Q&As

Week 5: Building energy efficiency

Question 1:
How does system sizing (based on design load) influence both operational efficiency and long-term costs in building heating and cooling systems?

System sizing directly affects both the efficiency and cost profile of a building's HVAC system. Undersizing often leads to unmet peak demand, requiring supplementary systems like ice storage, while oversizing raises both capital and maintenance expenses. According to the lecture (Slide "Sizing of Systems"), systems designed around the actual load profile rather than 100% peak load tend to achieve better seasonal efficiency and cost-effectiveness.

Question 2:
What is the role of the National Calculation Method (NCM) in the UK's building energy efficiency assessment, and how does it relate to BER and TER?

The NCM, outlined under the Energy Performance of Buildings Directive (EPBD), standardises how a building's emissions and energy use are calculated (see "Building Energy Efficiency Assessment" slides). It enables comparison between a designed building's emission rate (BER) and a notional building's target rate (TER). Essentially, compliance is demonstrated when BER ≤ TER, ensuring new designs meet national efficiency benchmarks.

Question 3:
In what ways do air source and ground source heat pumps differ in performance and initial investment, and what factors determine their suitability for a building?

Ground source heat pumps (GSHP) generally have higher coefficients of performance (COP) than air source (ASHP) systems because ground temperatures remain more stable throughout the year (see "ASHP vs GSHP"). However, GSHPs require higher initial investment due to drilling and installation complexity. Suitability depends on available space, soil type, and financial feasibility — GSHPs excel in efficiency, while ASHPs win on practicality.

Question 4:
What defines the efficiency of chillers and boilers over seasonal operation, and why is understanding part-load performance critical?

Seasonal efficiency, represented by SEER for chillers and seasonal boiler efficiency for boilers (see "System Efficiency" slides), depends on how systems perform under varying part-load conditions. Because buildings rarely operate at full capacity year-round, factoring in 15–100% load performance gives a more realistic measure of overall energy use. In practice, this helps engineers avoid overestimating efficiency during real-world operation.

Question 5:
How does the integration of systems such as Combined Cooling, Heat and Power (CCHP) and renewable energy sources contribute to achieving net-zero buildings?

Net-zero buildings balance their energy demand with renewable and recovered energy sources. According to the Net Zero Building slides, CCHP systems optimise fuel use by generating heat, power, and cooling simultaneously, while technologies like heat pumps and solar collectors reduce reliance on fossil-based inputs. When integrated with efficient control (e.g., variable speed drives), they form a system capable of near self-sufficiency.

Q1. Building Fabric influences a building's thermal performance and energy Consumption. Explain how this is the case.

Answer: Building fabric efficiency speaks to how well a building's envelope including walls, roofs, floors, windows, and doors to minimise heat transfer between the interior and exterior. A high-performing fabric will reduce heat loss during cold periods and limit heat gain in warm conditions. This creates stability in indoor environments with lower energy demand by using sustainable materials and construction methods, the building envelope is less dependent on mechanical heating and cooling systems. A well-designed building fabric directly enhances thermal performance, reduces operational costs, and supports long-term energy efficiency goals.

Q2. What are the main factors influencing building energy modelling accuracy?

Answer: The accuracy of building energy models is largely dependent on the data quality and the assumptions used in the simulations. Other factors include weather data, equipment and lighting loads, occupant's activities, and the properties of materials used in the building. Insufficient data can lead to inaccurate energy predictions. Reliable models enable better decision-making in the design and operation of energy-efficient buildings.

Q3. Discuss the UK's path to achieving net-zero carbon emissions by 2050 in the building sector.

Answer: The UK's path to net-zero carbon emissions by 2050 involves a combination of policy measures, technological innovation, and sustainable building practices. The building sector is a major contributor to energy consumption and carbon emissions, so improving energy efficiency is central to the strategy. Key initiatives include the Future Homes Standard, which aims to ensure that new homes produce 75–80% fewer carbon emissions, all heating system sales are low carbon from 2033, except buildings in low carbon district or hydrogen conversion zones, and by this year, all new gas boilers are hydrogen ready.

Q4. Explain the difference between centralised and partially centralised air/water systems. Briefly discuss which is better suited for commercial and residential buildings.

Answer: Centralised air/water systems have the heating, cooling, or ventilation equipment located in a single mechanical plant, distributing conditioned air or water throughout the entire building via ducts or pipes. These systems allow precise control of internal environments, making them ideal for large commercial buildings where consistent thermal comfort and central management are required.
Partially centralised systems combine a central plant with local units that serve specific zones or areas. This provides easier control over smaller spaces, and typically lower installation and maintenance costs which makes them ideal for residential use.

