a range of analytical methods. CO.5 Able to understand with a fundamental knowledge of materials properties. CO.6 Students would have acquired and developed the necessary background and skills for successful careers in the materials-related industries.
2ND YEAR II SEM		
A40312	PRODUCTION TECHNOLOGY	**At the end of this course, each student should be able to:** CO1. Able to integrate technology with management in planning and controlling the design, development and operation of manufacturing system. CO2. Able to get basic concepts in understanding the rapid advances in manufacturing technology, e.g., computer controlled processes and management information systems, ERP and new manufacturing concepts like TPS, agile manufacturing, pull system etc., are reinforcing the recognition of technological, organizational, economic and human factors.
A40309	KINEMATICS OF MACHINERY	**At the end of this course, each student should be able to:** CO1. Classify different types of links and mechanisms used for different purposes in different machines. CO2. Solve the forces, velocities and accelerations in different mechanisms and machines components CO3. List, Predict and Design different type of links applied to get the required motion of different types of the parts of machines
A40313	THERMAL ENGINERING-I	**At the end of this course, each student should be able to:** CO1. Get the basics of I.C Engine. CO2. Get the idea about the combustion in IC Engines. CO3. Learn about the different types of compressor and their application

A40112	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES	**At the end of this course, each student should be able to:** CO1. To study fundamental concepts in Fluid Mechanics including objectives, scope and importance CO2. Effective approach to the static fluids for measurement of physical properties such as viscosity, surface tension , bulk modulus and important fluid parameter like pressure and compressibility CO3. To discuss various technological approaches applied to the Fluid Mechanics specially pumps, compressors, Turbines CO4. To learn Boundary layer concept tp ascertain the crucial fluid parameters in the solid –fluid boundary region CO5. To understand the concept of Turbo Machinery run by hydraulic power. CO6. To study the turbine operational system with ios governing principles
A40310	MACHINE DRAWING	**At the end of this course, each student should be able to:** CO1. The students would develop spatial visualization and spatial reasoning skills, CO2. The students would develop freehand sketching skills, CO3. The students would be able to do dimensioning of machine components, CO4. The students would be able to present the standards and conventions required for machine drawing, CO5. The students would develop primary knowledge of working drawing, CO6. The students would develop skills to produce assembly drawings,
A40006	MATHEMATICS-II	**At the end of this course, each student should be able to:** CO1. The course of Numerical methods includes Roots of Nonlinear equations, Solution of linear equation Interpolation, Least squares method, Numerical differentiation and integration, Numerical solution of Initial Value Problems in Ordinary differential Equations ,Boundary values & Eigen value problems ,Solution of Partial Differential equations. CO2. The course strikes the right balance between theory and applications providing a comprehensive method of understanding numerical methods to apply on various linear and non-linear problems that arise in Engineering and Technology. This will enable the students to acquire mathematical skills and apply them to various Engineering and Technological Discrete Systems. Partial Differential Equations are used to solve numerically in higher and cumbersome problems arising in mechanical engineering. iii) The applications of Matrices and theory of Differential equations will be highly helpful to solve and understand several phenomenon's in nature.
A40382	Production Technology Lab	**At the end of this course, each student should be able to:** CO.1 Design and manufacture simple patterns. CO.2 Control sand properties in foundry. CO.3 Operate arc welding, gas welding and resistance welding equipment. CO.4 Use pipe bending and injection Moulding equipment
A40188	Mechanics of Fluids & Hydraulic Machinery Lab	**At the end of this course, each student should be able to:** CO.1 Able to explain the effect of fluid properties on a flow system. CO.2 Able to identify type of fluid flow patterns and describe continuity equation.

		CO.3 To analyze a variety of practical fluid flow and measuring devices and utilize fluid mechanics principles in design. CO.4 To select and analyze an appropriate turbine with reference to given situation in power plants. CO.5 To estimate performance parameters of a given Centrifugal and Reciprocating pump. CO.6 Able to demonstrate boundary layer concepts
3rd YEAR I SEM		
A50010	MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS	**At the end of this course, each student should be able to:** CO1. The student will be given an insight into what is Economic theory and what is Business and how one can integrate the economic theory with Business. CO2. The student will understand the Economic theories and Business Environment, and business related decisions in a day to day operations. CO3. The student will be in a position to understand the following concepts: Managerial Economics, Demand Analysis, Elasticity of Demand, Demand forecasting, Theory of production & cost analysis, Production function, Break even Analysis, Market Structures, Types of competition, Pricing Strategies, Business & New Economic Environment, Capital and capital budgeting, Introduction to Financial accounting, Financial Analysis through Ratios. CO4. Towards the end of the course it is expected that the students would be matured enough to understand and evaluate the Economics theories in real life situations of Business.
A50318	ENGINEERING METROLOGY	**At the end of this course, each student should be able to:** CO1. Able to understand the necessity of complete evaluation of newly developed products. CO2. able to standardize the measuring methods and maintain the accuracies of measurement CO3. Able to know the importance of legal metrology, industrial metrology and scientific metrology.
A50317	DYNAMICS OF MACHINERY	**At the end of this course, each student should be able to:** CO1. Able to understand the concepts of dynamic loads and undesired oscillations increase with higher speed of machines. CO2. Able to know the industrial safety standards that require better vibration reduction. CO3. able to generate the model, identification of parameter, balancing of mechanisms, torsion and bending vibrations, vibration isolation, and the dynamic behavior of drives and machine frames as complex systems. CO4. Able to analyze the typical dynamic effects, such as the gyroscopic effect, damping and absorption, shocks, resonances of higher order, nonlinear and self-excited vibrations are explained using practical examples. These include manipulators, flywheels, gears, mechanisms, motors, rotors, hammers, block foundations, presses, high speed spindles, cranes, and belts. CO5. Able to understand the various design features, which influence the dynamic behavior, are described.
A50321	MACHINE TOOLS	**At the end of this course, each student should be able to:** CO1. Able to understand the basic parameters of metal cutting

