Agricultural Engineering

Renewable Energy and Green Technology

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PDF Notes

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1. Energy Sources and Their Contribution to the Agricultural Sector

Introduction

Energy is a fundamental input in agriculture. It is required for **land preparation, irrigation, crop production, harvesting, processing, storage, and transportation**. With increasing mechanization and the need for sustainable farming, understanding different **energy sources and their contribution** to agriculture is essential.

Meaning of Energy Source

An **energy source** is any natural or man-made resource that can be used to produce power or heat for performing agricultural operations.

Classification of Energy Sources

Energy sources used in agriculture can be classified as follows:

A. Classification Based on Renewability

1. Renewable Energy Sources

These are energy sources that are **naturally replenished** and are environmentally friendly.

(a) Solar Energy

- **Source:** Sun
- **Forms Used:** Thermal and photovoltaic
- **Agricultural Uses:**
    - Solar irrigation pumps
    - Solar dryers for grains, fruits, vegetables
    - Solar cookers
    - Greenhouse heating
    - Solar fencing
- **Advantage**
    - Use of solar energy causes no environmental pollution, because no chemical waste or toxic gases get released while using solar energy
    - Solar energy can be used for practical purposes such as heating and lighting
    - The sun is an ever lasting source of energy which is freely available
    - Can be converted into electrical energy and put to many uses

- **Limitations**
    - Solar power plants can not produce energy if the sun is not shining ex: Night time or cloudy day
    - Establishment of solar power stations can be very expensive
    - Solar panels need to be regularly maintained and cleaned to continue generating electricity
- **Contribution:**
    - Reduces electricity and diesel dependence
    - Suitable for remote rural areas
    - Zero greenhouse gas emissions

(b) Wind Energy

- **Source:** Wind movement
- **Agricultural Uses:**
    - Windmills for water lifting
    - Electricity generation for farm operations

- **Advantage**
    - Wind energy is free of cost and reliable,
    - Wind power is clean and produces no environmental pollution,
    - In wind power generation no harmful by-products are left over as in case of burning of fossil fuels,
    - Wind energy is non-exhaustible
    - Farming and grazing can still take place on land occupied by wind turbines which can help in the production of bio fuels. When used inland, the land beneath the windmill can still be used for farming purposes.
    - Wind farms can be built off-shore.
    - In some cases wind farms can even be tourist attractions
- **Limitations**
    - Wind power is not available all the time, at all the places and has to be used while being produced, as it cannot be stored.

    - Persistent wind and consistent wind speeds are needed for continuous power generation. If wind speed decreases, the turbine lingers and less electricity is generated.
    - The wind farms, whether onshore or off shores are unsightly, noisy and generate a lot of opposition.
    - Large wind farms can have a negative effect on the scenery.
    - They are hazards for wildlife, especially birds who commonly fly into their blades.
- **Contribution:**
    - Useful in coastal and high-wind regions
    - Low operating cost after installation

(c) Biomass Energy

- **Source:** Plant and animal residues
- **Examples:**
    - Crop residues (straw, husk)
    - Animal dung
    - Firewood
- **Agricultural Uses:**
    - Biogas plants
    - Biomass gasifiers
    - Briquetting and pellet production
- **Contribution:**
    - Converts farm waste into useful energy
    - Improves waste management
    - Produces organic manure as by-product (biogas slurry)

(d) Biogas Energy

- **Source:** Anaerobic digestion of organic waste
- **Agricultural Uses:**
    - Cooking and lighting
    - Power generation
    - Running small engines

- **Contribution:**
    - Reduces use of firewood
    - Improves sanitation
    - Provides high-quality manure

(e) Small Hydro Energy

- **Source:** Flowing water
- **Agricultural Uses:**
    - Electricity for irrigation and farm processing
- **Advantages**
    - It is a source of renewable energy in the form of hydroelectric power.
    - It is cost effective and is competitively productive against non renewable sources.
    - Electricity can be generated constantly, because there are no external factors, which affect the availability of water.
    - Hydroelectric power produces no waste or pollution since no chemicals are involved.
    - Water used for hydro power can be reused for other purposes/like irrigation etc
- **Limitations**
    - The hydroelectric power plants cannot be sited at a place of our choice. There must be a strong current or considerable height to make the production worthwhile, as the capital cost of setting up production is relatively quite high.
    - Dams can be very expensive to build.
    - There needs to be a sufficient, and continuously strong water current, or water head, to produce energy.
- **Contribution:**
    - Reliable in hilly and canal-rich regions

Non-Renewable Energy Sources

These sources are **finite** and deplete with use.

