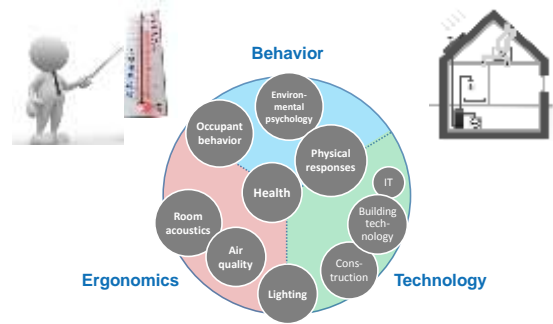


What does »Healthy Building« mean in terms of energy efficiency?

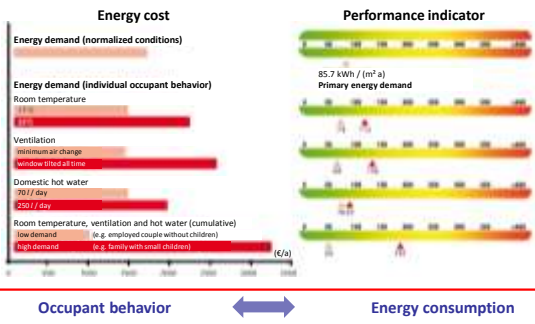
Univ.-Prof. Dr.-Ing. habil. Christoph van Treeck
 Healthy Buildings 2015, Keynote | TU/e Eindhoven, NL

(Re)creating healthy buildings beyond traditional boundaries



2 «Healthy Buildings» in terms of energy efficiency
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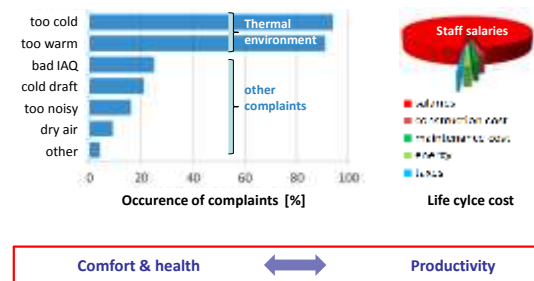
Energy efficiency and indoor climate (1)



(Picture source: BMVBS)

3 «Healthy Buildings» in terms of energy efficiency
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Energy efficiency and indoor climate (2)

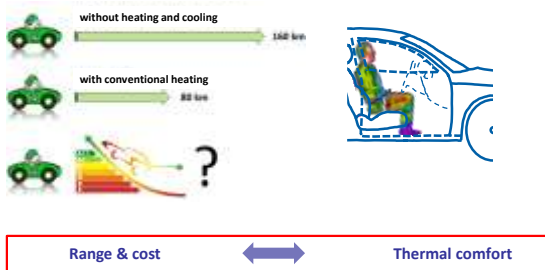


(International Facility Management Association 2009)
 (Urlaub 2011)

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Energy efficiency and indoor climate (3)

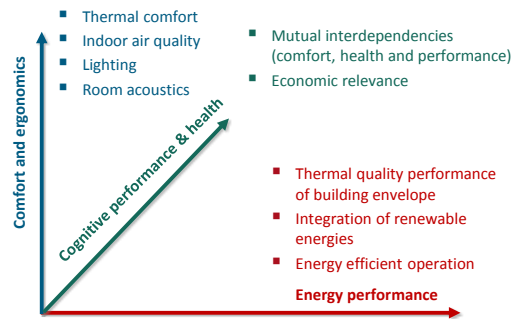
Electric drives: cabin climatization



(Schmidt et al., RWTH Aachen, FAT Schriftenreihe 272, VDA, 2015)

5 «Healthy Buildings» in terms of energy efficiency
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(Re)creating healthy buildings beyond traditional boundaries



6 «Healthy Buildings» in terms of energy efficiency
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(Re)creating healthy buildings beyond traditional boundaries

Buildings are constructed

- to provide a safe, healthy and comfortable indoor environment
- where people can live and work together in a productive manner

Buildings are not primarily built

- to save energy

Healthy buildings of the future...

