An Analytical Report on APJ Abdul Kalam Technological University Course BTT435: Sustainable Energy Process (2019 Scheme)

I. Executive Summary and Analytical Methodology

This report presents a comprehensive analysis of the APJ Abdul Kalam Technological University (KTU) course BTT435: Sustainable Energy Process, a Semester 7 Open Elective for the B.Tech Biotechnology Engineering 2019 Scheme.[1] The primary objective is to analyze previous question paper patterns, identify high-frequency topics by module, and generate predictive model question papers for the upcoming university examination.

A critical challenge in this analysis is the lack of available previous year question papers (PYQs) specifically for the BTT435 (2019 scheme) course code.[3] However, question papers are available for the antecedent course from the 2016 scheme, **BT362: Sustainable Energy Processes**.[5]

This analysis establishes that these two courses cover the same technical content but differ significantly in their structure:

1. **BTT435 (2019 Scheme):** Follows a **5-module** syllabus [8] and a 100-mark (30/70) Part A/Part B examination pattern.[9]
2. **BT362 (2016 Scheme):** Followed a **6-module** syllabus [11] and a 100-mark Part A/Part B/Part C pattern.[11]

Therefore, a direct analysis of the BT362 paper would be misleading for a 2019 scheme student. This report executes a necessary **syllabus reconciliation and question re-mapping**. The methodology is as follows:

1. **Define the BTT435 Exam Pattern:** The correct 2019 scheme (Part A/B) pattern is definitively established.[10]

2. **Consolidate the Syllabus:** The 6-module syllabus of BT362 [13] is logically consolidated into a 5-module structure representative of BTT435.
3. **Re-map and Analyze PYQs:** All questions from the BT362 May 2019 question paper [7] are sorted into this new 5-module structure.
4. **Identify Patterns:** The re-mapped questions are analyzed to identify high-frequency topics and the pedagogical focus of the examiner for each module.
5. **Predict and Model:** A predictive question bank and two full-fledged model question papers are constructed based on these identified patterns, adhering strictly to the 2019 scheme examination structure.

II. Examination Structure and Syllabus Reconciliation

A. Definitive Examination Pattern: BTT435 (2019 Scheme)

The BTT435 examination adheres to the standard 2019 scheme regulations for theoretical courses.[10] The total marks for the End Semester Examination (ESE) are 100, with a duration of 3 hours.[10]

The paper is divided into two parts:

- **Part A (30 Marks):** This section is compulsory. It consists of **10 short-answer questions** of 3 marks each. The questions are drawn uniformly from the syllabus, with **2 questions from each of the 5 modules**.[10]
- **Part B (70 Marks):** This section provides choice. It consists of **10 full questions**, with **2 full questions from each module**. Students must answer **1 full question from each module**, for a total of 5 questions. Each full question carries 14 marks.[10]
- **Sub-questions:** Each 14-mark question in Part B can be divided into a maximum of two sub-questions (e.g., 7 marks + 7 marks, or 8 marks + 6 marks).[10]

This structure ensures full syllabus coverage and tests both foundational knowledge (Part A) and in-depth understanding (Part B).

Table 1: BTT435 Examination Pattern (2019 Scheme)

Part	Question	Questions per	Total Question	Questions to	Marks per	Total

	Type	Module	s in Paper	Answer	Question	Marks
Part A	Short Answer	2	10	10 (Compulsory)	3	**30**
Part B	Long Answer (with choice)	2 (Answer 1)	10	5 (One from each module)	14	**70**
Total	-	-	20	15	-	**100**

B. Syllabus Reconciliation: Mapping BT362 (6-Module) to BTT435 (5-Module)

To analyze the BT362 (2016 scheme) question paper, its 6-module syllabus [13] must be re-mapped into the 5-module BTT435 (2019 scheme) structure.[8]

The 2016 scheme's Module 2 (Solar Energy) [13] is exceptionally large, covering two distinct topics: Solar Thermal and Solar Photovoltaics. The most logical consolidation involves bifurcating this module and combining its parts with other related modules. The resulting 5-module structure, which forms the basis for this report's analysis, is detailed in Table 2.

