

Government of Pakistan

**National Vocational and Technical Training Commission
(NAVTTTC)**

"Prime Minister Youth Skill Development Program"



Course Contents / Lesson Plan

Course Title: Renewable Energy (Biomass)

Duration: 6 Months

Author Name	Engr. Dr. Sajid Iqbal
Course Title	Renewable Energy (Biomass)
Training Objective & Learning Outcomes	This course aims to equip participants with comprehensive knowledge, practical skills, and problem-solving capacity for the sustainable design, installation, operation, and management of biomass-based renewable energy systems. Starting from the fundamentals of biomass resources and conversion technologies, the course emphasizes sustainability, efficiency, and safety while gradually progressing toward advanced system applications. With a market-centric and vocational approach, the program blends theory with robust hands-on practice, project prototypes, and industry exposure. Guided by professional instructors, trainees will be able to bridge the gap between classroom knowledge and workplace competency, preparing them for diverse market roles such as system installation, maintenance, project development, or technical consulting. By completion, participants will not only understand biomass technologies but will also be capable of applying their skills for wage or self-employment in the renewable energy sector. By the end of the course, students will be able to: 1. Explain the principles, benefits, and challenges of biomass as a renewable energy source. 2. Assess different biomass feedstocks and evaluate their suitability for specific conversion technologies. 3. Design and Size a small-scale biomass energy system (e.g., biogas digester, gasifier) based on given technical parameters and local needs. 4. Operate and Maintain biomass energy systems safely, following established technical standards and environmental protocols. 5. Conduct a preliminary feasibility study (technical and economic) for a biomass energy project, including cost–benefit considerations.
Entry-level of trainees	FA/F.Sc./DAE Electrician
Minimum Qualification of Teachers	Bachelor’s degree in Mechanical, Electrical, Agricultural, or Renewable Energy Engineering (Master’s preferred). • 3+ years practical experience in renewable energy systems, with focus on biomass. • Competency-Based Training (CBT\&A) certification or equivalent teacher training. • Ability to deliver both theory and hands-on practice; familiarity

with design software is desirable.

Scheme of Studies	Course Title				
	Sr. No	Modules	Theory Hrs.	Practical Hrs.	Total Hrs.
	1.	Introduction to Renewable Energy with a Focus on Biomass - Fundamentals of renewable energy - Biomass as an energy source - Global and local biomass potential - Environmental and social impacts	12	8	20
	2.	Biomass Resources and Feedstock Assessment - Types of biomass feedstocks - Physical & chemical properties - Site assessment & resource estimation - Supply chain & logistics	12	28	40
	3.	Biomass Conversion Technologies - Thermochemical (Combustion, Gasification, Pyrolysis) - Biochemical (Anaerobic Digestion) - Physical/Chemical (Pelletization, Biodiesel) - Technology selection criteria	16	64	80
	4.	Biogas Systems: Components, Design & Installation	20	100	120

		- Principles of anaerobic digestion - Biogas plant components & sizing - Design & hands-on installation - Biogas purification & utilization				
	5.	Biomass Gasification Systems – Installation, Operation & Maintenance - Types & applications of gasifiers - Operation of small-scale prototypes - Syngas cleaning & utilization - Safety protocols	16	80	96	
	6.	Operation, Maintenance & Troubleshooting - Routine operations & monitoring - Preventive/corrective maintenance - Troubleshooting failures - Hands-on repair & optimization	8	52	60	
	7.	Entrepreneurship, Project Viability & Market Opportunities - Financial analysis (NPV, Payback period) - Case studies of successful projects - Business plan development - Identifying market/job opportunities	12	20	32	
	8.	Field Visit & Final Project	0	28	28	