		operations. ii) able to Understand different components of Machine Tools and their functions CO2. able to Understand the basic structure of Lathe machines CO3. able to understand the features of Milling process, Milling machines, Milling operations and different types of indexing
A50316	DESIGN OF MACHINE MEMBERS - I	**At the end of this course, each student should be able to:** CO1. able to understand the important role of Design in all three of the major phases of a product lifecycle CO2. able to identify a need, development of requirements, concept generation, prototype development, manufacturing, and verification testing CO3. Able to enhance manufacturing efficiency, reducing service and maintenance demands, adding features and improving effectiveness, and validation testing CO4. Able to understand the concepts of decommissioning and disposal, recovery and reuse of materials and components
A50326	THERMAL ENGINEERING -II	**At the end of this course, each student should be able to:** CO1. Able to understand the schematic layout of steam power plant and concepts of improving cycle performance. CO2. Able to understand the working principles of boiler and chimney. CO3. Able to understand the application and basic analysis of steam nozzle. CO4. Able to understand the different steam and gas turbines and their performance analysis. CO5. Able to understand the basic principles of jet propulsion of air breathing and non-air breathing.
A50384	Machine Tools & Metrology Lab	**At the end of this course, each student should be able to:** CO.1 Understanding the properties of Moulding sands and pattern making. CO.2 Fabricate joints using gas welding and arc welding. Evaluate the quality of welded joints. CO.3 Basic idea of press working tools and performs Moulding studies on plastics. CO.4 Able to understanding patterns design and making. CO.5 Able to understanding basic Physical, Chemical Properties of materials
A50383	Thermal engineering Lab	**At the end of this course, each student should be able to:** CO.1 Determine the valve timing diagram of SI engine & CI engine. CO.2 Analyze the influence of variations in TDC and BDC operations. CO.3 Calculate the IP,BP, brake thermal efficiency. CO.4 Calculate & Compare the performance characteristics. CO.5 Apply the concept of Morse test on SI engine.(multi cylinder). CO.6 Determine the principle of various parameters in boilers.
3rd YEAR II SEM		
A62405	AUTOMOBILE ENGINEERING	**At the end of this course, each student should be able to:** CO1. To understands the basic concepts and working principle of automobile engineering. CO2. To get the basic idea about different types of automobile systems and their applications in present world. CO3. To learn about the different types of automobile components used in the present day and their importance. CO4. Formulate the real life problem CO5. Choose and apply the appropriate techniques to running a vehicle

		and usage of them. CO6. Test the vehicle and apply new techniques CO7. Implement new designs in automobiles components and structures.
A60330	FINITE ELEMENT METHODS	**At the end of this course, each student should be able to:** CO.1 Able to explain the concepts of FEM CO.2 To discretize the given problem CO.3 To define and identify nodes, elements, and stiffness matrices CO.4 To explain what is local co-ordinates system, global co-ordinate system CO.5 To formulate stiffness matrix and assembly of element matrices CO.6 To solve conventional mechanics problems like truss, bar (stepped/tapered) subjected to mechanical and thermal loads
A60334	REFRIGERATION AND AIR CONDITIONING	**At the end of this course, each student should be able to:** CO1. Able to understand the basic concepts of refrigeration. CO2. Able to Gets the basic idea about different types of refrigeration systems and their applications in real world. CO3. Able to know about the different types of refrigerants used in the present day refrigeration and their effects on environment. CO4. Able to know the basic concepts of air-conditioning and importance of psychometric.
A60329	DESIGN OF MACHINE MEMBERS - II	**At the end of this course, each student should be able to:** CO1. Develop equations and relations pertaining to the design of machines CO2. Develop fundamental knowledge of the Standards used in the design of machine elements CO3. Design component, machine, workstation and systems etc. for safe working by minimizing accidents and other health hazards. CO4. List and define functionality of various parts used in Automobiles, working principles and their design which include bearings, connecting rod, crankshaft, piston and cylinder etc. CO5. Design of gears and springs.
A60331	HEAT TRANSFER	**At the end of this course, each student should be able to:** CO1. To study fundamental concepts in Heat including objectives, scope and importance. CO2. To Highlight the basic modes of Heat Transfer CO3. To know the concepts and mathematical derivation of Steady and unsteady state one dimensional Heat transfer processes CO4. Discussing about Heat transfer with and without phase change. CO5. Dealing with critical equipment and their performance characteristics, such as boilers, heat exchangers, condensers CO6. To distinguish between Free and forced convection concepts
A60387	Heat Transfer Lab	**At the end of this course, each student should be able to:** CO.1 The student should be able to evaluate the amount of heat exchange for plane, cylindrical & spherical geometries. CO.2 The student should be able to compare the performance of extended surfaces and heat exchangers. CO.3 The student should be able to understanding Stefan Boltzmann constant. CO.4 The student should be able to evaluate the amount of heat exchange for natural and forced convection. CO.5 The student should be able to evaluate the efficiency of a pin-fin. CO.6 The student should be able to evaluate drop and film wise condensation

