Fundamentals of Building Energy Simulation

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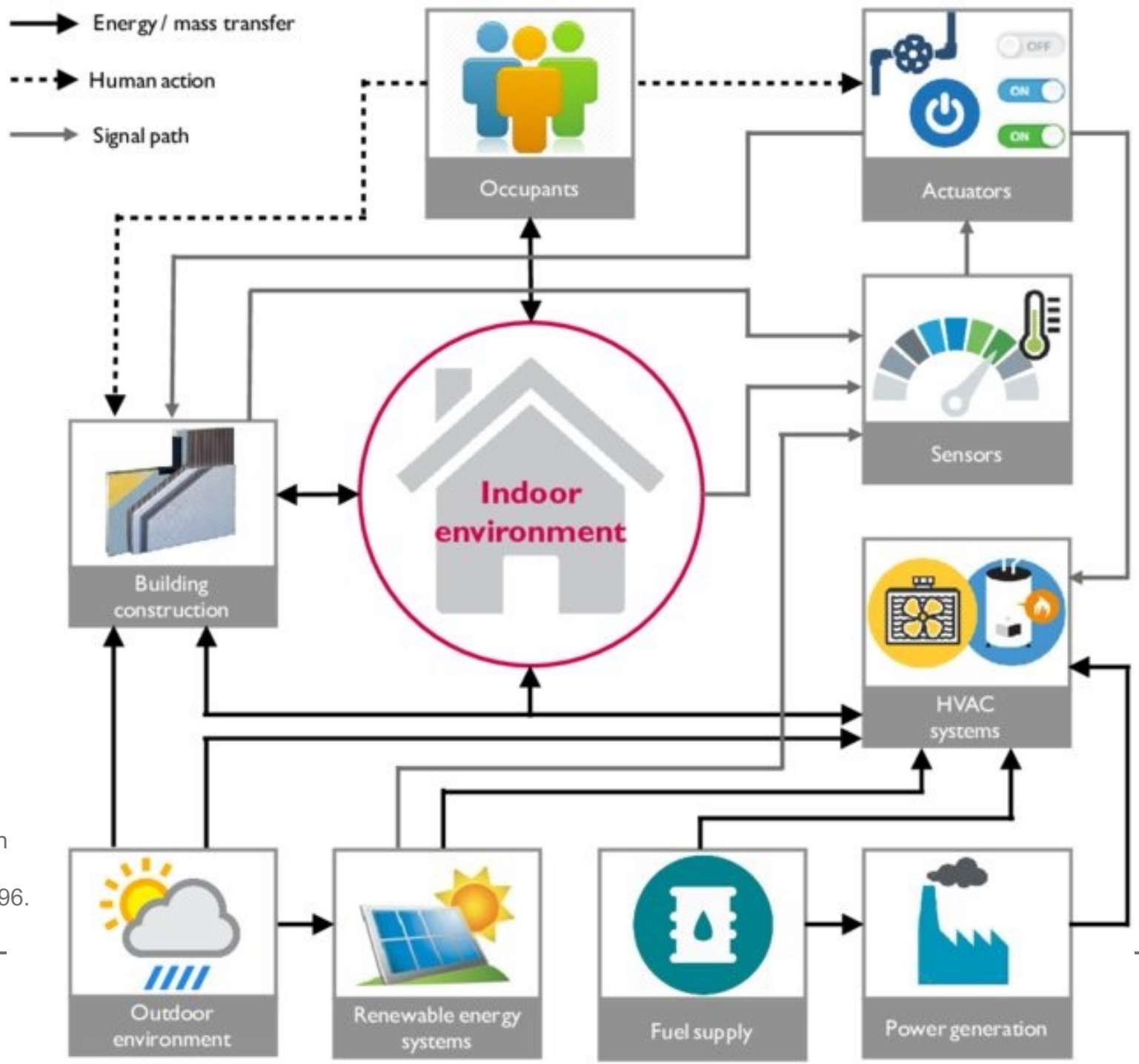
Principles

building energy simulation (BES)
building performance simulation (BPS)

It represents a computational modelling and simulation tool which basically works with simplified descriptions of complex systems and process.

