SRM VALLIAMMAI ENGINEERING COLLEGE

(Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

V SEMESTER

PEE601 ENERGY STORAGE SYSTEMS

Regulation – 2023

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Prepared by

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SUBJECT & SUBJECT CODE: PEE601 ENERGY STORAGE SYSTEMS SEM / YEAR: V/ III

UNIT-I INTRODUCTION

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	State two applications of energy storage systems.	BTL1	Remembering	CO1
2.	Mention any two types of energy storage systems.	BTL2	Understanding	CO1
3.	Define energy density.	BTL1	Remembering	CO1
4.	Define power density.	BTL2	Understanding	CO1
5.	Why is energy storage necessary in renewable energy systems?	BTL1	Remembering	CO1
6.	List two challenges of energy storage systems.	BTL2	Understanding	CO1
7.	What is the main function of an energy storage device?	BTL1	Remembering	CO1
8.	Name two mechanical energy storage systems.	BTL2	Understanding	CO1
9.	Mention two examples of thermal energy storage.	BTL1	Remembering	CO1
10.	List two electrical energy storage devices.	BTL2	Understanding	CO1
11.	Define round-trip efficiency.	BTL1	Remembering	CO1
12.	Mention one advantage and one limitation of chemical storage.	BTL2	Understanding	CO1
13.	What is meant by grid balancing?	BTL1	Remembering	CO1
14.	Name two energy storage technologies used in electric vehicles.	BTL2	Understanding	CO1
15.	Define "backup power" in the context of energy storage.	BTL1	Remembering	CO1
16.	What are hybrid energy storage systems?	BTL2	Understanding	CO1
17.	State two advantages of energy storage for smart grids.	BTL1	Remembering	CO1
18.	Mention any two factors affecting the selection of an ESS.	BTL2	Understanding	CO1
19.	Define intermittent energy sources.	BTL1	Remembering	CO1
20.	State one application of ESS in the residential sector.	BTL2	Understanding	CO1
21.	What is peak shaving?	BTL1	Remembering	CO1
22.	List two components of a typical energy storage system.	BTL2	Understanding	CO1

23.	Mention any two emerging trends in energy storage.		BTL1	Remembering	CO1
24.	Give one reason why energy storage reduces carbon footprint.		BTL2	Understanding	CO1
25.	State two applications of energy storage systems.		BTL1	Remembering	CO1
	PART-B				
1.	Discuss the necessity of energy storage in modern energy systems.	(16)	BTL3	Applying	CO1
2.	Explain in detail the different types of energy storage systems.	(16)	BTL4	Analyzing	CO1
3.	Compare mechanical, chemical, electrical, and thermal energy storage systems.	(16)	BTL3	Applying	CO1
4.	Analyze the criteria for selecting a suitable energy storage technology for grid applications.	(16)	BTL4	Analyzing	CO1
5.	Evaluate the advantages and limitations of energy storage technologies.	(16)	BTL3	Applying	CO1
6.	Write a detailed note on the role of energy storage in renewable energy integration.	(16)	BTL4	Analyzing	CO1
7.	Describe the applications of energy storage systems in electric vehicles and power backup systems.	(16)	BTL3	Applying	CO1
8.	Discuss how energy storage systems contribute to grid stability.	(16)	BTL4	Analyzing	CO1
9.	Explain the role of energy storage in peak load management.	(16)	BTL3	Applying	CO1
10.	Compare short-term and long-term energy storage systems with examples.	(16)	BTL4	Analyzing	CO1
11.	Discuss economic and environmental aspects of deploying energy storage systems.	(16)	BTL3	Applying	CO1
12.	A wind turbine generates 200 kW of power during the day for 6 hours and operates at 80 kW during the night. Calculate the energy required to store for the night. Assume that the storage system has 90% efficiency.	(16)	BTL4	Analyzing	CO1
13.	Describe the performance characteristics and design considerations for energy storage systems.	(16)	BTL3	Applying	CO1
14.	Compare energy storage systems based on energy density and power density.	(16)	BTL4	Analyzing	CO1
15.	Explain the impact of ESS on carbon emission reduction.	(16)	BTL3	Applying	CO1

16.	How do energy storage systems help in reducing transmission congestion?	(16)	BTL4	Analyzing	CO1
17.	Describe the classification of energy storage technologies with suitable examples.	(16)	BTL3	Applying	CO1
18.	Explain the relevance of energy storage in the context of smart grids.	(16)	BTL4	Analyzing	CO1