Table 2: BTT435 (2019 Scheme) Consolidated 5-Module Syllabus

BTT435 Module	Consolidated Topics (Derived from BT362 Syllabus)	Source References
Module 1: Energy Fundamentals & Solar Thermal Systems	• **Fundamentals:** Conventional vs. Non-conventional, Renewable vs.	[13]

	Non-renewable. Global/Indian energy sources. • **Fossil Fuels:** Problems, environmental aspects of energy utilization. • **Sustainability:** Energy and sustainable development, energy planning. • **Solar Thermal:** Solar radiation, flat plate collectors, concentrating collectors, solar desalination, solar pond, solar cookers, solar dryers, solar thermal electric power plant.	
Module 2: Solar Photovoltaic Systems & Wind Energy	• **Solar PV:** Solar photovoltaic conversion, semiconductor technology, solar cells, PV power generation, hybrid systems, merits/limitations of solar. • **Wind Fundamentals:** Wind energy availability, site characteristics. • **Wind Turbines:** Types (Horizontal axis, Vertical axis), design principles, wind power plants. • **Wind Systems:** Wind energy storage, safety, environmental aspects, merits/limitations.	13

Module 3: Biomass Energy & Biofuels	• **Biomass Resources:** Biomass resources, conversion technologies (direct combustion, pyrolysis, gasification). • **Biogas:** Biogas production, biomethanation. • **Biofuels:** Bioethanol production, biodiesel production, biobutanol production. • **Hydrogen Fuel:** Hydrogen as fuel, biohydrogen production, storage of hydrogen.	7
Module 4: Geothermal, Ocean, & Hydropower Systems	• **Ocean Energy:** Ocean Thermal Electric Conversion (OTEC), Tidal energy conversion. • **Geothermal Energy:** Geothermal energy conversion (methods). • **Hydropower:** Global/Indian scenario, positive/negative attributes, electricity from hydropower, small hydropower.	11
Module 5: Fuel Cells & Energy Storage	• **Fuel Cells:** Working principle of Alkaline, Phosphoric acid, Molten carbonate, Solid oxide, and Solid polymer electrolyte (SPE) fuel cells.	11

	• **Advanced Systems:** Magneto-hydrodynamic (MHD) systems, electric vehicles. • **Energy Storage:** Energy storage routes (thermal, chemical, mechanical, electrical), batteries.	

III. Analysis of Previous Year Questions (PYQ) and High-Frequency Topics

This section analyzes the questions from the BT362 Degree Examination, May 2019 [7], after re-mapping them to the 5-module BTT435 structure.

A. Module 1: Energy Fundamentals & Solar Thermal Systems

Mapped Previous Year Questions (BT362 May 2019) [7]:

- Q1a) Describe Conventional and nonconventional energy sources? (4 marks)
- Q1b) Briefly explain Solar thermal electric power plant? (6 marks)
- Q1c) Explain renewable energy sources and applications? (5 marks)
- Q2a) Describe working principle of solar pond? (8 marks)
- Q2b) Explain various Problems of fossil fuels? (4 marks)
- Q2c) Write a note on Solar cookers? (3 marks)
- Q3b) Explain working principle and construction of flat plate collector? (8 marks)

Analysis and High-Frequency Topics:
The pedagogical focus for this module is twofold.

1. **Working Principles with Diagrams:** The majority of marks are allocated to questions requiring a detailed explanation of a solar thermal device's working principle, explicitly or implicitly requiring a neat, labeled diagram. This pattern is seen for solar ponds (8 marks), flat plate collectors (8 marks), and solar thermal plants (6 marks).
2. **Fundamental Concepts:** Lower-mark questions test foundational definitions, such as

comparing conventional and non-conventional sources [7] and listing the problems of fossil fuels.

B. Module 2: Solar Photovoltaic Systems & Wind Energy

Mapped Previous Year Questions (BT362 May 2019) [7]:

- Q3a) Explain Solar photovoltaic power generation. Its advantage and disadvantages? (7 marks)
- Q4a) Describe working principles of horizontal and vertical wind turbines? (10 marks)
- Q5b) Explain Site characteristics of availability of wind energy? (3 marks)
- **(From other model papers):** Compare the components and working of a standalone and grid connected PV system. [18]

Analysis and High-Frequency Topics:
This module tests two core renewable technologies.