Q5. How can energy efficiency be improved in the Engineering Building of Queen Mary University?

Answer: Energy efficiency in the Engineering Building can be improved by enhancing the building envelope, optimising service systems, and using renewable energy. Lowering the U-value of the exterior fabric through insulation and efficient lighting reduces heat loss and energy demand. Also, integrating renewable sources such as solar or non-electric cooling technologies further reduces carbon emissions and supports sustainable operation.

How does GSHP differ from ASHP?

GSHP uses heat from the ground which is a steady temperature.

Why system sizing is important?

It affects comfort if the system is smaller than required and cost increases if the sizing is bigger.

What is SEER?

Measures performance of a cooling system over time by taking overall seasonal efficiency.

What is natural ventilation?

Airflow made by wind or temperature difference rather than fans or mechanical system.

What factors affect energy loads in buildings?

Weather, insulation, solar gains, lighting, occupancy, ventilation.

1. **What factors should be considered when sizing heating and cooling systems for buildings?**

Answer: System sizing is typically based on the peak load, which represents the maximum heating or cooling demand. Options include designing for 100%, 70–90%, or 150% of peak load.

- Undersized systems require cool storage (e.g., ice made at night) to meet peak demand.
- Oversized systems increase capital cost and maintenance expenses. The goal is to balance system capacity, investment, and operational efficiency.

2. What are the three main types of air conditioning systems?

Answer:

1. Centralised systems: All heating and cooling are done in a central plant room; air is distributed via ductwork.
2. Partially centralised systems: Air is centrally cooled/heated but further conditioned at room entry.
3. Local systems: Operate independently in each room (e.g., split or packaged AC). Each system varies in control complexity, installation cost, and efficiency.

3. How does the National Calculation Method (NCM) contribute to building energy efficiency assessment?

Answer: The NCM is used in the UK to demonstrate compliance with the Energy Performance of Buildings Directive (EPBD). It compares the Building Emission Rate (BER) of a proposed design with the Target Emission Rate (TER) of a notional building using standardised data (e.g., U-values, HVAC systems). This ensures new buildings meet energy efficiency standards before construction approval.

4. What is a Combined Cooling, Heat, and Power (CCHP) system, and how does it improve efficiency?

Answer: A CCHP system simultaneously produces electricity, heating, and cooling from one energy source (e.g., natural gas).

- Example setups: gas engine with heat recovery or steam turbine with a steam boiler.

It improves overall fuel efficiency by reusing waste heat, achieving efficiencies above 70–80%, compared to 35–40% for conventional power generation.

5. What defines a net zero building, and what systems are typically included?

Answer: A net zero building generates as much energy as it consumes annually through renewable and efficient technologies. Common components include:

- Heat pumps (for both heating and cooling)
- Thermal storage systems (e.g., warm well/cold well)
- Solar collectors and wind turbines Energy flows are carefully managed through modes like heating, cooling, and charging to balance demand and renewable supply

1. According to UK government data, only 5.5% household in the UK have solar panels installed. Discuss how to improve the percentage of solar panel installation in the UK household.

Reason:

1. High installation cost, includes high labour cost, equipment cost (VAT)
2. Smart Export Guarantee tariff system not attractive
3. High maintenance cost, high labour cost

How to improve:

1. Government can take action, provide subsidy for solar panel installation
2. Government can raise the tariff for electricity generated by solar panel

2. Discuss how to further increase heating efficiency of commercial building.

1. Switch to double concrete wall as insulated exterior wall
2. Mandate heating source with heat pump than traditional boiler
3. Mandate smart control system to provide even heating distribution

3. Discuss how to harvest solar energy with maximum efficiency

1. in theory vacuum is the best condition for sunlight to travel
2. use naked solar cell to absorb maximum sunlight (without laminated glass for protection)

3. use direct water cooling on solar cell to reduce generation loss induce by heat absorption of the solar cell

1. How to use the psychrometric chart to practically map a full

air-conditioning process, like the "Cooling & dehumidifying" mentioned in the slide. How the specific path and state points are determined on the chart.

2. How the metrics quantitatively of PMV and PPD integrate the six main factors affecting thermal comfort, like metabolism, clothing, velocity in a practical calculation.

3. About the concept of seasonal efficiency, like SEER for chillers and Seasonal Boiler Efficiency, why the weighting factors for part-loads are so much higher than the factor for 100% full-load in the calculation.

4. In the building energy efficiency assessment, how the 'notional Building' is defined and how it helps determine the final EPC rating.

5. Given the UK's plan to phase out residential gas boilers by 2033, how to choose between an Air Source (ASHP) and Ground Source (GSHP) heat pump, especially regarding their efficiency (COP) versus the high initial investment cost