UNIT-II THERMAL STORAGE SYSTEM

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Define thermal energy storage.	BTL1	Remembering	CO2
2.	Mention any two types of thermal energy storage.	BTL2	Understanding	CO2
3.	What is sensible heat storage?	BTL1	Remembering	CO2
4.	What is latent heat storage?	BTL2	Understanding	CO2
5.	Define thermal conductivity.	BTL1	Remembering	CO2
6.	Name a common material used in rock bed storage systems.	BTL2	Understanding	CO2
7.	What is a phase change material (PCM)?	BTL1	Remembering	CO2
8.	Define thermal stratification.	BTL2	Understanding	CO2
9.	What is the function of a heat exchanger in TES?	BTL1	Remembering	CO2
10.	Mention two advantages of latent heat storage.	BTL2	Understanding	CO2
11.	What is a packed bed thermal storage system?	BTL1	Remembering	CO2
12.	Write one advantage of a pressurized water storage system.	BTL2	Understanding	CO2
13.	What is the use of TRNSYS software?	BTL1	Remembering	CO2
14.	What is thermochemical energy storage?	BTL2	Understanding	CO2
15.	Define energy retention.	BTL1	Remembering	CO2
16.	Mention one limitation of PCM systems.	BTL2	Understanding	CO2
17.	What is the role of insulation in TES systems?	BTL1	Remembering	CO2
18.	Write two criteria for selecting thermal storage materials.	BTL2	Understanding	CO2
19.	Name two industrial applications of TES.	BTL1	Remembering	CO2
20.	What is the porous medium approach?	BTL2	Understanding	CO2
21.	Define specific heat.	BTL1	Remembering	CO2
22.	What is the difference between active and passive TES?	BTL2	Understanding	CO2
23.	Mention one benefit of using molten salt in TES.	BTL1	Remembering	CO2

24.	List two advantages of using TRNSYS in modeling.		BTL2	Understanding	CO2
25.	What is the impact of TES on peak load management?		BTL1	Remembering	CO2
	PART-B				
1.	Define thermal energy storage. Describe its need and benefits.	(16)	BTL3	Applying	CO2
2.	Classify the different types of thermal energy storage systems.	(16)	BTL4	Analyzing	CO2
3.	Explain the working principle of a simple water and rock bed thermal storage system.	(16)	BTL3	Applying	CO2
4.	Discuss the design and modeling aspects of pressurized water storage systems.	(16)	BTL4	Analyzing	CO2
5.	Explain the modeling of phase change material (PCM) based storage units.	(16)	BTL3	Applying	CO2
6.	Describe the operation of a packed bed thermal storage system.	(16)	BTL4	Analyzing	CO2
7.	How is the porous medium approach used for modeling thermal energy storage?	(16)	BTL3	Applying	CO2
8.	Discuss the role of TRNSYS software in simulating thermal storage systems.	(16)	BTL4	Analyzing	CO2
9.	i If a thermal storage system uses water with a specific heat of 4.18 kJ/kg°C, and 2000 kg of water is heated by 50°C, calculate the amount of energy stored in the system.	(8)	BTL3	Applying	CO2
	ii For a phase change material (PCM) with a latent heat of fusion of 150 kJ/kg, calculate the energy stored when 80 kg of PCM undergoes a phase change.	(8)	BTL3	Applying	CO2
10.	Compare sensible heat storage and latent heat storage systems.	(16)	BTL4	Analyzing	CO2
11.	What are the challenges in designing PCM-based thermal storage systems?	(16)	BTL3	Applying	CO2
12.	Describe thermal stratification in water-based thermal energy storage.	(16)	BTL4	Analyzing	CO2
13.	Write a note on thermochemical energy storage systems.	(16)	BTL3	Applying	CO2
14.	Compare thermal storage systems based on heat retention and discharge rates.	(16)	BTL4	Analyzing	CO2
15.	Explain the modeling of thermal storage unit.	(16)	BTL3	Applying	CO2
16.	Explain the energy balance and efficiency of	(16)	BTL4	Analyzing	CO2

	thermal storage units.				
17.	How does the choice of material affect the design of thermal energy storage?	(16)	BTL3	Applying	CO2
18.	Evaluate the performance of hybrid thermal storage systems.	(16)	BTL4	Analyzing	CO2