1. **Comparative Analysis:** The questions are inherently comparative. The 10-mark question on HAWT vs. VAWT [7] is a classic 14-mark question in the 2019 scheme, likely to be split into two 7-mark parts. It requires a clear distinction based on operational principles (e.g., lift vs. drag, yaw mechanism).
2. **System-Level Understanding:** For PV, the focus is not on solid-state physics but on the *system* level: the principle of PV power generation [7] and the difference between standalone and grid-connected systems.[18]
3. **Site Selection:** Factors for wind energy site selection are a recurring topic.[7]

C. Module 3: Biomass Energy & Biofuels

Mapped Previous Year Questions (BT362 May 2019) [7]:

- Q4b) Explain Bioethanol production (5 marks)
- Q5a) Explain various Biomass conversion technologies-? (8 marks)
- Q5c) Describe biodiesel production? (4 marks)
- Q6a) Explain various steps involved in biogas production? (7 marks)
- Q6b) Explain different methods of biohydrogen production? (8 marks)

Analysis and High-Frequency Topics:
This module is the most aligned with the core Biotechnology curriculum, and the questions

reflect a focus on bio-chemical processes.

1. **Production Processes:** The keywords "production," "steps involved," and "methods" are dominant.[7] Students are expected to explain the entire process for biogas (anaerobic digestion), bioethanol (fermentation), biodiesel (transesterification), and biohydrogen.
2. **Conversion Technologies:** The question on "Biomass conversion technologies" (8 marks) [7] is a key "umbrella" topic, requiring the student to list and explain methods like pyrolysis, gasification, and direct combustion.[15]

D. Module 4: Geothermal, Ocean, & Hydropower Systems

Mapped Previous Year Questions (BT362 May 2019) [7]:

- Q7a) Describe Electricity from hydropower. (8 marks)
- Q7b) Distinguish between tidal and ocean thermal energy conversion system (4 marks)
- Q8b) Explain various methods of Geothermal energy conversion? (10 marks)
- Q9a) Describe Positive and negative attributes of hydropower? (10 marks)

Analysis and High-Frequency Topics:
This module groups three large-scale, earth-based energy systems.

1. **Broad Descriptive Questions:** The 10-mark questions [7] are broad and descriptive, making them ideal 14-mark questions. "Methods of Geothermal energy conversion" requires explaining and sketching the 2-3 main types (dry steam, flash, binary).
2. **Balanced Analysis:** The question on "Positive and negative attributes of hydropower" (10 marks) [7] requires a balanced discussion of its benefits (clean, dispatchable) and its significant environmental/social drawbacks (displacement, ecological impact).
3. **Core Comparison:** The distinction between OTEC and tidal energy (4 marks) [7] is a fundamental concept, making it a high-probability question for Part A or a 7-mark sub-question.

E. Module 5: Fuel Cells & Energy Storage

Mapped Previous Year Questions (BT362 May 2019) [7]:

- Q7c) Explain Alkaline fuel cells and its working principle? (8 marks)
- Q8a) Explain working principle of Magneto-hydrodynamic systems? (10 marks)
- Q9b) Describe working principles of Solid oxide fuel cell and Solid polymer (10) electrolyte fuel cell?

Analysis and High-Frequency Topics:
This is the most technically dense module, and the PYQ analysis shows a clear examiner preference.

1. **Fuel Cell Working Principles:** The examiner *repeatedly* asks for the working principles of specific, named fuel cells. The May 2019 paper alone covers three types: Alkaline (AFC), Solid Oxide (SOFC), and Solid Polymer (SPEFC).[7] This is the module's most critical topic. Students must be prepared to draw a schematic (anode, cathode, electrolyte) and describe the chemical reactions and ion flow.
2. **Advanced Systems:** The working principle of MHD systems is also a high-mark (10 marks) topic.[7]
3. **Syllabus Gap:** The 2016 syllabus includes "Energy storage routes" (thermal, chemical, mechanical, electrical, batteries).[11] This topic was *not* asked in the May 2019 paper [7], making it a **high-probability topic** for future examinations.

IV. Predictive Question Bank for BTT435

This question bank is derived from the preceding analysis. The frequency of question *types* in the May 2019 paper reveals a clear pattern, as summarized in Table 3.