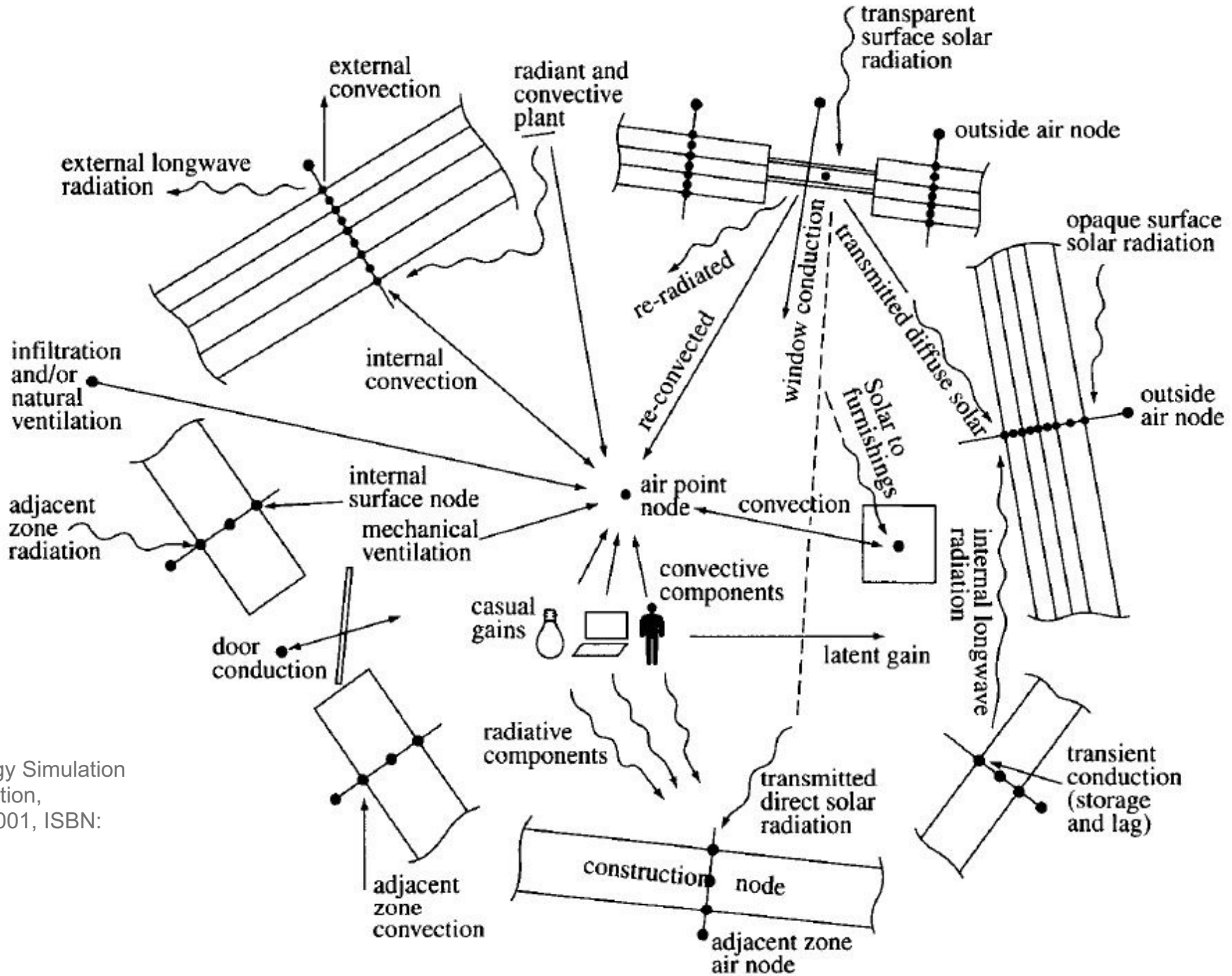
Main role is in the optimization of the building system during the different phases, from pre-design through commissioning to operation.