	- Industrial site visit to biomass facility - Hands-on project: design/demo of a biomass system for real-world application				
	Total	96	376	480	
Course Execution Plan	Duration of the course: 6 Months (24 Weeks) Class Hours per Day: 4 hours per day Weekly hours: 20 hours per week Total contact hours: Maximum 480 hours Theory: 20% Practical: 80%				
Companies offering jobs in the respective trade	- Power Sector – Biomass power plants, independent power producers (IPPs), renewable energy utilities, and grid-connected co-generation units. - Industrial Sector – Sugar mills, food processing units, textile industries, and other manufacturing units utilizing biomass fuels for energy. - Commercial and Office Sector – Renewable energy solution providers, consultancy firms, design offices, and after-sales service companies.				
No of Students	25				
Learning Place	Classroom (Theory Sessions) - Laboratory / Workshop (Hands-on Practice & Prototyping) - Field Visits (Biomass Plants, Industries, and Relevant Sites) - Industry Exposure / On-site Demonstrations				
Instructional Resources	Books - Biomass Energy Data Book – Edition 4 (https://tedb.ornl.gov/wp-content/uploads/2019/04/Biomass_Energy_Data_Book_Edition_4.pdf) - Biomass for Renewable Energy and Fuels				

<https://scispace.com/pdf/biomass-for-renewable-energy-and-fuels-2oruihxr83.pdf>

- Bioenergy Project Development and Biomass Supply (IEA)
(<https://www.ieabioenergy.com/wp-content/uploads/2013/10/Good-Practice-Guideines-Bioenergy-Project-Development-and-Biomass-Supply.pdf>)
- Energy Production from Biomass – Overview (McKendry)
(<https://faculty.washington.edu/stevehar/Biomass-Overview.pdf>)
- Biomass — Renewable Energy from Plants and Animals
(<https://ei.lehigh.edu/learners/energy/readings/biomass.pdf>)

Video Tutorials

- NREL: Energy Basics – Biomass
(<https://www.youtube.com/watch?v=7cCSV0lO4zE>)
- How to Generate Energy from Biomass?
(<https://www.youtube.com/watch?v=96oM08gBQKM>)
- Stanford Lecture – Biomass Energy (Diana Gragg)
(<https://www.youtube.com/watch?v=zPkm4njPZol>)

DETAIL OF COURSE CONTENTS

Module Title	Days	Learning Units	Task/Practical
Module-1: Introduction to Renewable Energy with a Focus on Biomass	1.	Global & Local Energy Scenario	Conduct Group Discussion on Pakistan's Energy Crisis (40–50 min).
	2.	Renewable Energy Overview	Prepare a chart of renewable energy sources (solar, wind, biomass, etc.).
	3.	Biomass Fundamentals	Brainstorm local biomass examples and share findings.
	4.	Biomass vs. Fossil Fuels	Analyze case study comparing coal vs. biomass.
	5.	Policies & Sustainable Development Goals (SDGs)	- Review Pakistan's Renewable Energy policy document and - Summarize (1–2 pages).
	6.	Biomass Energy Pathways	Draw a flowchart of biomass conversion routes.
	7.	Global Biomass Success Stories	- Watch a documentary (20-30 min) and - Write a short reflection.
	8.	Local Biomass Availability	Conduct a resource mapping exercise.
	9.	Economics of Biomass	Calculate payback period of a small biogas unit.
	10.	Biomass & Rural Development	Role-play planning a village biogas project.
	11.	Safety in Biomass Use	Demonstrate proper use of Personal Protective Equipment (PPE).
	12.	Key Stakeholders	Map key stakeholders in a biomass project.
	13.	Social Acceptance Issues	Design and perform a mock awareness campaign.
	14.	Future Trends	Create a poster on biomass & circular economy.
	15.	Review & Assessment	Take a quiz of 10

			MCQs. Design a simple Biomass Village Model project.
Module-2: Biomass Resources and Feedstock Assessment	16.	Biomass Sources	Collect and document biomass samples.
	17.	Crop Residues	Visit nearby farms and record agricultural residues.
	18.	Animal Waste Potential	Assess dairy waste quantity and composition.
	19.	Forestry & Agro Waste	Analyze case study on feedstock challenges.
	20.	Municipal Solid Waste	Survey local waste composition and report results.
	21.	Feedstock Collection Systems	Role-play logistics planning for feedstock collection.
	22.	Biomass Properties	Calculate moisture and energy content of biomass.
	23.	Lab Methods	Demonstrate simple calorific value measurement.
	24.	Storage & Handling	Conduct a safety demonstration on drying & storage of biomass.
	25.	Seasonal Variation	Prepare a chart of local feedstock availability.
	26.	Biomass Supply Chains	Draw a flow diagram of feedstock-to-energy process.
	27.	Case Studies (Pakistan)	Write a 1–2 page feedstock survey report.
	28.	Resource Mapping Tools	- Observe GIS demonstration for resource mapping, OR - Observe GIS simulation for resource mapping.
	29.	Biomass Economics	Perform cost analysis exercise for feedstock supply.
	30.	Assessment	Conduct a project: survey feedstock in a local area.