(a) Fossil Fuels

- **Types:** Diesel, petrol, coal, natural gas
- **Agricultural Uses:**

    - Tractors and farm machinery
    - Diesel pump sets
    - Electricity generation
- **Contribution:**
    - Backbone of farm mechanization
    - High energy density and reliability
- **Limitations:**
    - High cost
    - Pollution
    - Greenhouse gas emissions

(b) Electrical Energy (Conventional)

- **Source:** Thermal power plants (coal-based)
- **Agricultural Uses:**
    - Irrigation pumps
    - Processing units
    - Cold storage
- **Contribution:**
    - Efficient and widely used
- **Limitations:**
    - Power shortages
    - Transmission losses

(c) Nuclear Energy

- **Source:** Nuclear fission
- **Agricultural Contribution:**
    - Indirect contribution through electricity supply
- **Limitations:**
    - High cost
    - Safety and waste disposal issues

B. Classification Based on Origin

1. Primary Energy Sources

Used directly from nature.

- Solar radiation
- Wind
- Biomass
- Coal
- Water

2. Secondary Energy Sources

Produced from primary sources.

- Electricity
- Biogas
- Producer gas
- Diesel and petrol

C. Classification Based on Use in Agriculture

1. Animate Energy

- **Source:** Humans and animals
- **Contribution:**
    - Traditional farming operations
    - Small and marginal farms
- **Limitation:**
    - Low efficiency and output

2. Inanimate Energy

- **Source:** Mechanical, electrical, thermal energy
- **Contribution:**
    - Increased productivity
    - Timely farm operations
    - Reduced drudgery

Contribution of Energy Sources in Agriculture

Energy Source	Major Contribution
Solar	Sustainable irrigation, drying, fencing
Biomass	Waste utilization, biogas, manure
Fossil Fuels	Mechanization, transport

Energy Source	Major Contribution
Electricity	Irrigation, processing, storage
Wind	Water pumping
Animal Power	Small-scale farming

Ultimate Source of Energy

- **Solar energy** is the **ultimate source** of:
    - Biomass energy (photosynthesis)
    - Wind energy (uneven heating of earth)
    - Ocean thermal energy
- **Geothermal and nuclear energy** are **not solar-derived** and originate from **earth's internal heat** and **atomic reactions**, respectively.

Advantages of Renewable Energy in Agriculture

- Environment-friendly
- Reduces dependence on fossil fuels
- Suitable for rural and off-grid areas
- Long-term cost effectiveness

Limitations of Renewable Energy

- High initial cost
- Weather dependency
- Need for storage systems

Conclusion

The agricultural sector relies on a mix of conventional and renewable energy sources. With rising energy costs and environmental concerns, renewable energy sources such as solar, biomass, and biogas play a crucial role in achieving sustainable and climate-resilient agriculture.

Objective type questions-

1. **Which of the following agricultural energy sources is** renewable, secondary, and inanimate **in nature?**

A. Solar radiation

B. Biogas

C. Wind energy

D. Animal power

Answer: B. Biogas

Explanation: Biogas is renewable, derived from biomass (secondary), and inanimate.

2. **The ultimate source of energy for** biomass, wind, and ocean thermal energy **is:**

A. Earth's core

B. Gravitational force

C. Solar radiation

D. Nuclear reactions

Answer: C. Solar radiation

3. **Which energy source contributes to agriculture** indirectly **but plays a major role in irrigation and cold storage?**

A. Biomass energy

B. Wind energy

C. Nuclear energy

D. Electrical energy

Answer: D. Electrical energy

Explanation: Electricity is a secondary energy source with indirect but significant agricultural impact.

