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AEE Certified Energy Manager (CEM) Sample Questions (Q112-Q117):

NEW QUESTION # 112

Which of the advantages listed below, makes an ice TES system more preferred over a water TES system, when a load shifting strategy is considered?

- A. Ice-storage systems require lower maintenance due to lower pumping volume
- B. Ice-storage systems operate with a higher coefficient of performance (COP)
- C. Water-storage systems require smaller storage tanks since water has a higher density than ice
- D. Ice-storage systems require smaller storage tanks since ice has a higher energy storage density

Answer: D

Explanation:

To determine which advantage makes an ice Thermal Energy Storage (TES) system more preferred over a water TES system for a load shifting strategy, we need to evaluate each option based on the principles of thermal energy storage as outlined in the Association of Energy Engineers (AEE) Certified Energy Manager (CEM) training materials. Load shifting involves storing energy (cooling capacity) during off-peak periods and releasing it during peak demand, making storage efficiency and capacity critical. Let's analyze each option step-by-step.

Step 1: Understand Ice TES vs. Water TES in Load Shifting

- * Ice TES: Uses the latent heat of fusion of water (ice melting) to store cooling energy. Ice is formed during off-peak hours (e.g., overnight) and melted during peak hours to provide cooling.
- * Water TES: Uses the sensible heat capacity of water, storing chilled water (typically 4–6°C) to provide cooling.
- * Load Shifting Goal: Maximize cooling storage in minimal space and cost, shifting electrical demand from peak to off-peak periods.
- * CEM Reference: CEM materials in the "Thermal Energy Storage" section highlight ice TES for its high energy density and compact storage, contrasted with water TES for simpler operation but larger volume requirements.

Step 2: Evaluate Each Option

Option A: Ice-storage systems operate with a higher coefficient of performance (COP)

* Analysis:

- * COP Definition: $COP = (\text{Cooling Output}) / (\text{Energy Input})$. For TES, this relates to the chiller's efficiency.
- * Ice TES: Requires chillers to operate at lower temperatures (e.g., -5°C to 0°C) to freeze water, which typically reduces chiller COP (e.g., 3–4) compared to water TES chillers operating at 4–6°C (COP ~5–6).
- * Reality: Ice TES systems often have a lower COP due to the additional energy needed for phase change, though total system efficiency may improve with load shifting benefits.
- * CEM Reference: CEM notes that ice TES energy input is higher per unit of cooling due to lower evaporating temperatures, contradicting a "higher COP" claim.
- * Conclusion: This statement is incorrect and not an advantage for ice TES in load shifting.

Option B: Ice-storage systems require smaller storage tanks since ice has a higher energy storage density

* Analysis:

* Energy Storage Density:

- * Ice TES: Relies on latent heat of fusion = 334 kJ/kg (80 kcal/kg or ~144 Btu/lb). This is the energy absorbed/released when water freezes/melts, far exceeding sensible heat.
- * Water TES: Relies on sensible heat = $cp \cdot \Delta T$, where $cp = 4.18 \text{ kJ/kg} \cdot ^\circ\text{C}$ (1 Btu/lb · °F). For a typical $\Delta T = 10^\circ\text{C}$ (e.g., 4°C to 14°C), energy stored = $4.18 \times 10 = 41.8 \text{ kJ/kg}$ (~20 Btu/lb).
- * Comparison: Ice stores ~8 times more energy per kg than water for a 10°C range (334 vs. 41.8 kJ/kg).

* Volume Impact: Ice's density (~917 kg/m³) is slightly less than water (~1000 kg/m³), but the latent heat advantage dominates, reducing required tank volume significantly.

* Load Shifting: Smaller tanks mean less space and potentially lower capital costs, a key advantage for peak load management.

* CEM Reference: CEM training emphasizes ice TES's high energy density as a primary reason for its preference in space-constrained load shifting applications.

* Conclusion: This statement is correct and a clear advantage for ice TES.

Option C: Water-storage systems require smaller storage tanks since water has a higher density than ice

* Analysis:

- * Density: Water = 1000 kg/m³; Ice = 917 kg/m³. Water is denser, but density alone doesn't determine storage size in TES.
- * Energy Storage: As calculated, water's sensible heat capacity (e.g., 41.8 kJ/kg for 10°C) is much lower than ice's latent heat (334 kJ/kg). To store the same cooling capacity, water TES requires ~8 times more mass and thus larger tanks (even accounting for density differences).
- * Implication: Water TES tanks are larger, not smaller, contradicting the statement.
- * CEM Reference: CEM materials note water TES's larger volume requirements as a disadvantage compared to ice TES.
- * Conclusion: This statement is incorrect and not an advantage for ice TES (it favors water TES incorrectly).