Module-3: Biomass Conversion Technologies	31.	Conversion Routes	Prepare a chart of thermal, biochemical, and chemical routes.
	32.	Thermal Processes	Demonstrate a small biomass combustion stove.
	33.	Biochemical Processes	Set up a simple fermentation demonstration.
	34.	Thermo-Chemical Processes	Analyze case study of a pyrolysis plant.
	35.	Energy Balances	Perform heat and mass balance calculations.
	36.	Small-Scale Combustion	Test stove efficiency in laboratory.
	37.	Fermentation for Ethanol	Take demo notes and prepare group summary.
	38.	Pyrolysis Products	Conduct sample analysis activity.
	39.	Gasification Basics	Draw flowcharts of different conversion methods.
	40.	Integrated Systems	Brainstorm ideas for hybrid biomass systems.
	41.	Efficiency Factors	Practice conversion-related calculations.
	42.	Technology Selection	Use decision matrix for technology selection.
	43.	Environmental Impacts	Debate (in ENGLISH) on biomass vs. fossil fuel technologies.
	44.	International Case Studies	Deliver a group presentation on findings.
	45.	Review and Assessment	• Take a quiz AND/OR • Design a simple biomass system.
	46.	Biogas Basics	• Observe gas sample demo and • Record observations.
	47.	Biogas Plant Types	Draw a model of a simple biogas plant.
	48.	Components of Plant	Label diagrams of plant components.

Module-4: Biogas Systems: Components, Design & Installation	49.	Digester Design	Practice simple volume calculations for digesters.
	50.	Feedstock Ratios	Demonstrate Carbon-to-Nitrogen (C:N) ratio in biogas production.
	51.	Gas Storage Systems	Perform balloon gas storage demo.
	52.	Piping & Safety	Practice mock installation of a small digester.
	53.	Slurry Handling	Engage in field practice for system setup.
	54.	Small Biogas Kits	Observe assembling demo of biogas plant parts.
	55.	Installation Steps	Prepare site layout activity for a plant design.
	56.	Safety Standards	Participate in a fire safety drill.
	57.	Pakistan Biogas Projects	Analyze a case study of rural biogas systems.
	58.	Field Examples	Take a virtual or physical plant tour.
Module 5: Biomass Gasification Systems – Installation, Operation & Maintenance	59.	Cost Estimation	Prepare a basic project budget.
	60.	Assessment	Design a mini-project: biogas plant for 5 households.
	61.	Gasifier Basics	Draw schematic diagrams of gasifier systems.
	62.	Types of Gasifiers	Compare gasifier designs in groups.
	63.	Downdraft Operation	Observe simulation demo for system functioning.
	64.	Updraft Operation	Analyze diagrams of gasifier operations.
	65.	Fluidized Bed	Study case study of small-scale gasification.
	66.	Gas Cleaning	Demonstrate gas filtration process.
	67.	Storage Systems	Conduct safety inspection exercise.
	68.	Start-up Procedures	Prepare a mock SOP for gasifier use.