4. **Identify the correctly matched pair:**

A. Biomass – Primary energy – Non-renewable

B. Electricity – Secondary energy – Renewable

C. Solar radiation – Primary energy – Renewable

D. Biogas – Primary energy – Non-renewable

Answer: C. Solar radiation – Primary energy – Renewable

5. **Which of the following is** NOT **a limitation of renewable energy in agriculture?**

A. Weather dependency

B. High initial cost

C. Greenhouse gas emission

D. Need for energy storage

Answer: C. Greenhouse gas emission

6. **The major reason fossil fuels are still dominant in farm mechanization is due to their:**

A. Environmental safety

B. Renewability

C. High energy density and reliability

D. Availability in rural areas

Answer: C. High energy density and reliability

7. **Which energy source improves** both sanitation and soil fertility **in agricultural systems?**

A. Biomass briquettes

B. Solar energy

C. Biogas energy

D. Wind energy

Answer: C. Biogas energy

8. **Which of the following energy forms is classified as** renewable but secondary**?**

A. Wind energy

B. Solar radiation

C. Biogas

D. Water flow

Answer: C. Biogas

9. **Animate energy in agriculture is mainly associated with:**

A. High field efficiency

B. Mechanized farming

C. Traditional and small-scale farming

D. Precision agriculture

Answer: C. Traditional and small-scale farming

10. **Which renewable energy source is most location-specific for agricultural use?**

A. Solar energy

B. Wind energy

C. Biomass energy

D. Biogas energy

Answer: B. Wind energy

11. **Which of the following combinations is** incorrect**?**

A. Solar energy – Greenhouse heating

B. Wind energy – Water lifting

C. Biomass energy – Cold storage

D. Electrical energy – Irrigation

Answer: C. Biomass energy – Cold storage

12. **Nuclear energy is different from solar-derived energy because it originates from:**

A. Atmospheric circulation

B. Photosynthesis

C. Earth's internal heat

D. Atomic fission reactions

Answer: D. Atomic fission reactions

13. **Which energy source provides** energy as well as manure **simultaneously?**

A. Biomass gasifier

B. Solar photovoltaic system

C. Biogas plant

D. Windmill

Answer: C. Biogas plant

14. **Electrical energy used in agriculture is mostly classified as:**

A. Primary and renewable

B. Primary and non-renewable

C. Secondary and renewable

D. Secondary and conventional

Answer: D. Secondary and conventional

15. **Which statement is** most scientifically accurate**?**

A. All renewable energies are secondary

B. All non-renewable energies are primary

C. Solar energy is the ultimate source of most renewable energies

D. Nuclear energy is indirectly solar-derived

Answer: C. Solar energy is the ultimate source of most renewable energies

16. **The energy source best suited for** off-grid irrigation in remote villages **is:**

A. Diesel engine

B. Coal-based electricity

C. Solar photovoltaic pump

D. Nuclear power

Answer: C. Solar photovoltaic pump

17. **Which agricultural energy source has** zero fuel cost but high initial investment**?**

A. Diesel engine

B. Biogas plant

C. Solar energy system

D. Biomass gasifier

Answer: C. Solar energy system

18. **Producer gas obtained from biomass is classified as:**

A. Primary renewable energy

B. Secondary renewable energy

C. Primary non-renewable energy

D. Secondary non-renewable energy

Answer: B. Secondary renewable energy

19. **Which factor mainly limits the large-scale adoption of renewable energy in agriculture?**

A. Low efficiency

B. High operational cost

C. Initial investment and storage requirement

D. Environmental pollution

Answer: C. Initial investment and storage requirement

20. **The most sustainable energy option that directly links** agriculture, energy production, and soil health **is:**

A. Solar thermal system

B. Windmill

C. Biogas plant

D. Diesel generator

Answer: C. Biogas plant

2. **Familiarization with Biomass Utilization for Biofuel Production and Their Applications**

Introduction

Biomass is one of the most important renewable energy resources directly linked with agriculture. Agricultural residues, animal wastes, and organic by-products can be converted into **biofuels**, providing clean energy, additional farm income, and sustainable waste management. Biomass-based biofuels play a crucial role in reducing dependence on fossil fuels and mitigating climate change.

Biomass

Biomass refers to **organic material of plant or animal origin** that can be used as a source of energy.