- are more than perfectly insulated, »passive buildings«

(Re)creating healthy buildings | an interdisciplinary task

1. Passive measures

- Thermal quality of building envelope

Building envelope | thermal quality performance

- Thermal insulation composite system | after renovation

Thermal decoupling

Reduced thermal capacity

Dew point undercut

Algae growth

Picture sources: ¹ D. Haas-Armdt, Hannover, www.baunetzwissen.de (2015)
² Stuttgart University (2012); ³ Künzel et al., 3rd Dahlberg-Kolloquium, Wismar (2001)

Building envelope | energy generation

- Photobiocollectors | BIQ (Hamburg Wilhelmsburg)

Chloroplast

Sun, CO₂, nutrients

Biomass and waste heat

Methane & heat

Picture sources: C. van Treec (2014)

(Re)creating healthy buildings | an interdisciplinary task

1. Passive measures

- Thermal quality of building envelope
- Balance btwn. insulation and HVAC
- Air tightness & heat recovery

Building envelope | thermal quality performance

- Faulty workmanship-related structural damages (Böhmer 2014)

Missing competence

Faulty workmanship

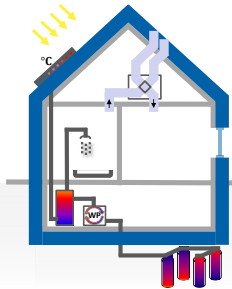
Consequential damage

Quality assurance?

Sources: ¹ H. Böhmer, Gemeinschaftsstudie Bauherren-Schutzbund e.V. und Institut für Bauforschung, Hannover (2014)

(Re)creating healthy buildings | an interdisciplinary task

- 1. Passive measures**
 - Thermal quality of building envelope
 - Balance btwn. insulation and HVAC
 - Air tightness & heat recovery
 - Passive use of solar energy
- 2. Active measures**
 - Active use of solar energy
 - Environmental energy (heat pump)

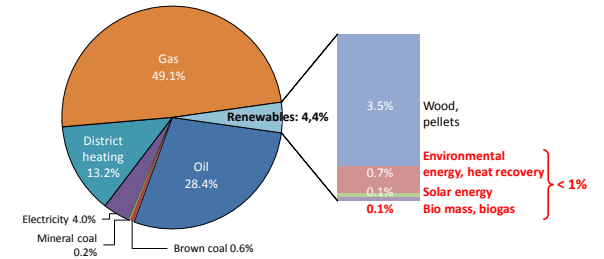


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Energy types for space heating (2010)

- Need for action:
Share of **new renewables** for space conditioning <1%



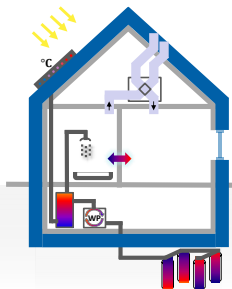
Source: Statistisches Bundesamt: Bauen und Wohnen – Mikrozensus Zusatzhebung 2010; Fachserie 5 Heft 1, modified

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(Re)creating healthy buildings | an interdisciplinary task

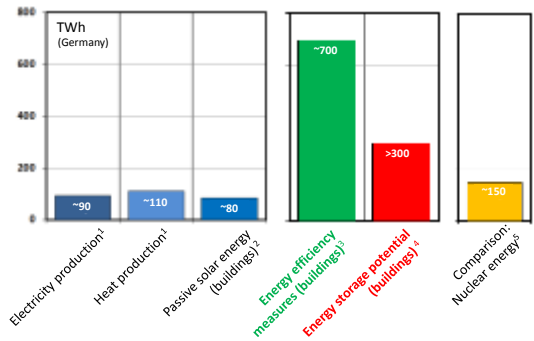
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 - Power heat co-generation
 - Load shifting (in space and time)



15 #Healthy Buildings in terms of energy efficiency
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Largest single potential for energy savings

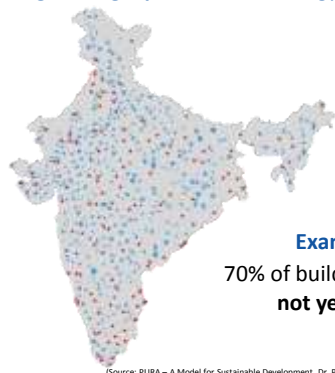


Sources: ¹ Agentur für Erneuerbare Energien (2009); ² Energiesparkompass (2009); ³ Fraunhofer/Hauser (2012); ⁴ RWTH Müller/Monti (2013); ⁵ Statistisches Bundesamt (2009)

