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HIGH-PERFORMANCE BUILDING DESIGN PROFESSIONAL - HBDP EXAM REFRESHER

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ONLINE TRAINING BY KRISHNAJI PAWAR

LEED AP(BD+C),GSAS CGP,GCP,ISO 14001

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MODULE 13

Energy Compliance Modeling

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Energy compliance modeling is a process that simulates and analyzes the energy performance of buildings to ensure adherence to regulatory frameworks, codes, and standards. These frameworks promote energy efficiency, reduce greenhouse gas emissions, and foster sustainable building practices.

Learning Objectives +

- Energy Analysis: Envelope, Massing, and Orientation Optimization
- Energy Analysis: Initial Assessment
- Energy Analysis: Ventilation
- Energy compliance modeling
- Indoor and Site Environment: Thermal Comfort
- Indoor and site environments: air quality
- Indoor and Site Environment: Lighting
- Controls and monitoring: Control Hardware
- Controls and Monitoring: Control Strategies

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INTRODUCTION

Energy compliance modeling simulates and analyzes building energy performance to ensure adherence to regulatory frameworks, codes, and standards, promoting energy efficiency, reducing emissions, and fostering sustainable practices.

Regulatory Frameworks and Standards

- Energy compliance modeling is governed by various codes and standards, including the International Energy Conservation Code (IECC) and ASHRAE Standard 90.1.
- These standards prescribe minimum energy efficiency requirements for buildings and outline specific methodologies for compliance verification.

Energy Modeling Methods

- Prescriptive compliance involves following predefined measures that must be implemented in the building design.
- Performance-based compliance allows for greater flexibility by enabling the use of energy modeling software to predict the building's energy performance.

Tools and Software for Energy Modeling

- Commonly used tools include EnergyPlus, COMEEN, eQuest, and OpenStudio.

ENERGY MODELING TECHNIQUES FOR PREDICTING CODE COMPLIANCE

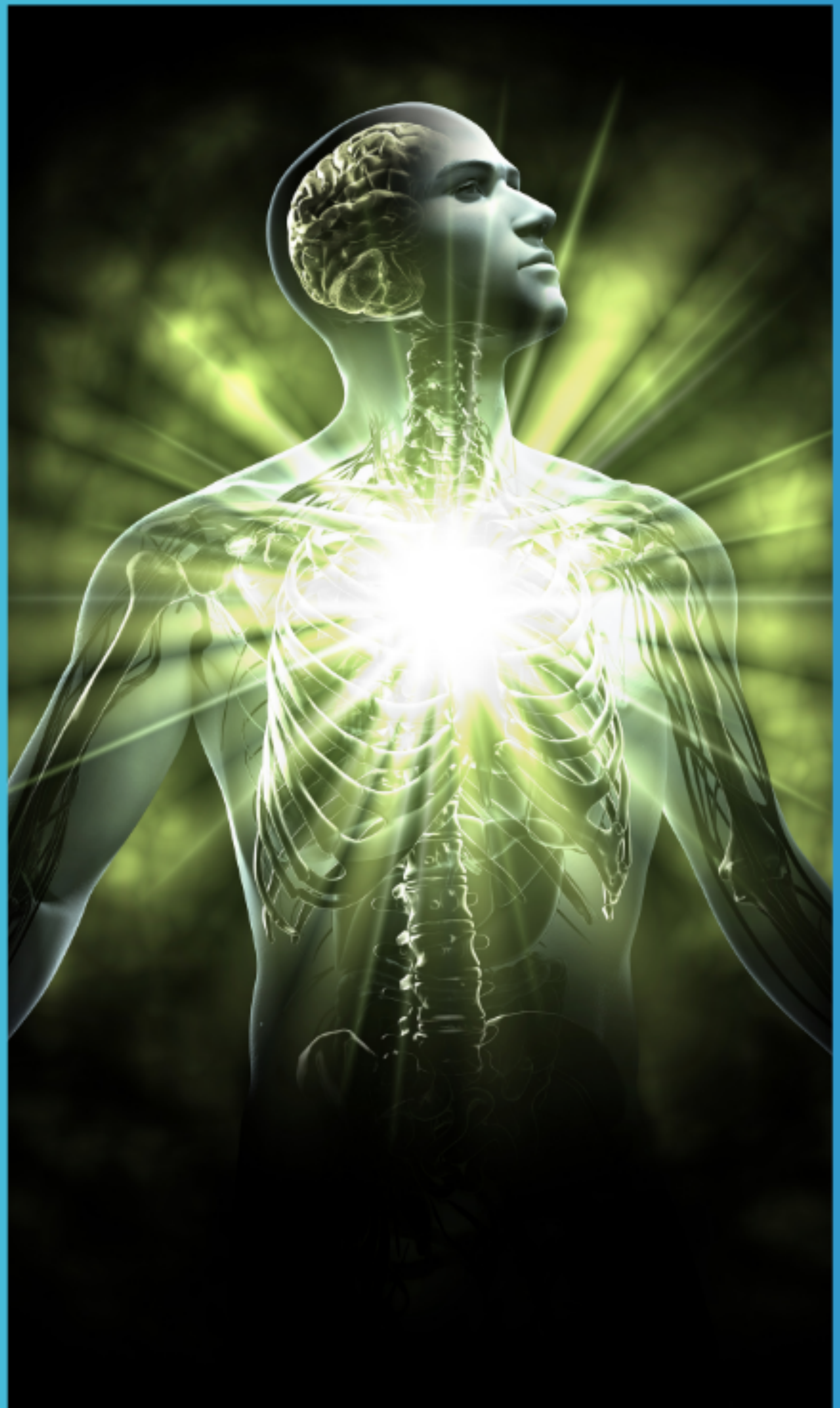
Understanding Energy Codes and Compliance Targets