Table 3: Question Type and Frequency Matrix (Analysis of BT362 May 2019)

Question Pattern	Module 1	Module 2	Module 3	Module 4	Module 5	Total PYQ Instances
"Explain working principle + diagram"	3 (Thermal plant, pond, flat plate)	2 (PV, HAWT/VAWT)	1 (Biogas)	3 (Hydro, Geo, OTEC)	4 (AFC, MHD, SOFC, SPEFC)	**13**
"Describe steps/methods"	-	-	4 (Bioethanol, Biodiesel, Biohydro	1 (Geo methods)	-	**5**

			gen, Conversion)			
"Compare/Distinguish"	1 (Conv. vs. Non-conv.)	2 (HAWT vs. VAWT, Grid vs. Standalone)	-	1 (Tidal vs. OTEC)	-	**4**
"List attributes (adv/disadv, merits, problems)"	2 (Fossil fuel problems, Renewable apps)	1 (PV adv/disadv)	-	1 (Hydro attributes)	-	**4**

This matrix demonstrates that the vast majority of marks are awarded for explaining "working principles with a diagram." The predictive questions below reflect this emphasis.

A. Part A (3-Mark Questions)

Module 1:

1. Define conventional energy sources. List two examples.[13]
2. What is a non-convective solar pond?.[7]
3. State the principle of a flat plate collector.[7]
4. List any three problems associated with fossil fuel use.[7]
5. What is a concentrating solar collector?

Module 2:
6. What is a solar photovoltaic (PV) cell?.13
7. Differentiate between a HAWT and a VAWT.7
8. List three key factors for wind turbine site selection.7
9. What is a grid-connected PV system?.18
10. What is the principle of a Darrieus-type wind turbine?
Module 3:

11. What is biomass gasification?.13
12. Define transesterification in the context of biodiesel production.7
13. What is biomethanation?.13
14. List three methods of hydrogen storage.13
15. What is pyrolysis?
Module 4:
16. Define Ocean Thermal Electric Conversion (OTEC).13
17. What is a "binary cycle" geothermal power plant?.7
18. List three positive attributes of hydropower.7
19. What is tidal energy?.13
20. What is a "flash steam" geothermal plant?
Module 5:
21. What is an Alkaline Fuel Cell (AFC)?.7
22. State the working principle of an MHD system.7
23. List three routes for energy storage.11
24. What is a Solid Oxide Fuel Cell (SOFC)?.7
25. Define a fuel cell stack.

B. Part B (14-Mark Questions)

Module 1:

1. (a) Explain the working principle of a solar pond with a neat diagram. (8m)

   (b) Differentiate between conventional and non-conventional energy sources, providing two examples of each. (6m) [7]
2. (a) With a neat, labelled diagram, explain the construction and working of a flat plate solar collector. (8m)

   (b) Briefly explain the operation of a solar thermal electric power plant. (6m) [7]

Module 2:
3. (a) Explain the working principle of solar photovoltaic power generation. (7m)

(b) List and discuss the advantages and disadvantages of solar PV systems. (7m) 7
4. (a) Describe the working principles of a Horizontal Axis Wind Turbine (HAWT) with a neat sketch. (7m)

(b) Describe the working principles of a Vertical Axis Wind Turbine (VAWT) with a neat sketch. (7m) 7
5. (a) With block diagrams, compare the components and working of a standalone PV system

and a grid-connected PV system. (8m) 18

(b) Explain the site characteristics that must be analyzed for the availability of wind energy. (6m) 7

Module 3:
6. Explain the main biomass conversion technologies. Briefly describe (i) Pyrolysis, (ii) Gasification, and (iii) Direct Combustion. (14m) 7
7. (a) Explain the various steps involved in biogas production through anaerobic digestion, with a diagram of a biogas plant. (7m)

(b) Explain the process of bioethanol production from a suitable biomass source. (7m) 7
8. (a) Describe the process of biodiesel production via transesterification. (7m)

(b) Explain two different methods of biohydrogen production. (7m) 7

Module 4:
9. (a) Describe the main methods of geothermal energy conversion (Dry Steam, Flash Steam, Binary) with neat sketches. (9m)

(b) Distinguish between a tidal energy system and an OTEC system. (5m) 7
10. (a) Describe in detail the positive and negative attributes (environmental and social) of large-scale hydropower plants. (10m)