	69.	Monitoring	Practice filling log sheets for daily operations.
	70.	Common Issues	Draw a troubleshooting chart for gasifier issues.
	71.	Maintenance Protocols	Develop maintenance checklist.
	72.	Safety Procedures	Participate in fire drill for safety.
	73.	Local Installations	Work on gasifier performance case study.
	74.	Cost & Viability	Practice calculation exercises related to efficiency.
	75.	Assessment	Mini-project: design a small gasifier system plan.
Module 6: Operation, Performance Monitoring & Troubleshooting	76.	O&M Basics	Take a virtual or real plant visit for O&M.
	77.	Performance Parameters	Prepare data sheets for plant performance.
	78.	Instrumentation	Demonstrate gauge and meter readings.
	79.	Data Logging	Practice spreadsheet use for monitoring data.
	80.	Efficiency Testing	Do calculation exercises for efficiency tracking.
	81.	Fault Diagnosis	Analyze troubleshooting cases in groups.
	82.	Shutdown Procedures	Write a sample Standard Operating Procedure (SOP).
	83.	Emergency Response	Participate in mock safety drill.
	84.	Maintenance Planning	Create preventive maintenance checklist.
	85.	Record Keeping	Prepare a sample logbook for O&M data.
	86.	Environmental Monitoring	Observe emission test demo.
	87.	Cost of O&M	Conduct cost tracking exercise for O&M.
	88.	Local Plant Examples	Attend a guest lecture on performance monitoring.
	89.	Reporting	Prepare a short monitoring

			report.
	90.	Assessment	Complete O&M mini-project with findings.
Module 7: Entrepreneurship, Project Viability & Market Opportunities	91.	Entrepreneurship Basics	Pitch an entrepreneurial idea in groups.
	92.	Biomass Value Chains	Conduct mapping exercise of biomass businesses.
	93.	Business Models	Develop a business canvas model.
	94.	Market Study	Complete survey assignment on market needs.
	95.	Policy Incentives	Analyze case study of successful projects.
	96.	Financial Literacy	Calculate break-even point of a biomass project.
	97.	Project Financing	Draft a short business proposal.
	98.	Risk Assessment	Perform SWOT analysis of a project idea.
	99.	Feasibility Studies	Prepare standard proposal template.
	100.	Cost-Benefit Analysis	Practice spreadsheet tasks for project costing.
	101.	Marketing Strategies	Design an awareness poster for biomass business.
	102.	Pitching Skills	Role-play as entrepreneur pitching idea.
	103.	Case Studies	Study Pakistan's biomass business landscape.
	104.	Guest Lecture	Interact with entrepreneurs (guest session).
	105.	Assessment	Present a business plan as a group project.
	106.	Orientation to Project	Attend a briefing on final project requirements.
	107.	Field Visit 1	Go on a plant site tour (REAL / VIRTUAL).
	108.	Field Visit 2	Conduct feedstock survey in field.

Module 8: Field Visit & Final Project	109.	Field Visit 3	Observe O&M during visit and note practices.
	110.	Field Visit 4	Engage in interactive session with entrepreneurs.
	111.	Field Report Prep	Prepare short write-up on visit experience.
	112.	Project Topic Finalization	Hold team discussions for project ideas.
	113.	Project Proposal	Submit first draft of project proposal.
	114.	Data Collection	Carry out field and lab work for project.
	115.	Project Development	Build PROTOTYPE or project MODEL.
	116.	Interim Presentation	Exchange peer feedback on project draft.
	117.	Project Refinement	Receive mentor review on progress.
	118.	Final Report Draft	Submit final write-up of project.
	119.	Final Presentation	Present project to panel for assessment.
	120.	Closing & Certificates	Showcase project and reflect on learning journey.

LIST OF MACHINERY / EQUIPMENT

For the Class of 25 Students (6-Month Course)

Sr #	Name of Items	Specifications (If Required)	Unit
1	Lab and Analytical Equipment		
	Analytical Balance	Precision 0.01g, digital, for lab tests	1 Pc
	Moisture & Calorific Value Tester	Portable moisture meter & bomb calorimeter	1 set
	pH Meter	Digital, handheld, for anaerobic digestion monitoring	1 Pc
	Gas Analyzer	Portable, measures CO, H ₂ , CH ₄ , CO ₂	1 Pc
	Flow Meters & Pressure Gauges	For monitoring gas/liquid flow rates in training setups	2 Pcs
	Laboratory Glassware & Chemicals	Beakers, flasks, test tubes, reagents	20 set
	Field Measurement Tools	GPS, measuring tapes, portable scales for resource mapping	5 set
2	Biomass Conversion & Processing		
	Biogas Plant (Pilot Scale)	5–10 m ³ capacity, complete with gas storage & piping	1
	Biomass Gasifier (Small Scale)	Downdraft type, 5–10 kW equivalent	1
	Biomass Stove / Combustion Unit	High-efficiency model for energy conversion experiments	2
	Briquetting / Pelletizing Machine	Small-scale manual/electric, capacity 50–100 kg/day	1
	Feedstock Preparation Unit	Chopper/Grinder/Shredder (0.5–1 HP motorized)	1