16 #Healthy Buildings in terms of energy efficiency
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Largest single potential for energy savings



Example India
70% of building stock in 2030
not yet been built

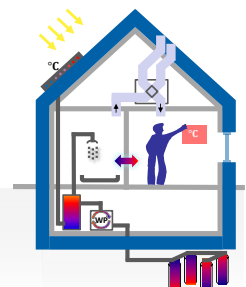
(Source: PURA – A Model for Sustainable Development, Dr. P.S. Rana, Boston Infrastructure & Development Pvt. Ltd.)

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(Re)creating healthy buildings | an interdisciplinary task

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 - Load shifting (in space and time)
- 3. Control and optimization**
 - Model predictive control
 - Commissioning & optimizing operation

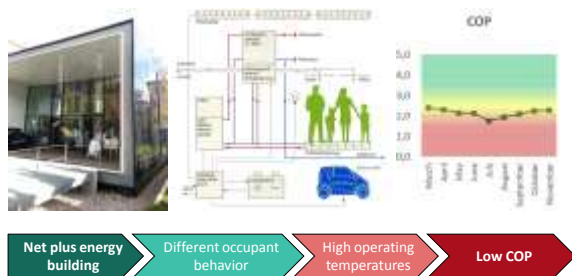


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Occupant behavior | and system behavior

- Example: Influence of occupant behavior
Berlin EfficiencyPlus Building



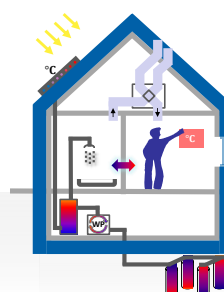
Sources: left: C. van Treeck (2014), center: BMVBS (2013), right: based on data from www.bmvbs.de/.../Monitoring/node.html

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(Re)creating healthy buildings | an interdisciplinary task

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- Control and optimization**
 - Model predictive control
 - Commissioning & optimizing operation
 - Fault detection and diagnosis

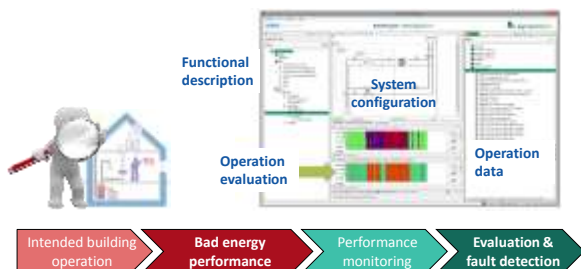


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Optimizing operation | fault detection and diagnosis

- Example: Software "Energie Navigator"
KPIs and operation rules as active functional descriptions

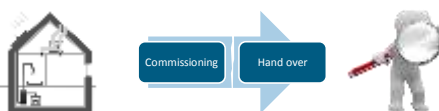


(Plessner, Pinkernell, Fisch, Rumpel et al. 2013; Synavision 2014)

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Optimizing operation | fault detection and diagnosis



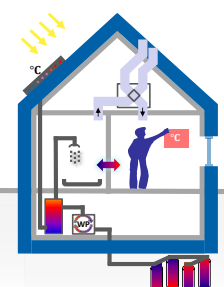
- Healthy buildings of the future...
- close the gap between commissioning and handover
 - are equipped with smart meters
 - support operation optimization by fault detection systems
 - communicate diagnostics with its users via 'smart devices'

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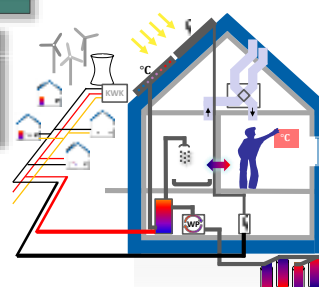
(Re)creating healthy buildings | an interdisciplinary task

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(Re)creating healthy buildings | an interdisciplinary task