UNIT-III ELECTRICAL ENERGY STORAGE

Fundamental concept of batteries – measuring of battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Define a battery.	BTL1	Remembering	CO3
2.	What is a flow battery?	BTL2	Understanding	CO3
3.	Name two types of rechargeable batteries.	BTL1	Remembering	CO3
4.	Define charge efficiency of a battery.	BTL2	Understanding	CO3
5.	What is the function of an electrolyte?	BTL1	Remembering	CO3
6.	Define depth of discharge (DoD).	BTL2	Understanding	CO3
7.	Mention one advantage of a Li-ion battery.	BTL1	Remembering	CO3
8.	What is the typical voltage of a lead-acid cell?	BTL2	Understanding	CO3
9.	Define battery cycle life.	BTL1	Remembering	CO3
10.	What is the role of the separator in a battery?	BTL2	Understanding	CO3
11.	Write the chemical formula for lead-acid battery reaction.	BTL1	Remembering	CO3
12.	What is energy density?	BTL2	Understanding	CO3
13.	Mention one limitation of Nickel-Cadmium batteries.	BTL1	Remembering	CO3
14.	What is the significance of battery safety?	BTL2	Understanding	CO3
15.	Define battery management system (BMS).	BTL1	Remembering	CO3
16.	Write two characteristics of flow batteries.	BTL2	Understanding	CO3
17.	What is a zinc-air battery?	BTL1	Remembering	CO3
18.	Mention one feature of sodium-ion batteries.	BTL2	Understanding	CO3
19.	State two uses of Li-ion batteries.	BTL1	Remembering	CO3
20.	Define open-circuit voltage.	BTL2	Understanding	CO3
21.	What is a solid-state battery?	BTL1	Remembering	CO3
22.	List two causes of battery degradation.	BTL2	Understanding	CO3
23.	Mention two performance parameters of a battery.	BTL1	Remembering	CO3
24.	What is the function of a cathode?	BTL2	Understanding	CO3
25.	What is trickle charging?	BTL1	Remembering	CO3

PART-B					
1.	Explain the working principle of a battery and describe its key components.	(16)	BTL3	Applying	CO3
2.	Discuss battery performance metrics like energy density, power density, and efficiency.	(16)	BTL4	Analyzing	CO3
3.	Compare the working, advantages, and limitations of Lead Acid and Li-ion batteries.	(16)	BTL3	Applying	CO3
4.	Describe the charging and discharging characteristics of batteries.	(16)	BTL4	Analyzing	CO3
5.	Explain the mathematical modeling of lead-acid batteries.	(16)	BTL3	Applying	CO3
6.	Compare different battery chemistries: Nickel-Cadmium, Zinc-MnO_2, Li-ion.	(16)	BTL4	Analyzing	CO3
7.	Discuss the safety issues associated with various battery technologies.	(16)	BTL3	Applying	CO3
8.	Explain the design considerations for batteries used in EVs.	(16)	BTL4	Analyzing	CO3
9.	Analyze the impact of temperature on battery performance and lifecycle.	(16)	BTL3	Applying	CO3
10.	Analyze different battery storage technologies.	(16)	BTL4	Analyzing	CO3
11.	Compare conventional batteries with flow batteries for large-scale applications.	(16)	BTL3	Applying	CO3
12.	Explain the concept of battery management systems (BMS).	(16)	BTL4	Analyzing	CO3
13.	Write a detailed note on battery degradation mechanisms.	(16)	BTL3	Applying	CO3
14.	How is battery capacity measured? Explain different techniques.	(16)	BTL4	Analyzing	CO3
15.	A Li-ion battery has an energy density of 180 Wh/kg and a capacity of 120 Ah. Calculate the total energy stored in the battery, assuming a nominal voltage of 3.7 V.	(16)	BTL3	Applying	CO3
16.	Compare Li-ion and sodium-ion batteries for grid applications.	(16)	BTL4	Analyzing	CO3
17.	Explain the principle and design of Zinc-Air and Iron-Air batteries.	(16)	BTL3	Applying	CO3
18.	Discuss the role of batteries in energy storage for renewable energy systems.	(16)	BTL4	Analyzing	CO3
UNIT-IV FUEL CELL					