Common Biomass Sources in Agriculture

- Crop residues: rice straw, wheat straw, maize stalks, sugarcane bagasse
- Animal wastes: cattle dung, poultry litter
- Agro-industrial wastes: press mud, husk, shells
- Energy crops: sugarcane, maize, sorghum, switchgrass
- Forestry residues and weeds

Classification of Biomass

A. Based on Origin

1. **Agricultural biomass**
2. **Animal biomass**
3. **Forest biomass**
4. **Industrial and municipal organic waste**

B. Based on Physical Form

- Solid biomass
- Liquid biomass
- Gaseous biomass

Biofuel

Biofuels are fuels produced from biomass through **biological, chemical, or thermochemical processes**.

Types of Biofuels Produced from Biomass

A. Solid Biofuels

1. Firewood

- Traditional fuel
- Used for cooking and heating

2. Briquettes and Pellets

- Made by compressing loose biomass
- Higher density and uniform shape
- Used in boilers and industrial furnaces

B. Liquid Biofuels

1. Bioethanol

- Produced by fermentation of sugars and starch
- Raw materials: sugarcane, maize, sweet sorghum
- Applications:
    - Blended with petrol (E10, E20)
    - Used in IC engines

2. Biodiesel

- Produced from vegetable oils and animal fats
- Raw materials: Jatropha, Karanja, used cooking oil
- Applications:
    - Blended with diesel (B5, B20)
    - Used in tractors, generators

C. Gaseous Biofuels

1. Biogas

- Produced by anaerobic digestion
- Composition:
    - Methane (55–65%)
    - Carbon dioxide (30–40%)
- Applications:
    - Cooking
    - Lighting

    - Electricity generation
    - Organic manure (slurry)

2. Producer Gas

- Produced through gasification of biomass
- Used in engines and power generation

Biomass Conversion Technologies

A. Biochemical Conversion

- Fermentation (bioethanol)
- Anaerobic digestion (biogas)

B. Thermochemical Conversion

- Combustion
- Gasification
- Pyrolysis

C. Chemical Conversion

- Transesterification (biodiesel)

Biomass Utilization Pathway

Biomass → Conversion Process → Biofuel → Energy Application

Example:

- Crop residue → Anaerobic digestion → Biogas → Cooking & electricity

Applications of Biomass-Based Biofuels

A. On-Farm Applications

- Cooking and heating
- Irrigation pumps
- Farm machinery
- Drying of grains and produce

B. Industrial Applications

- Power generation
- Boilers and furnaces
- Agro-processing industries

C. Environmental Applications

- Waste management
- Reduction in greenhouse gas emissions
- Carbon neutrality

Advantages of Biomass Biofuels

- Renewable and sustainable
- Reduces fossil fuel dependency
- Converts waste into wealth
- Provides employment in rural areas
- Produces valuable by-products (manure, biochar)

Limitations of Biomass Utilization

- Collection and transportation issues
- Seasonal availability
- Lower energy density than fossil fuels
- Technology and initial cost constraints

Role of Biomass Biofuels in Sustainable Agriculture

- Supports circular economy
- Enhances soil health
- Reduces residue burning
- Promotes energy self-sufficiency on farms

Government Initiatives (India – for awareness)

- National Bio-Energy Mission
- Ethanol Blended Petrol Programme (EBP)
- National Biogas and Organic Manure Programme (NBOMP)
- SATAT Scheme (Compressed Biogas)

Ultimate Source of Biomass Energy

- **Solar energy**, through the process of **photosynthesis**

Objective type questions-

1. The direct link between agriculture and biomass energy exists mainly because:

A. Agriculture consumes more electricity than industry

B. Most fossil fuels are produced on farms

C. Agricultural activities continuously generate organic residues usable as energy

D. Biomass energy requires irrigation water

Answer: C

Concept: Crop residues and animal wastes are unavoidable outputs of agriculture.

2. Which statement best explains why biomass is considered a renewable energy source?

A. It is cheaper than fossil fuels

B. It is derived from underground carbon reserves

C. It is replenished through natural biological processes

D. It emits no carbon dioxide

Answer: C

Concept: Renewability depends on regeneration, not emissions.

