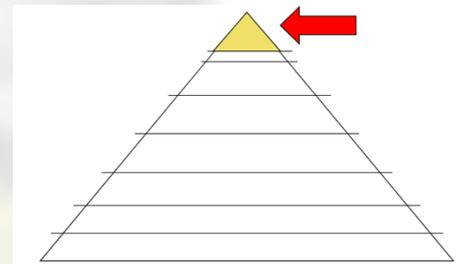


# Cooperative Research for High Performance buildings

WSBE17 Hong Kong, 7 June 2017

Herbert C. Leindecker

University of Applied Sciences Upper Austria



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# INTRODUCTION

- TQA - Total Quality Assessment
- 2 research projects 2008 - 2016
- Results, examples
- Conclusions



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# Quality Optimization of Buildings

- Steadily growing number of relevant aspects
  - Technological advances in product development
  - Building simulation, measurement, monitoring...
  - Changing relations of influencing life cycle factors
- **Need for cooperation**

2 research projects, founded by the Austrian government:

- **LQG:** Life cycle improvement of the building quality
- **MOFNUG:** Modular questionnaire for user satisfaction in buildings



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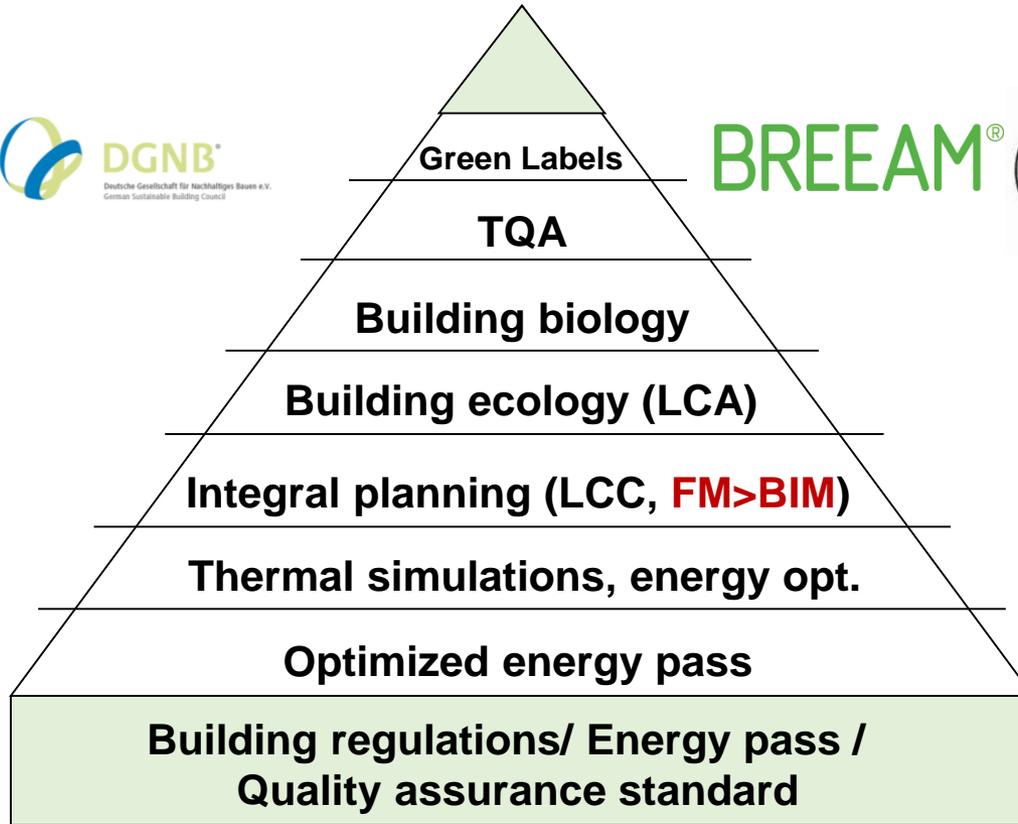


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# Quality Pyramid

**User satisfaction, comfort**



**BREEAM**<sup>®</sup>



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# 1. LQG project

## Life Cycle Oriented Quality Optimization of Buildings



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# LQG- Introduction

- Research project 2008-2013
- Cooperation of 5 universities of applied sciences
- Objectives
  - Qualitative database:  
Collection of tools for building quality assurance
  - Quantitative database:  
Practical deliverable, leading to an „energy certificate plus“