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantages and disadvantages.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	What is a fuel cell?	BTL1	Remembering	CO4
2.	Define electrochemical energy conversion.	BTL2	Understanding	CO4
3.	Mention any two types of fuel cells.	BTL1	Remembering	CO4
4.	What are the reactants in a hydrogen-oxygen fuel cell?	BTL2	Understanding	CO4
5.	What is the electrolyte in an alkaline fuel cell?	BTL1	Remembering	CO4
6.	Write the basic chemical reaction in a fuel cell.	BTL2	Understanding	CO4
7.	Mention one advantage of fuel cells.	BTL1	Remembering	CO4
8.	List two applications of fuel cells.	BTL2	Understanding	CO4
9.	What is a PEM fuel cell?	BTL1	Remembering	CO4
10.	Define operating temperature of a fuel cell.	BTL2	Understanding	CO4
11.	What is the output of a fuel cell?	BTL1	Remembering	CO4
12.	Mention one disadvantage of using hydrogen as fuel.	BTL2	Understanding	CO4
13.	What is the role of the catalyst in a fuel cell?	BTL1	Remembering	CO4
14.	Define efficiency of a fuel cell.	BTL2	Understanding	CO4
15.	What is the main challenge in hydrogen storage?	BTL1	Remembering	CO4
16.	Mention two applications of hydrogen fuel cells.	BTL2	Understanding	CO4
17.	Name one fuel cell suitable for transportation.	BTL1	Remembering	CO4
18.	What is the by-product of a hydrogen-oxygen fuel cell?	BTL2	Understanding	CO4
19.	State one difference between battery and fuel cell.	BTL1	Remembering	CO4
20.	Define power density in a fuel cell.	BTL2	Understanding	CO4
21.	What is methanol fuel cell?	BTL1	Remembering	CO4
22.	Mention one issue in fuel cell durability.	BTL2	Understanding	CO4
23.	Write two features of a hydrocarbon-air cell.	BTL1	Remembering	CO4
24.	Name two materials used in fuel cell electrodes.	BTL2	Understanding	CO4
25.	What is the significance of fuel cell stack?	BTL1	Remembering	CO4

PART-B

1.	Describe the working principle of a fuel cell with a schematic diagram.	(16)	BTL3	Applying	CO4
2.	Explain the electrochemical reactions in a hydrogen-oxygen fuel cell.	(16)	BTL4	Analyzing	CO4
3.	Trace the historical development and evolution of fuel cell technologies.	(16)	BTL3	Applying	CO4
4.	Discuss different types of fuel cells with structure	(16)	BTL4	Analyzing	CO4

	and applications.					
5.	Compare hydrogen-air and hydrocarbon-air fuel cells.		(16)	BTL3	Applying	CO4
6.	Explain the operating principles and efficiency of alkaline fuel cells.		(16)	BTL4	Analyzing	CO4
7.	Discuss the advantages and limitations of fuel cell technologies.		(16)	BTL3	Applying	CO4
8.	Explain the role of catalysts in fuel cell reactions.		(16)	BTL4	Analyzing	CO4
9.	Evaluate the application of fuel cells in transportation and stationary power.		(16)	BTL3	Applying	CO4
10.	Compare fuel cells and batteries based on performance parameters.		(16)	BTL4	Analyzing	CO4
11.	Describe the challenges involved in hydrogen production and storage.		(16)	BTL3	Applying	CO4
12.	Write a note on fuel cell system integration in hybrid vehicles.		(16)	BTL4	Analyzing	CO4
13.	Discuss the thermodynamic analysis of a typical fuel cell.		(16)	BTL3	Applying	CO4
14.	Explain the safety aspects of using hydrogen in fuel cells.		(16)	BTL4	Analyzing	CO4
15.	Describe the design and operation of a Proton Exchange Membrane (PEM) fuel cell.		(16)	BTL3	Applying	CO4
16.	Analyze the impact of temperature and pressure on fuel cell performance.		(16)	BTL4	Analyzing	CO4
17.	i	A hydrogen fuel cell operates with a hydrogen flow rate of 0.5 kg/h. Calculate the energy produced by the fuel cell per day, assuming that 1 kg of hydrogen produces 120 kWh.	(8)	BTL3	Applying	CO4
	ii	A fuel cell operates with a hydrogen flow rate of 0.2 kg/h. Calculate the total energy produced by the fuel cell in a 10-hour operation period.	(8)	BTL3	Applying	CO4
18.	Discuss future prospects and ongoing research in fuel cell technology.		(16)	BTL4	Analyzing	CO4
UNIT-V ALTERNATE ENERGY STORAGE TECHNOLOGIES						
Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.						
PART-A						