Source: J.L.M. Hensen, R. Lamberts (eds): Building Performance Simulation for Design and Operation. 2nd Edition, Routledge, 2019, ISBN: 9780429402296.

Fundamentals

A building is a very complex system (from physical point of view), which is influenced by a wide range of parameters. For clear understanding of the simulation approach, it is useful to visualise such a system as an electrical network of time dependent resistances and capacitances subjected to time dependent potential differences.



Source: J.A. Clarke: Energy Simulation in Building Design. 2nd Edition, Butterworth-Heinemann, 2001, ISBN: 0750650826..

Fundamentals

A simulation model is an abstraction of the real building which allows to consider the influences on high level of detail and to analyze key performance indicators without expensive measurements. The user should work with the considerable amount of input data according to the required level of detail and modelling approaches.

Category	Input
Geometry	Building plan and elevation Internal space layout Window sizes, locations, and shades Shading by neighbouring buildings and objects
Materials	Properties of structural and insulating materials Radiative properties of glazings
HVAC	Energy conversation and distribution systems Ventilation systems Component and supervisory controls
Airflow	Window and other intentional openings Cracks, holes, and defects in air barrier Airflow paths between internal spaces
Internal gains	Electrical appliances and lighting Moisture sources, such as cooking and plants
Occupants	Occupant density and schedule Activities that generate heat and moisture Control of appliances and lighting Interactions with windows and thermostats
Weather	Solar radiation Air temperature and humidity Wind speed and direction Sky conditions Ground snow cover Microclimates effects

Source: I. Beausoleil-Morison: Fundamentals of building performance simulation. Routledge, 2021, ISBN: 9780367518066.

Category	Prediction
Thermal	Predicting energy consumption Estimating peak heating and cooling loads Sizing HVAC equipment Assessing building form and fabric Examining external shading Determining overheating risks Comparing HVAC systems Assessing natural and hybrid ventilation Exploring novel energy systems
Indoor environment	Ventilation effectiveness Airflow distribution, Indoor air quality Daylighting, Lighting quality, Thermal comfort
Operations	Fault detection Model predictive control Comparing control options
Other	Occupant behaviour and movement Coupled heat, air, and moisture transfer Acoustics Fire propagation Building evacuation External airflow

Source: I. Beausoleil-Morison: Fundamentals of building performance simulation. Routledge, 2021, ISBN: 9780367518066.

Criteria

The BES community does not have clear criteria to classify and evaluate the facilities offered by tools. There are not yet uniform definitions of tool requirements and specifications based on formal consultations with users, practitioners and tool developers. Additionally, there is no clear methodology to compare BES tools.

Software

Nowadays, there is a variety of energy modelling applications (DesignBuilder, IDA-ICE, EnergyPlus, TRNSYS, eQUEST, Autodesk Green Building Studio, Ecotect etc.) available with different levels of complexity and responses to different presumed design parameters and operating conditions. There is a growing number of BPS software available on the market that are updated and listed here (buildingenergysoftwaretools.com).

Software

10 reasons why not to simulate

1. The problem can be solved using “common sense analysis”;
2. The problem can be solved analytically (using a closed form);
3. It’s easier to change or perform direct experiments on the real thing;
4. The cost of the simulation exceeds possible savings;
5. There aren’t proper resources available for the project;
6. There isn’t enough time for the model results to be useful;
7. There is no data – not even estimates;
8. The model can’t be verified or validated;
9. Project expectations can’t be met;
10. System behaviour is too complex, or can’t be defined.

DesignBuilder

- It represents an advanced "user-friendly" computational tool for integrated building design.
- It enables easy entry of the geometry of the building in 3D.
- HVAC systems are simply entered using graphic diagrams.
- Dynamic simulations of energy demand for heating and cooling
- Calculation of BREEM and LEED credits.
- CFD
- Optimization

THANK YOU FOR YOUR ATTENTION

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