- Energy codes set minimum energy efficiency standards for buildings.
- Compliance often involves meeting specific performance targets related to energy use intensity (EUI), lighting power density (LPD), and thermal performance.

Energy Modeling Techniques

- Utilizes specialized software tools to simulate the energy consumption of a building throughout its lifecycle.
- Simulation-Based Energy Modeling: Creates a detailed digital representation of a building, incorporating architectural, mechanical, and operational characteristics.
- Whole-Building Energy Modeling (WBEM) assesses the cumulative energy performance of a building as a single system.

CALIBRATION AND VALIDATION OF ENERGY MODELS



- Calibration involves adjusting model inputs based on measured energy consumption data from a similar existing building or post-occupancy evaluations.
- Validation assesses whether the model can reliably predict performance across various scenarios.

Practical Applications

- Office Building Compliance: An energy model of a newly designed office building is created to comply with the local energy code requiring a maximum EUI of 40 kBtu/sf/year.
- Retail Space Evaluation: An energy model predicts compliance with energy codes that emphasize both lighting efficiency and overall energy consumption.

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ENERGY MODELING TECHNIQUES FOR PREDICTING ENERGY CONSUMPTION

Understanding Energy Modeling

- Energy modeling involves mathematical representations of energy flows within a system to simulate and predict its energy consumption over time.
- Types of Energy Models include Statistical Models, Simulation Models, and Hybrid Models.

Establishing Energy Targets

- Organizations must establish clear energy consumption targets based on regulatory requirements, corporate sustainability goals, or benchmarking against similar facilities.
- SMART targets should be formulated according to the following criteria: Specific, Measurable, Achievable, Relevant, and Time-bound.

ENERGY MODELING TECHNIQUES FOR PREDICTING ENERGY CONSUMPTION +

Utilizing Energy Modeling Techniques

- Energy models can be employed to predict energy consumption and assess the impact of various strategies to achieve these targets.
- Key variables influencing energy consumption predictions include Building Characteristics, Occupancy Patterns, Equipment Efficiency, and Weather Data.

Calibrating and Validation

- The model's accuracy is ensured by adjusting the model parameters based on actual energy consumption data.
- Validation involves comparing the model's predictions with real-world outcomes to assess its reliability.

ENERGY MODELING TECHNIQUES FOR PREDICTING ENERGY CONSUMPTION +

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Scenario Analysis

- Energy modeling allows for scenario analysis where different strategies can be tested to determine their impact on energy consumption.
- This could include evaluating the effects of renewable energy systems, retrofitting existing buildings, or changing operational practices.

Monitoring and Adjusting Strategies

- Continuous monitoring of energy consumption against the established targets is vital for effective energy management.
- If energy consumption consistently exceeds model predictions, it may indicate a need to revisit the original assumptions, update the model parameters, or implement additional Energy Conservation Measures.

ENERGY MODELING TECHNIQUES AND EMISSIONS PREDICTIONS

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- Energy modeling uses mathematical and computational tools to simulate energy systems and predict their behavior.
- It aids policymakers, researchers, and industry stakeholders in understanding how different energy sources, technologies, and consumption patterns influence greenhouse gas emissions and energy use.

Types of Energy Models

- Bottom-Up Models: Focus on individual technologies and sectors, aggregating data from various sources to forecast overall energy consumption and emissions.
- Top-Down Models: Apply macroeconomic frameworks to understand the relationships between energy use, economic activity, and emissions.
- Hybrid Models: Integrate elements of both bottom-up and top-down approaches for a comprehensive analysis of the energy system.

ENERGY MODELING TECHNIQUES AND EMISSIONS PREDICTIONS +

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Emissions Predictions Relative to Targets

- Methods include establishing baselines, developing scenarios, running simulations, and assessing impacts.
- The baseline serves as a reference point against which alternative scenarios can be measured.
- Scenarios can include aggressive emissions reduction targets, technological advancements, and regulatory changes.
- The results are analyzed to determine the emissions impacts relative to the established targets.

ENERGY MODELING TECHNIQUES: A COMPARATIVE ANALYSIS

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Bottom-Up Energy Modeling

- Focuses on detailed representations of individual components within an energy system.
- Example: LEAP model, which allows users to input specific data regarding energy consumption patterns.
- Similar to constructing a detailed mosaic, it provides a comprehensive picture of total energy consumption.