3. Rice straw, wheat straw, and maize stalks are classified as:

A. Energy crops

B. Agro-industrial wastes

C. Forestry residues

D. Agricultural biomass

Answer: D

4. The most appropriate classification of cattle dung based on origin is:

A. Agricultural biomass

B. Forest biomass

C. Animal biomass

D. Industrial organic waste

Answer: C

5. Which biomass form requires the *least* preprocessing before direct combustion?

A. Liquid biomass

B. Gaseous biomass

C. Solid biomass

D. Fermented biomass

Answer: C

6. Briquettes and pellets are preferred over loose biomass mainly because they:

A. Are chemically treated

B. Have higher moisture content

C. Possess higher bulk density and uniform shape

D. Produce more smoke

Answer: C

Concept: Densification improves transport, storage, and combustion efficiency.

7. Bioethanol production is best described as a:

A. Thermochemical process

B. Chemical cracking process

C. Biochemical conversion through fermentation

D. Mechanical extraction process

Answer: C

8. Which factor makes sugarcane a preferred raw material for bioethanol?

A. High oil content

B. High cellulose content

C. High fermentable sugar content

D. Low moisture content

Answer: C

9. The main purpose of blending ethanol with petrol (E10, E20) is to:

A. Increase engine size

B. Reduce fuel evaporation

C. Reduce fossil fuel consumption and emissions

D. Increase fuel viscosity

Answer: C

10. Biodiesel differs fundamentally from bioethanol because biodiesel:

A. Is produced only from crops

B. Uses transesterification of oils and fats

C. Is produced by fermentation

D. Cannot be blended with fossil fuels

Answer: B

11. Which raw material is least suitable **for biodiesel production?**

A. Jatropha oil

B. Karanja oil

C. Used cooking oil

D. Sugarcane juice

Answer: D

12. Biogas production mainly depends on:

A. Presence of oxygen

B. High temperature combustion

C. Anaerobic microbial activity

D. Chemical catalysts

Answer: C

13. The major energy-rich component of biogas is:

A. Carbon dioxide

B. Nitrogen

C. Methane

D. Hydrogen sulphide

Answer: C

14. Biogas slurry is valuable because it:

A. Increases methane content

B. Acts as a chemical pesticide

C. Serves as nutrient-rich organic manure

D. Reduces digester temperature

Answer: C

15. Producer gas is obtained through:

A. Fermentation of biomass

B. Pyrolysis in absence of oxygen

C. Partial oxidation of biomass (gasification)

D. Complete combustion

Answer: C

16. Which conversion technology directly converts biomass into heat energy?

A. Gasification

B. Fermentation

C. Combustion

D. Transesterification

Answer: C

17. Transesterification is essential in biodiesel production mainly to:

A. Reduce moisture

B. Increase calorific value of ethanol

C. Reduce viscosity of vegetable oils

D. Increase carbon content

Answer: C

18. The biomass utilization pathway emphasizes that:

A. All biomass must be burned

B. One biomass source can yield multiple energy forms

C. Conversion process determines the final energy application

D. Biofuels cannot be used on farms

Answer: C

19. Which on-farm application best reflects energy self-sufficiency?

A. Diesel-powered tractors

B. Grid electricity usage

C. Biogas-based cooking and pumping

D. LPG usage

Answer: C

20. Biomass biofuels are considered carbon-neutral because:

A. They release no CO_2

B. Carbon released was earlier absorbed during plant growth

C. Carbon is permanently stored in soil

D. Fossil fuels absorb carbon

Answer: B

21. The biggest logistical limitation of biomass energy is:

A. High toxicity

B. Difficulty in ignition

C. Collection and transportation of bulky material

D. Lack of combustion technology

Answer: C

22. Reduction of crop residue burning through biomass utilization mainly improves:

A. Soil salinity

B. Air quality and soil health

C. Crop variety

D. Irrigation efficiency

Answer: B

23. The SATAT scheme in India primarily promotes:

A. Solar pumps

B. Wind energy

C. Compressed biogas production

D. Nuclear energy

Answer: C

24. Which concept best describes biomass biofuels in sustainable agriculture?

A. Linear economy

B. Circular economy

C. Import-dependent economy

D. Fossil-fuel-based economy

Answer: B

25. The ultimate source of energy **stored in biomass is:**

A. Soil nutrients

B. Microorganisms

C. Fossil fuels

D. Solar energy

Answer: D