A60086	Advanced Communication Skills Lab	**At the end of this course, each student should be able to:** CO.1 The student should be able to Accomplishment of sound vocabulary and its proper use contextually. CO.2 Student should be able to Flair in Writing and felicity in written expression. CO.3 Student should be able to Enhanced job prospects. CO.4 Student should be able to Effective Speaking Abilities.
4TH YEAR I SEM		
A70352	OPERATIONS RESEARCH	**At the end of this course, each student should be able to:** CO1. Able to understand the advanced analytical methods like Dynamic Programming, Simulation Methods, Linear Programming Methods, Transportation, Assignment, Sequencing, Replacement, Theory of Games, Analytical Waiting Lines and Inventory Methods to help make better decisions. CO2. Able to formulate the real life problem into an appropriate mathematical model. CO3. Able to choose and apply the appropriate techniques to solve the formulated model. CO4. Able to test the model and its solution CO5. Able to implement the solution.
A70353	POWER PLANT ENGINEERING	**At the end of this course, each student should be able to:** CO1. Able to get the basics of Power Plants. CO2. Able to get the idea about the power generation by renewable and non-renewable energy resources. CO3. Able to know about the different types of cycles and natural resources used in power plants and their applications.
A70328	CAD/CAM	**At the end of this course, each student should be able to:** CO4. Able to know the concepts of CAD and CAM, types of manufacturing industries, product cycle. CO1. Able to formulate the CAD/CAM technology and its applications to design and manufacturing. CO2. Able to implement CAD/CAM hard ware and provide the solutions for software modules and graphics standards. CO3. able to test the drafting and modeling with its solution in design and manufacturing CO4. Able to implement the types of manufacturing and systems in industries.
A70343	INSTRUMENTATION & CONTROL SYSTEMS	**At the end of this course, each student should be able to:** CO1. Able to get an insight of tools problems associated with mechanical equipment, automobiles etc. CO2. Able to learn the measurement concepts of displacement , temperature ,pressure ,level , speed ,acceleration , strain ,humidity , force , torque and power iii) Able to acquire the knowledge of measurement of the various sources by measuring instruments.
A70359	UNCONVENTIONAL MACHINING PROCESSES	**At the end of this course, each student should be able to:** CO1. Able to get the basics of types of machines CO2. Able to get the idea about various nonconventional machines and their applications CO3. Able to know about the different types of un conventional machining processes
A70332	Industrial Management	CO1. Explain the concepts of management and explore the management practices in their domain area within society. CO2. Evaluate different types of organizational structures and

		Design them. CO3. Explain about product design process and Design product layout. CO4. Explain about method study and Use various work measurement methods. CO5. Draw various statistical quality control charts and Interpret them. CO6. Apply the techniques of PERT/CPM in project.
A70391	Production Drawing Practice & Instrumentation Lab	**At the end of this course, each student should be able to:** CO.1 Understand the conventions used in a production drawing. CO.2 Determine limits and fits and allocate tolerances for machine components. CO.3 Convert machine drawings into production drawings. CO.4 Apply concepts and methods in the preparation of production drawings.
4TH YEAR II SEM		
A80366	PRODUCTIN PLANNING AND CONTROL	**At the end of this course, each student should be able to:** CO1. Able to understand the requirement of production planning and control for manufacturing organizations. CO2. Able to develop skills to estimate and use appropriate planning and control techniques. CO3. Ability to evaluate, analyze and make decisions for short term as well as long term organizational growth, and CO4. Able to develop skills to perform production planning and control operations for any manufacturing organization.
A80365	PLANT LAYOUT & MATERAIL HANDLING	**At the end of this course, each student should be able to:** CO1. Able to get the basics of process layout & product layout. CO2. Able to get the idea about the material handling systems. CO3. Able to know about the different type's material handling methods, paths equipment's and functions.
A80525	RENEWABLW ENERGY SOURCE	**At the end of this course, each student should be able to:** CO1. Able to explore each of the principal renewable energy sources. CO2. Each technology is examined in terms of the relevant physical principles; the main technologies involved; their costs and environmental impact; the size of the potential renewable resource; and their future prospects.