(b) What is small hydropower and why is it preferred? (4m) 7

Module 5:
11. (a) With a neat diagram, explain the working principle of a Solid Oxide Fuel Cell (SOFC). (7m)

(b) With a neat diagram, explain the working principle of a Solid Polymer Electrolyte Fuel Cell (SPEFC). (7m) 7
12. (a) Explain the working principle of a Magneto-Hydrodynamic (MHD) system for power generation. (8m)

(b) With a neat diagram, explain the working of an Alkaline Fuel Cell (AFC). (6m) 7
13. (a) Explain the different routes for energy storage (thermal, chemical, mechanical, electrical). (8m) 11

(b) Describe the working of a Phosphoric Acid Fuel Cell (PAFC) with a neat diagram. (6m) 11

V. Model Question Paper - 1

Course Code: BTT435
Course Name: Sustainable Energy Process
Max. Marks: 100 | Duration: 3 Hours
PART A
(Answer all questions. Each carries 3 marks. 10 x 3 = 30)

1. List any three major environmental problems associated with the use of fossil fuels. (Module 1)
2. What is a solar thermal electric power plant? (Module 1)
3. State the advantages of a grid-connected PV system over a standalone system. (Module 2)
4. What is the function of a yaw mechanism in a Horizontal Axis Wind Turbine? (Module 2)
5. Define "biomass pyrolysis." (Module 3)
6. What is bioethanol? Name one feedstock used for its production. (Module 3)
7. What is the working principle of OTEC? (Module 4)
8. List any three negative attributes of large-scale hydropower. (Module 4)
9. What is a Magneto-Hydrodynamic (MHD) system? (Module 5)
10. Differentiate between a primary and a secondary battery. (Module 5)

PART B
(Answer one full question from each module. Each carries 14 marks. 5 x 14 = 70)
Module I

11. (a) With a neat, labelled diagram, explain the construction and working of a flat plate solar collector. (8m)
    (b) Differentiate between conventional and non-conventional energy sources. (6m)
    OR
12. (a) Describe the working principle of a non-convective solar pond with a neat sketch. (8m)
    (b) Briefly explain the global and Indian energy source scenario. (6m)

Module II

13. (a) With a neat sketch, explain the working principle of a Solar Photovoltaic (PV) cell. (7m)
    (b) List and discuss the advantages and disadvantages of solar PV power generation. (7m)
    OR
14. (a) With a neat sketch, explain the working principle and components of a Horizontal Axis Wind Turbine (HAWT). (8m)
    (b) Discuss the key site characteristics for selecting a wind power plant location. (6m)

Module III

15. (a) Explain the process of transesterification for biodiesel production. (7m)
    (b) Explain the various steps involved in the production of biogas by anaerobic digestion. (7m)
    OR
16. Explain any three main biomass conversion technologies. Briefly describe (i) Gasification, (ii) Pyrolysis, and (iii) Biomethanation. (14m)

Module IV

17. (a) With neat sketches, explain the three main types of geothermal energy conversion systems (Dry Steam, Flash, Binary). (9m)
    (b) Explain the working of a tidal barrage system for power generation. (5m)
    OR
18. (a) Describe the electricity generation process from a hydropower plant with a neat layout. (8m)
    (b) Discuss the positive and negative environmental attributes of hydropower. (6m)

Module V

19. (a) With a neat schematic, explain the working principle of a Solid Oxide Fuel Cell (SOFC), showing the reactions at the anode and cathode. (7m)
    (b) With a neat schematic, explain the working principle of a Solid Polymer Electrolyte Fuel Cell (SPEFC). (7m)
    OR
20. (a) Explain the different routes for energy storage (thermal, chemical, mechanical, electrical). (8m)
    (b) Explain the working principle of an Alkaline Fuel Cell (AFC) with a diagram. (6m)

VI. Model Question Paper - 2

Course Code: BTT435
Course Name: Sustainable Energy Process
Max. Marks: 100 | Duration: 3 Hours
PART A
(Answer all questions. Each carries 3 marks. 10 x 3 = 30)

1. Differentiate between renewable and non-renewable energy sources. (Module 1)
2. What is a box-type solar cooker? (Module 1)
3. What is a Vertical Axis Wind Turbine (VAWT)? Give an example. (Module 2)
4. List the main components of a standalone PV system. (Module 2)