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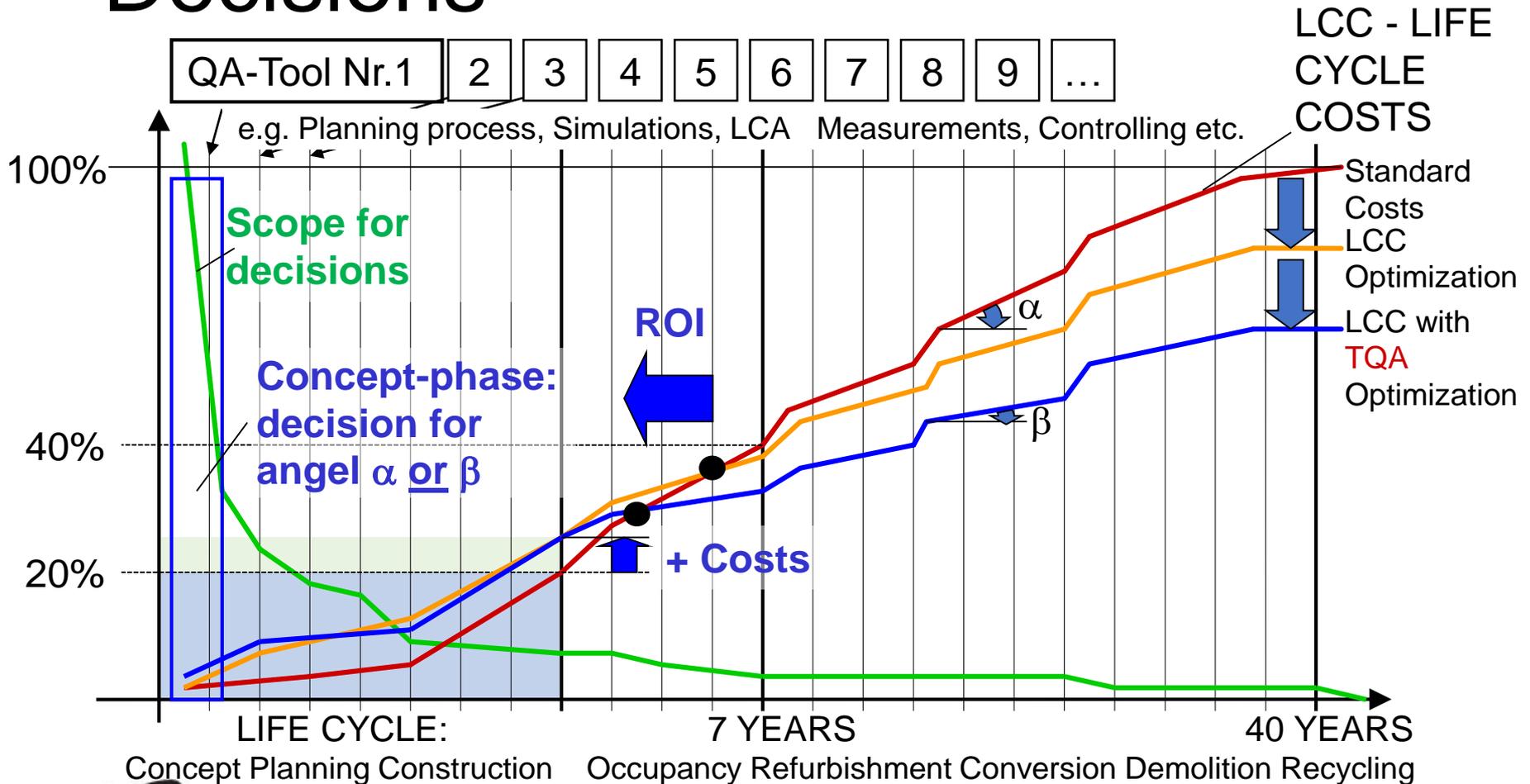
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# Life Cycle Costs and Impact of Decisions