Option D: Ice-storage systems require lower maintenance due to lower pumping volume

* Analysis:

* Pumping Volume: Ice TES often uses glycol or brine solutions to transfer heat at lower temperatures, requiring pumps sized for smaller volumes due to concentrated cooling capacity.

Water TES circulates larger volumes of chilled water. However, "lower pumping volume" doesn't directly translate to "lower maintenance."

* Maintenance: Ice TES systems are more complex (ice-making equipment, heat exchangers), potentially increasing maintenance (e.g., defrost cycles, corrosion from brine). Water TES is simpler, often with lower maintenance needs.

* CEM Reference: CEM discusses ice TES complexity as a trade-off for its density advantage, not a maintenance benefit.

* Conclusion: This statement is questionable and not a primary advantage for load shifting.

Step 3: Identify the Key Advantage for Load Shifting

* Load Shifting Context: The goal is to store maximum cooling capacity efficiently during off-peak hours. Option B (smaller tanks due to higher energy storage density) directly supports this by reducing space and installation costs, a critical factor in TES design per CEM guidelines.

* Elimination:

- * A: Incorrect (lower COP, not higher).
- * C: Incorrect (water TES tanks are larger).

- * D: Weak (maintenance isn't clearly lower; not the primary driver).
- * B: Correct and relevant.

NEW QUESTION # 113

How much fuel is required to heat 50 kg water from 20°C water to 200°C saturated steam? Assume the boiler is 80% efficient (based on the higher-heating value of the fuel).

- A. 127.2 MJ
- B. 210.5 MJ
- C. 511.2 MJ
- D. 169.3 MJ

Answer: D

NEW QUESTION # 114

You can buy air compressor A for \$15,000 or air compressor B for \$6,000. Compressor A will cost \$10,000 per year to operate. Compressor B will cost \$11,500 per year to operate. If both air compressors have a 10- year life and your required return on investment is 12%, which air compressor has the lowest total life-cycle cost?

- A. Both air compressors have the same life-cycle cost
- B. Compressor B
- C. Compressor A

Answer: B

NEW QUESTION # 115

Which motor parameter is the most difficult to measure with precision?

- A. Output power capacity
- B. Input power
- C. Operating (rotating) speed
- D. Alternating current (AC) frequency
- E. Operating load factor

Answer: E

NEW QUESTION # 116

A facility has the thermal cooling load profile shown in the table below. The utility rate tariff has an on-peak time-of-use billing period that begins at 10:00 a.m. and ends at 7:00p.m. Calculate the storage capacity required for a load-shifting operating strategy, to make sure that no thermal cooling is generated by the chiller during the on-peak utility rate period.

Time of Day	Facility Design Cooling Load	Time of Day	Facility Design Cooling Load
Midnight to 1:00 a.m.	2 GJ	Noon to 1:00 p.m.	8 GJ
1:00 a.m. to 2:00 a.m.	2 GJ	1:00 p.m. to 2:00 p.m.	9 GJ
2:00 a.m. to 3:00 a.m.	2 GJ	2:00 p.m. to 3:00 p.m.	9 GJ
3:00 a.m. to 4:00 a.m.	2 GJ	3:00 p.m. to 4:00 p.m.	9 GJ
4:00 a.m. to 5:00 a.m.	2 GJ	4:00 p.m. to 5:00 p.m.	9 GJ
5:00 a.m. to 6:00 a.m.	2 GJ	5:00 p.m. to 6:00 p.m.	8 GJ
6:00 a.m. to 7:00 a.m.	4 GJ	6:00 p.m. to 7:00 p.m.	6 GJ
7:00 a.m. to 8:00 a.m.	4 GJ	7:00 p.m. to 8:00 p.m.	6 GJ
8:00 a.m. to 9:00 a.m.	4 GJ	8:00 p.m. to 9:00 p.m.	4 GJ
9:00 a.m. to 10:00 a.m.	6 GJ	9:00 p.m. to 10:00 p.m.	4 GJ
10:00 a.m. to 11:00 a.m.	6 GJ	10:00 p.m. to 11:00 p.m.	2 GJ
11:00 a.m. to Noon	8 GJ	11:00 p.m. to Midnight	2 GJ

[Question from the previous image, which was about storage capacity for load shifting, but the table was missing]

- A. 72 GJ
- B. 66 GJ
- C. 84 GJ
- D. 48 GJ

Answer: B

NEW QUESTION # 117

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