Top-Down Energy Modeling

- Starts at a macro scale, focusing on aggregate data and relationships within the entire energy system.
- Example: IMPLAN model, which uses economic input-output tables to analyze how changes in one sector affect other sectors and overall energy consumption.
- Similar to viewing a large city from an airplane, it provides insights into urban planning at a macro level.

ENERGY MODELING TECHNIQUES: A COMPARATIVE ANALYSIS +

Hybrid Energy Modeling

- Combines the strengths of both bottom-up and top-down methods to provide a more comprehensive understanding of energy systems.
- Example: MARKAL model, which combines bottom-up technological detail with top-down economic analysis.
- Similar to a detailed blueprint of a building that also includes the surrounding landscape.

Simulation Models

- Employ stochastic methods to account for uncertainties and variability within energy systems.
- Example: Homer software, which uses simulation modeling to optimize the design of microgrids.

Optimization Models

- Use mathematical techniques to find the most efficient configuration of energy systems under given constraints and objectives.

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ENERGY MODELING LIMITATIONS AND ALTERNATIVE CALCULATION METHODS

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- Energy modeling is a crucial tool for assessing energy performance in buildings, systems, and processes.
- However, it has limitations such as assumptions and simplifications, which can lead to significant discrepancies between predicted and actual energy consumption.
- The accuracy of an energy model is heavily dependent on the quality of the input data. Inaccurate, outdated, or insufficient data can lead to erroneous outcomes.

Model Resolution and Complexity

- Energy models vary in their level of detail and complexity. High-resolution models provide more accurate predictions but require more extensive data and computational resources. Simplified models may overlook critical interactions, leading to an oversimplified understanding of energy dynamics.

ENERGY MODELING LIMITATIONS AND ALTERNATIVE CALCULATION METHODS +

Calibration and Validation Challenges

- Calibration is the process of adjusting model parameters to improve accuracy.
- Validation involves comparing model outputs with actual measurements.

Dynamic Behavior of Systems

- Energy models often struggle to capture the dynamic behavior of systems over time.
- Building performance can change due to aging, maintenance practices, or occupancy changes, making it difficult for static models to remain accurate.

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ALTERNATIVE CALCULATION METHODS +

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- Statistical Methods: Utilize historical energy consumption data to identify trends and make predictions.
- Monitoring-Based Approaches: Involves the continuous measurement of energy consumption using smart meters and building management systems.
- Life Cycle Assessment (LCA): Evaluates the environmental impacts associated with all stages of a product's life, including energy use.
- Machine Learning and Artificial Intelligence: Offer new avenues for analyzing energy data.

FUTURE WORKFLOW FOR BUILDING DESIGN AND OPERATION

- An integrated design team creates a building envelope in an object-oriented CAD system.
- Generative design algorithms generate different building and energy system architectures and optimize these variants.
- The dashboard provides feedback on the environmental impact and life-cycle costs of these design variants.
- The team selects a design and saves its representation in a Building Information Model (BIM).
- The BIM is sent to code authorities for performance-based code compliance checking and to builders, mechanical system providers, and control providers for bids.
- Building elements are automatically prefabricated based on the digital model during construction.

A VIEW ON FUTURE BUILDING SYSTEM MODELING AND SIMULATION

- Control sequences and functional verification tests are automatically translated from the design specification to the building automation system.
- During building operation, BIM data is used to generate models for model predictive control, fault detection and diagnostics, preventive maintenance, and energy use monitoring.
- The generation of these models is initiated by the digital twin of the building.
- The next generation of tools interface with the workflow of simulators and become part of building automation systems are not building simulation programs in the conventional sense.
- The mathematical model represents the user interface, while the simulation program computes the system's response.
- The separation between mathematical model and simulation program is a critical principle for future modeling and simulation environments for building systems.

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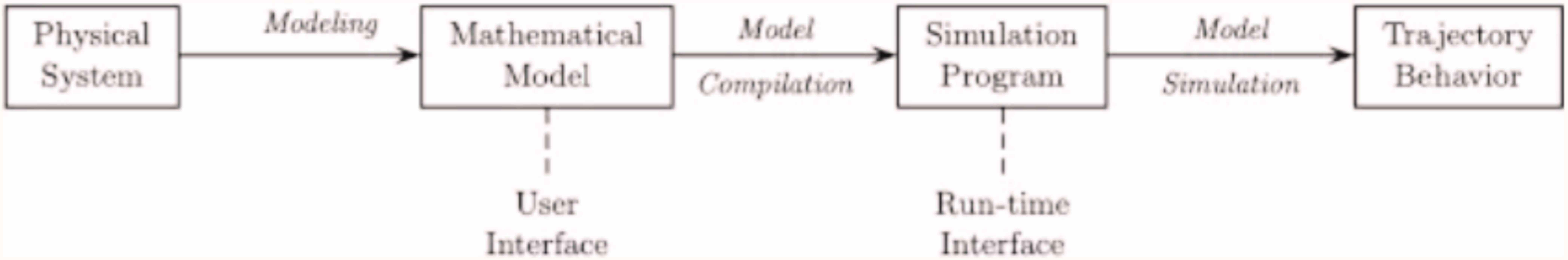

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