	Biodiesel Production Kit	Lab-scale reactor for oilseed-to-fuel conversion	1
	Small Generator (Biogas Operated)	2–3 kVA for electricity generation demonstration	1
3	Workshop & Maintenance Tools		
	Workshop Tools	Wrenches, screwdrivers, clamps, spanners, tubing connectors	2 sets
	Soldering Iron Kit	For basic electrical work	1 set
	Trolley / Cart	For moving heavy equipment and materials	1 Pc
4	IT & Classroom Equipment		
	Computers with Software	With simulation & design tools (HOMER, RETScreen, MS Excel)	5 No
	Multimedia Projector & Screen	For class presentations	1 No
	Storage Cabinets	Lockable, for securing tools and materials	1 Pc
	Display Boards	For project presentations and class notes	2 Pcs
5	Safety & Utilities		
	Safety Equipment	Fire extinguisher, gas leak detector, helmets, gloves, goggles	25 sets
	Workbenches	Heavy-duty, with vises and storage	5 Pcs

LIST OF CONSUMABLE MATERIAL

For the Class of 25 Students (6-Month Course)

Sr#	Name of Items	Specifications (If Required)	Unit
General Lab & Safety			
	Safety Goggles	Transparent, anti-fog	25 Pcs
	Lab Coats	Standard white, cotton/polyester blend	25 Pcs
	Nitrile Gloves	Disposable, various sizes (S, M, L)	5 Boxes
	Pens and Markers	Black, blue, and permanent markers	25 Pcs
Biomass Feedstock & Lab Analysis			
	Biomass Samples	Sawdust, wood chips, agricultural residue, food waste	40 kg
	Manure (for biogas)	Fresh cattle or poultry manure	40 kg
	Containers	For sample collection and storage, 1-5 kg capacity	5 Pcs
	Weighing Boats	Disposable, plastic	2 Pcs
	Moisture Meter	Digital handheld device	1 Pcs
Biogas System Components			
	PVC Sheets	Thick, durable, for digester body fabrication	5 Pcs
	PVC Pipes	Various diameters (e.g., 2-inch, 1-inch, 1/2-inch)	20 Meter
	PVC Connectors, Tees, and Elbows	Assorted sizes to match pipes	20 Pcs
	PVC Cement & Primer	For bonding pipes and fittings	10 Liters
	Ball Valves	1/2-inch, quarter turn	10 Pcs
	Pressure Gauges	Low-pressure, for biogas output	1 Pc
	Tubing	Flexible, for gas transfer	20 Meter

Biomass Gasification Lab			
	Wood Pellets	Standard size, low moisture content	20 kg
	Filters & Sieves	For cleaning syngas	5 Sets
	Thermocouple	For temperature monitoring	1 Pc
	Gas Analysis Kit	Basic kit to test for CO, CO ₂ , H ₂	1 Set
Operation & Maintenance (O&M)			
	Lubricants & Greases	For moving parts on prototypes	2 Tubes
	Cleaning Brushes & Tools	Assorted sizes for maintenance	2 Sets
	Spare Gaskets & Seals	For prototype systems	10 Pcs
General Consumables & Tools			
	Drill Bits	Various sizes, for plastics and metals	2 Sets
	Measuring Tapes & Rulers	Steel and plastic	10 Pcs
	Safety Tape	For marking hazards	10 Rolls
	First-Aid Kit	Standard industrial kit	1 Unit