Q. No	Questions		BT Level	Competence	CO
1.	What is a flywheel energy storage system?		BTL1	Remembering	CO5
2.	Define kinetic energy storage.		BTL2	Understanding	CO5
3.	Mention two features of supercapacitors.		BTL1	Remembering	CO5
4.	What is compressed air energy storage (CAES)?		BTL2	Understanding	CO5
5.	Define hybrid energy storage.		BTL1	Remembering	CO5
6.	What is pumped hydro storage?		BTL2	Understanding	CO5
7.	Mention one limitation of flywheel storage.		BTL1	Remembering	CO5
8.	State one advantage of CAES.		BTL2	Understanding	CO5
9.	What is the energy source in supercapacitors?		BTL1	Remembering	CO5
10.	Define power density in capacitors.		BTL2	Understanding	CO5
11.	Mention one difference between capacitor and battery.		BTL1	Remembering	CO5
12.	What is SMES?		BTL2	Understanding	CO5
13.	Define gravitational energy storage.		BTL1	Remembering	CO5
14.	What are the advantages of hybrid systems?		BTL2	Understanding	CO5
15.	Mention one application of supercapacitors.		BTL1	Remembering	CO5
16.	What is round-trip efficiency in hydro storage?		BTL2	Understanding	CO5
17.	Mention one environmental impact of pumped hydro storage.		BTL1	Remembering	CO5
18.	What is meant by long-duration storage?		BTL2	Understanding	CO5
19.	Write one benefit of combining battery and capacitor systems.		BTL1	Remembering	CO5
20.	What is the typical response time of supercapacitors?		BTL2	Understanding	CO5
21.	Define energy recovery.		BTL1	Remembering	CO5
22.	Name two components of a flywheel system.		BTL2	Understanding	CO5
23.	What is the role of control strategy in hybrid systems?		BTL1	Remembering	CO5
24.	Define magnetic energy storage.		BTL2	Understanding	CO5
25.	Mention two uses of CAES in renewable energy systems.		BTL1	Remembering	CO5
PART-B					
1.	Explain the working principle of a flywheel energy storage system.	(16)	BTL3	Applying	CO5
2.	Discuss about pumped hydro storage.	(16)	BTL4	Analyzing	CO5
3.	Describe the process of compressed air energy storage (CAES) and its applications.	(16)	BTL3	Applying	CO5
4.	Compare super capacitors and batteries in terms of charge-discharge capabilities.	(16)	BTL4	Analyzing	CO5
5.	Explain the concept of hybrid energy storage systems.	(16)	BTL3	Applying	CO5

6.	Describe the structure and operation of a pumped hydro storage system.	(16)	BTL4	Analyzing	CO5
7.	Analyze the role of flywheels in high power and short-duration energy storage.	(16)	BTL3	Applying	CO5
8.	Discuss the integration of CAES with renewable energy sources.	(16)	BTL4	Analyzing	CO5
9.	A flywheel with a rotor mass of 300 kg is spinning at 5000 RPM. The radius of the flywheel is 0.5 meters. Calculate the energy stored in the flywheel, assuming it is modeled as a solid cylinder.	(16)	BTL3	Applying	CO5
10.	Evaluate the economic feasibility of using alternate energy storage technologies.	(16)	BTL4	Analyzing	CO5
11.	Write a note on gravitational and magnetic energy storage systems.	(16)	BTL3	Applying	CO5
12.	Compare different alternate storage systems based on cost and efficiency.	(16)	BTL4	Analyzing	CO5
13.	Describe the working and construction of superconducting magnetic energy storage (SMES).	(16)	BTL3	Applying	CO5
14.	A flywheel energy storage system has a rotor mass of 500 kg and a radius of 0.8 meters. The flywheel is spun at 3000 RPM (revolutions per minute). Calculate the energy stored in the flywheel. Assume that the flywheel can be modeled as a solid cylinder.	(16)	BTL4	Analyzing	CO5
15.	Discuss use cases of hybrid systems in electric vehicles.	(16)	BTL3	Applying	CO5
16.	Describe the control strategies used in hybrid energy storage systems.	(16)	BTL4	Analyzing	CO5
17.	Compare performance characteristics of flywheels and CAES systems.	(16)	BTL3	Applying	CO5
18.	Explain the environmental impact and sustainability of alternate energy storage technologies.	(16)	BTL4	Analyzing	CO5
Course Outcome:					
To understand the various types of energy storage Technologies.					
To analyze thermal storage system.					
To analyze different battery storage technologies.					

To analyze the thermodynamics of Fuel Cell.
To study the various applications of energy storage systems.