- Passive measures**
- Active measures**
- Control and optimization**
- Network compatibility**
 - Decentralized energy storage
 - Extension of system boundaries (city quarter, mobility)
 - Demand side management



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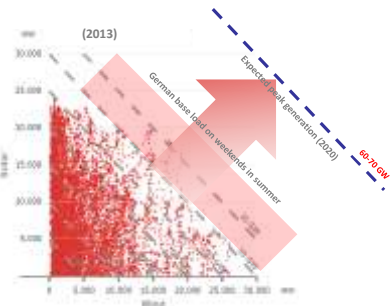


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Network compatibility

- Volatile nature of renewable energy sources

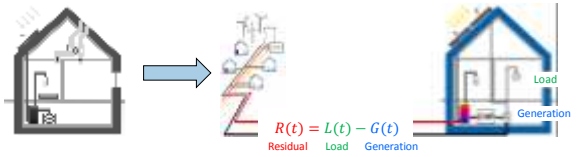


(Source: Fraunhofer ISE, Freiburg, 2014, modified; H. Wolisz, BauSIM2014, RWTH Aachen, 2014)

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Network compatibility



Healthy buildings of the future...

- are **energy efficient** and use less **fossil energy**
- are not autonomous energy systems due to the **volatile nature of renewable energy**
- can **store electrical and thermal energy** to contribute to wind and solar energy utilization
- are **network compatible** - and not 'passive' systems

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(Re)creating healthy buildings | an interdisciplinary task

1. Passive measures
2. Active measures
3. Control and optimization
4. Network compatibility
 - Decentralized energy storage
 - Extension of system boundaries (city quarter, mobility)
 - Demand side management
5. Integral planning aids
 - Digital planning tools
 - Multi-scale and multi-level performance simulation
 - Life cycle (cost) analysis
 - Sustainability certification



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Multi-scale and multi-level simulation

EnEff:Campus Roadmap RWTH Aachen (2015 – 2017)



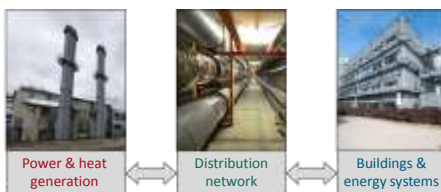
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Multi-scale and multi-level simulation

EnEff:Campus Roadmap RWTH Aachen (2015 – 2017)

- Model generation
- Energy performance monitoring
- Refurbishment scenarios and optimization



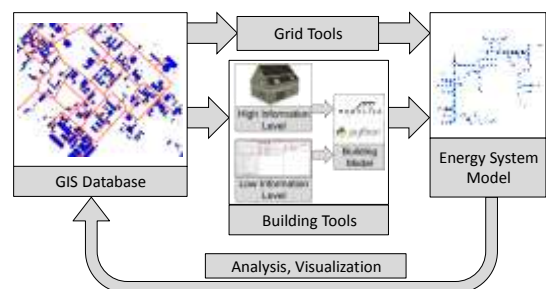
Picture source: D. Müller, RWTH Aachen (2015)

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Multi-scale and multi-level simulation

EnEff:Campus Roadmap RWTH Aachen (2015 – 2017)

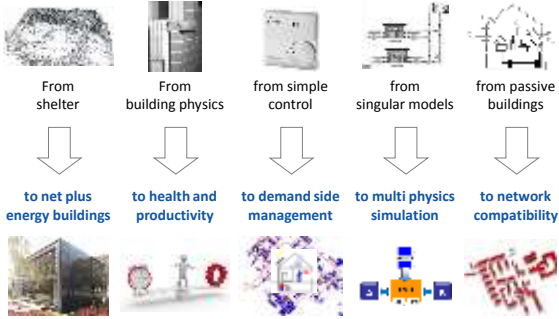


Picture source: D. Müller, R. Streblow, M. Lauster, E.ON ERC, RWTH Aachen (2015)

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(Re)creating healthy buildings | a summary



What does »Healthy Building« mean
in terms of energy efficiency?

Univ.-Prof. Dr.-Ing. habil. Christoph van Treck

Healthy Buildings 2015 | TU/e