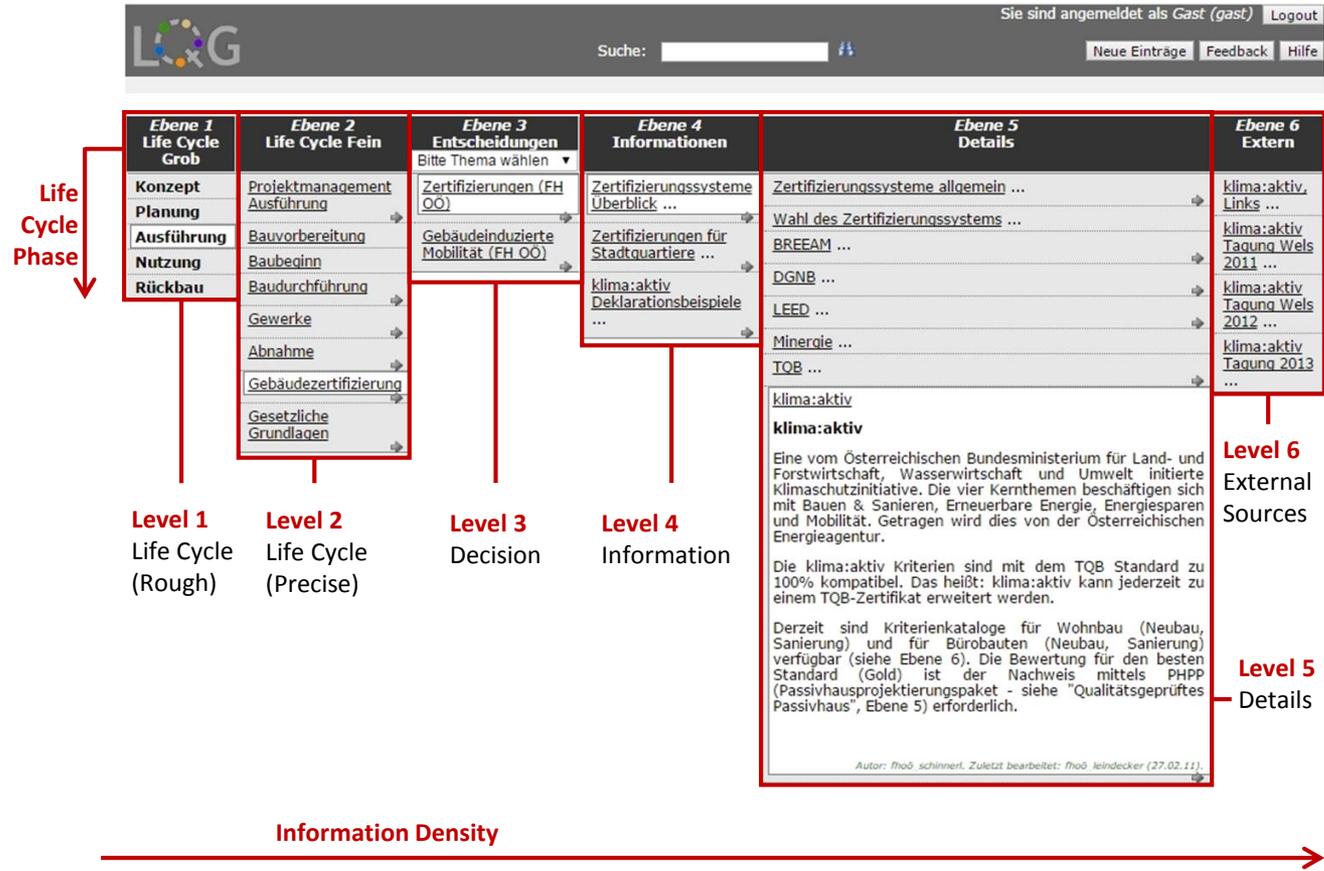
# Initial Idea of the LQG Database

- Improvement of building quality over lifecycle by adding quality assurance methods
  - Important aims: satisfaction and comfort for users
  - Building certification systems can be one (the only one?) possibility
    - klimaaktiv, TQB (Austrian systems)
    - DGNB, BREEAM, LEED (international)
- have been considered and compared

# Results of LQG: Homepage

- Supporting online database used for

- Projects
- Teaching
- Research



# Results of LQG: Energy Pass **Plus**

(3D model > > part of BIM process...)