5. What is biomass? List two sources of biomass. (Module 3)
6. Define biohydrogen. (Module 3)
7. What is a "small hydropower" plant? (Module 4)
8. Distinguish between Tidal and OTEC systems. (Module 4)
9. What is a Phosphoric Acid Fuel Cell (PAFC)? (Module 5)
10. What is a "fuel cell stack"? (Module 5)

PART B
(Answer one full question from each module. Each carries 14 marks. 5 x 14 = 70)

Module I

11. (a) With a neat sketch, explain the working of a solar thermal electric power plant. (8m)
    (b) Discuss the major problems associated with over-reliance on fossil fuels. (6m)
    OR
12. (a) With a neat, labelled diagram, explain the construction and working of a flat plate solar collector. (8m)
    (b) Write a note on solar cookers and solar dryers. (6m)

Module II

13. (a) With a block diagram, explain the operation of a grid-connected solar PV power generation system. (7m)
    (b) With a block diagram, explain the operation of a standalone solar PV system. (7m)
    OR
14. (a) Describe the working principle of a Vertical Axis Wind Turbine (VAWT), focusing on the Savonius and Darrieus types. (8m)
    (b) Explain the merits and limitations of wind energy. (6m)

Module III

15. (a) With a flowchart, explain the complete process of bioethanol production from a sugar-based feedstock. (7m)
    (b) With a flowchart, explain the production of biodiesel from vegetable oils. (7m)
    OR
16. (a) Explain the different methods of biohydrogen production. (7m)
    (b) Explain the main steps in a modern biogas plant with a neat diagram. (7m)

Module IV

17. (a) Explain the working principle of an Ocean Thermal Energy Conversion (OTEC) system with a neat diagram. (8m)
    (b) Describe the positive and negative attributes of geothermal energy. (6m)
    OR
18. (a) Explain the various methods for geothermal energy conversion. (8m)
    (b) Discuss the global and Indian scenario for hydropower. (6m)

Module V

19. (a) Explain the working principle of a Magneto-Hydrodynamic (MHD) power generation system with a neat schematic. (8m)
    (b) Write short notes on electric vehicles and their batteries. (6m)
    OR
20. (a) With a neat schematic, explain the working principle of a Molten Carbonate Fuel Cell (MCFC). (7m)
    (b) With a neat schematic, explain the working principle of an Alkaline Fuel Cell (AFC). (7m)

VII. Conclusions and Strategic Recommendations

The analysis of the antecedent PYQ [7] and syllabus structure [13] confirms that the BTT435 examination is highly predictable. The pedagogical focus is heavily skewed toward a specific type of question for each module.

Based on this analysis, the following strategic recommendations are provided for students preparing for the BTT435 examination:

1. **Prioritize "Working Principle + Diagram" Questions:** For Modules 1, 2, 4, and 5, the vast majority of marks are allocated to questions testing the working principle of a specific technology (e.g., flat plate collectors, HAWT/VAWT, geothermal plants, OTEC, fuel cells, MHD).[7] Preparation *must* involve practicing the drawing and labeling of neat schematics for all major technologies listed in the syllabus.
2. **Prepare Process Flowcharts for Module 3:** Module 3 (Biomass) is unique in its focus on *processes*. Students should prepare and memorize the process flowcharts for biogas production (anaerobic digestion), bioethanol production (fermentation), and biodiesel production (transesterification), as questions are structured around these "steps" and "methods".[7]
3. **Focus on the High-Probability "Gap" Topic:** The topic of "Energy Storage" (thermal, chemical, mechanical, electrical, batteries) from Module 5 [11] is a significant part of the syllabus but was conspicuously *absent* from the May 2019 examination.[7] This indicates a very high probability of it appearing as a 7-mark or 14-mark question in the upcoming examination.
4. **Master Comparative Questions:** Several key topics are best understood as comparisons. Students should be prepared to "compare and contrast" or "distinguish between" the following pairs:
    - Conventional vs. Non-conventional energy (Module 1)
    - HAWT vs. VAWT (Module 2)

- Grid-connected vs. Standalone PV (Module 2)
- OTEC vs. Tidal Energy (Module 4)

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