Trade Registration Form

1. Title of the Qualification

Renewable Energy (Biomass) Technician — Level 2 (6 Months)
--

2. Organogram / Pathway / Equivalencies

Entry Level	Vocational Qualification	Equivalence	Next Progression
FA/F.Sc./DAE (Electrical/Electronics/Mechatronics)	Level-2	N/A	N/A

3. List of Competencies / Modules

Competency Standards/ Modules
Competency-1: Apply Principles of Renewable Energy with Emphasis on Biomass
Competency-2: Assess Biomass Resources and Feedstock Availability
Competency-3: Operate Biomass Conversion Technologies
Competency-4: Design and Install Biogas Systems
Competency-5: Install, Operate and Maintain Biomass Gasification Systems
Competency-6: Monitor Performance and Troubleshoot Biomass Systems
Competency-7: Evaluate Entrepreneurship, Project Viability and Market Opportunities
Competency-8: Conduct Field Visits and Execute Final Project Work

4. Class / Workshop Size/ Dimension (25 Students Capacity)

	Requirement	Size / Dimensions (feet)
Classroom size	Yes	25x30
Workshop/Laboratory size	Yes	40x40
Any other Requirement	NA	NA

5. Machinery / Lab Equipment (with quantity/25 Students)

Sr. No.	Machinery / Lab Equipment	Quantity
1.	Analytical Balance	1 Pc
2.	Moisture & Calorific Value Tester	1 set
3.	pH Meter	1 Pc
4.	Gas Analyzer	1 Pc
5.	Flow Meters & Pressure Gauges	2 Pcs

6.	Laboratory Glassware & Chemicals	20 set
7.	Field Measurement Tools	5 set
8.	Biogas Plant (Pilot Scale)	1
9.	Biomass Gasifier (Small Scale)	1
10.	Biomass Stove / Combustion Unit	2
11.	Briquetting / Pelletizing Machine	1
12.	Feedstock Preparation Unit	1
13.	Biodiesel Production Kit	1
14.	Small Generator (Biogas Operated)	1
15.	Workshop Tools	2 sets
16.	Soldering Iron Kit	1 set
17.	Trolley / Cart	1 Pc
18.	Computers with Software	5 No
19.	Multimedia Projector & Screen	1 No
20.	Storage Cabinets	1 Pc
21.	Display Boards	2 Pcs
22.	Safety Equipment	25 sets
23.	Workbenches	5 Pcs

6. Consumable (with Quantity / 25 Students)

Sr. No.	Consumable	Quantity
1.	Analytical Balance	1 Pc
2.	Moisture & Calorific Value Tester	1 set
3.	pH Meter	1 Pc
4.	Gas Analyzer	1 Pc
5.	Flow Meters & Pressure Gauges	2 Pcs
6.	Laboratory Glassware & Chemicals	20 set
7.	Field Measurement Tools	5 set
8.	Biogas Plant (Pilot Scale)	1
9.	Biomass Gasifier (Small Scale)	1
10.	Biomass Stove / Combustion Unit	2
11.	Briquetting / Pelletizing Machine	1
12.	Feedstock Preparation Unit	1
13.	Biodiesel Production Kit	1

14.	Small Generator (Biogas Operated)	1
15.	Workshop Tools	2 sets
16.	Soldering Iron Kit	1 set
17.	Trolley / Cart	1 Pc
18.	Computers with Software	5 No
19.	Multimedia Projector & Screen	1 No
20.	Storage Cabinets	Pc

7. Student Teacher Ratio

25:1

8. Teacher Qualification

Bachelor's degree in Mechanical, Electrical, Agricultural, or Renewable Energy Engineering (Master's preferred).

- 3+ years practical experience in renewable energy systems, with focus on biomass.
- Competency-Based Training (CBT\&A) certification or equivalent teacher training.
- Ability to deliver both theory and hands-on practice; familiarity with design software is desirable.

9. Duration / Credit Hours / Contact Hours

Credit Hours	Duration
120	6 Months

10. Any other co-curricular activities

Activity	Requirement
Playgrounds	Yes
Industry linkages	Yes
Teacher training	Yes