## Energy Output

© Forschungsprojekt "Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden"  
Hinweis: Für die erzielten Ergebnisse wird keine Haftung übernommen

**Output - Energie**

| Abweichung zu Standard - Grob | Standard | Variante | EH                   |
|-------------------------------|----------|----------|----------------------|
| HWB Standortklima             | 33,65    | 21,01    | kWh/m <sup>2</sup> a |

Spezifischer Heizwärmebedarf bei 3400 Heizgradtagen (Referenzklima)

**Abweichung zu Standard - Fein**

|                                | Standard | Variante | EH                   |
|--------------------------------|----------|----------|----------------------|
| HWB Heizwärmeenergiebedarf     | 33,65    | 21,01    | kWh/m <sup>2</sup> a |
| HTEB Heiztechnikenergiebedarf  | 36,34    | 36,34    | kWh/m <sup>2</sup> a |
| KB Kühlbedarf                  | 28,81    | 36,64    | kWh/m <sup>2</sup> a |
| KTEB Kältetechnikenergiebedarf | 1,09     | 1,06     | kWh/m <sup>2</sup> a |
| EEB Endenergiebedarf           | 93,27    | 93,24    | kWh/m <sup>2</sup> a |

**Quellenhinweis:**  
EXCEL-Schulungs-Tool für Nicht-Wohngebäude, URL: <http://www.oib.or.at/>

## LCA

© Forschungsprojekt "Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden"  
Hinweis: Für die erzielten Ergebnisse wird keine Haftung übernommen

**Output - LCA**

Die ermittelten Daten für LCA beziehen sich derzeit zur Analyse auf die Fassaden und Energieerzeugung.

**Abweichung zu Standard - Grob**

|         | Standard | Variante |
|---------|----------|----------|
| ARV     | 946.0E+0 | 728.2E+0 |
| KEA     | 2.1E+6   | 1.6E+6   |
| Eutr.   | 191.9E+0 | 146.8E+0 |
| AP      | 327.8E+0 | 250.8E+0 |
| POCP    | 28.2E+0  | 52.5E+0  |
| GWP-100 | 150.3E+3 | 116.0E+3 |

**Abweichung zu Standard - Fein**

**Quellenhinweis:**  
Daten zu Material und Recycling aus Datenbank Ecoinvent 2.0  
Daten für Energie aus eigenen Berechnungen

## LCC

© Forschungsprojekt "Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden"  
Hinweis: Für die erzielten Ergebnisse wird keine Haftung übernommen

**Output - LCC**

| Abweichung zu Standard - Grob                   | Standard     | Variante     | Delta |
|---|--------------|--------------|-------|
| Bauwerkskosten:                                 | € 332.114,10 | € 338.306,46 | 1,86% |
| Bauwerkskosten / m <sup>2</sup> BGF             | € 1.363,61   | € 1.409,61   |       |
| Anteilig Elemente Gebäudehülle und Haustechnik: | € 80.171,70  | € 86.364,06  | 7,72% |
| Elemente Gebäudehülle / m <sup>2</sup> BGF      | € 334,05     | € 359,85     |       |
| Anteilig Elemente Gebäudehülle und Haustechnik  | 24,14%       | 25,53%       |       |

**Abweichung - LCC für Hülle und TGA**

**Abweichung LCC Gesamt**  
ausgewählte Kostenpositionen

**Gesamtabweichung in %**

|                          | Standard     | Variante     | Delta |
|--------------------------|--------------|--------------|-------|
| Absolutwerte Herstellung | € 332.114,10 | € 338.306,46 | 1,86% |
| Lebenszykluskosten       | € 505.925,08 | € 512.262,78 | 1,25% |

**Quellenhinweis:**  
Quelle Kostenkennwerte Investition: BKI 2008 & Erfahrungswerte  
Quelle Kostenkennwerte Folgekosten: BKI 2008 (Rückbau), VDI 2067 & Erfahrungswerte, FM Benchmarking 2009  
Quelle technischer Lebensdauer: Leitfaden Nachhaltiges Bauen, VDI 2067 & Annahmen



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International Co-owners:

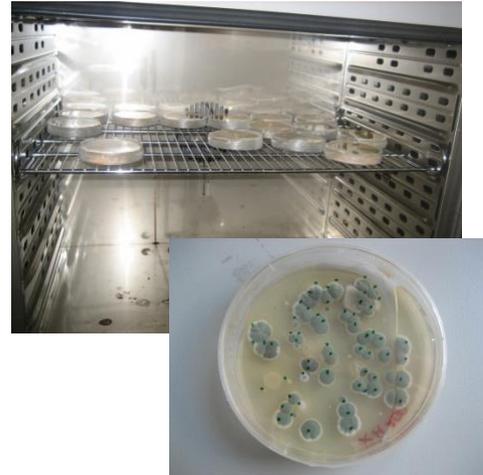


# Total Quality Tools:

VOC



Mould



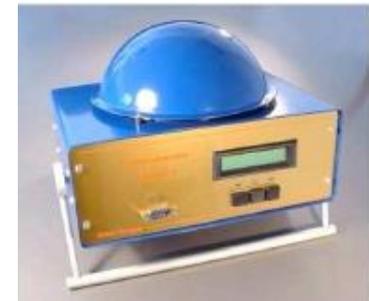
Sun Charts



Temp./rH/CO<sub>2</sub>



Radon



## 2. MOFNUG project

# Modular Questionnaire for User Satisfaction in Buildings



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International Co-owners:

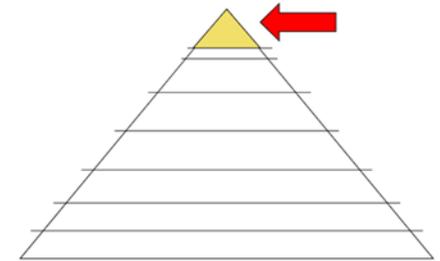


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# MOFNUG Introduction



- User satisfaction still is the highest aim
- Wide range of factors is covered by this topic
- Research project between 2013-2016
- Cooperation of 4 universities of applied sciences
- with different perspectives  
(energy / FM / psychology / marketing)
- Survey platform to measure relevant aspects
- Modular structured → different buildings possible
- Steadily improvements have been done

# Appearance of the MOFNUG Website

**Mofnug** Welcome, Armin Weberb...  
Suche...

**Fragen-Katalog:** **Clusters**

Frage hinzufügen

|                                |                    |                              |                     |
|--------------------------------|--------------------|------------------------------|---------------------|
| 68 Luftqualität (inkl. Geruch) | 32 Licht           | 36 Steuerbarkeit von Technik | 126 Orientierung    |
| 511 Möbel                      | 179 Raumkonzept    | 748 Funktionalität           | 107 Ästhetik        |
| 26 Thermischer Komfort         | 179 Sicherheit     | 263 FM Dienstleistungen      | 18 Personendaten    |
| 62 Soziale Interaktion         | 47 Akustik         | 906 Sauberkeit               | 3 Bewertung Umfrage |
| 23 Photovoltaik                | 69 Quick Screening |                              |                     |

**Navigation**

- Dashboard
- Projekte
- Template-Umfragen
- Fragen-Katalog**
- Fragen-Cluster
- Kalender
- Ausführbare Umfragen
- Benutzer
- Umfrage erstellen
- Meine Kontakte

**Questions** **Building Type**

Standard-Sortierung festlegen

| Questions   | Question Type                                     | Target Group                                 | Building Type                               | Actions  |
|---|---|--|---|--|
| 10 Einträge anzeigen  |   |  |   | suchen   |
| <b>Frage</b><br>1 Wie zügig empfinden Sie die Raumluft?<br>2 Wie zügig empfinden Sie die Raumluft im Sommer?<br>3 Wie zügig empfinden Sie die Raumluft im Winter? | <b>Frage</b><br>7-Point-Custom-Label-Likert-Scale | <b>Zielgruppe:</b><br>Laie & Experte<br>Laie | <b>Gebäude-Typ:</b><br>Alle<br>Alle<br>Alle | <b>Aktionen:</b><br>Labels anzeigen<br>Frage kopieren<br>Bearbeiten<br>Labels anzeigen<br>Frage kopieren<br>Bearbeiten<br>Löschen<br>Labels anzeigen<br>Frage kopieren<br>Bearbeiten |

# Typical Survey on the Platform

- Clusters on top  
→ Left to right
- Exactly knowledge of progress
- Error message when mandatory questions are not answered

Currently open cluster      Progress bar

|               |                           |       |                             |                     |                   |
|---------------|---------------------------|-------|-----------------------------|---------------------|-------------------|
| Personendaten | Steuerbarkeit von Technik | Licht | Luftqualität (inkl. Geruch) | Thermischer Komfort | Bewertung Umfrage |
|---------------|---------------------------|-------|-----------------------------|---------------------|-------------------|

**Translation:**

Welchem Typ entspricht Ihre Kleidung gerade am ehesten?  
[Dropdown selection] kurze Hose, kurzes shirt

Wie würden Sie Ihre körperliche Aktivität beschreiben?  
[Dropdown selection] angelehnt

Wie empfinden Sie die Temperatur?  
[7pt. Likert Scale] zu kalt - 1 2 3 4 5 6 7 - zu warm

Alles in allem, wie zufrieden sind Sie mit dem Raumklima?  
[7pt. Likert Scale] nicht zufrieden - 1 2 3 4 5 6 7 - sehr zufrieden

Gibt es Veränderungsbedarf in Bezug auf thermischen Komfort?  
[Free text area]

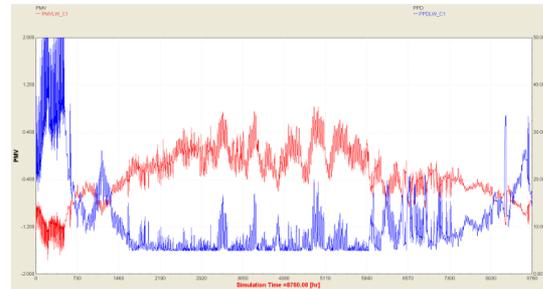
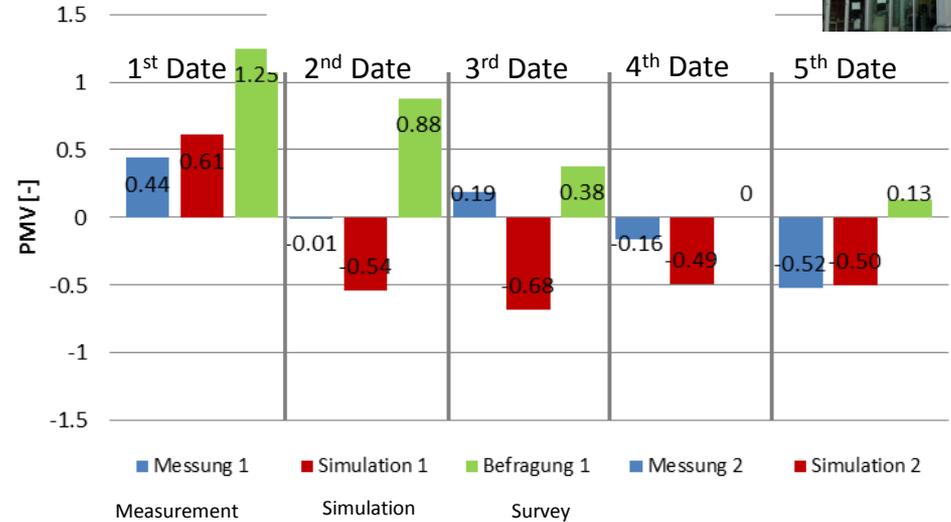


# Difference in PMV: Simulation, Measurement and Survey (example)



- Planning  
→ Simulation
- Execution  
→ Measurements
- Operation  
→ Monitoring  
→ User surveys

Vergleich des PMV



**2. Aktivitätsgrad und Bekleidungsgrad**

2.1 Wie würden Sie Ihren derzeitigen Aktivitätsgrad (metabolic rate) beurteilen?  
(Beurteilung mit Hilfe der Tabelle 1 – metabolic rate im Anhang)

0,8  
 1,0  
 1,2  
 1,6  
 2,0

2.2 Wie würden Sie Ihren derzeitigen Bekleidungsgrad (clothing factor) beurteilen?  
(Beurteilung mit Hilfe der Tabelle 2 – clothing factor im Anhang)

0,2  
 0,3  
 0,5  
 1,0

**3. Befragbarkeit**

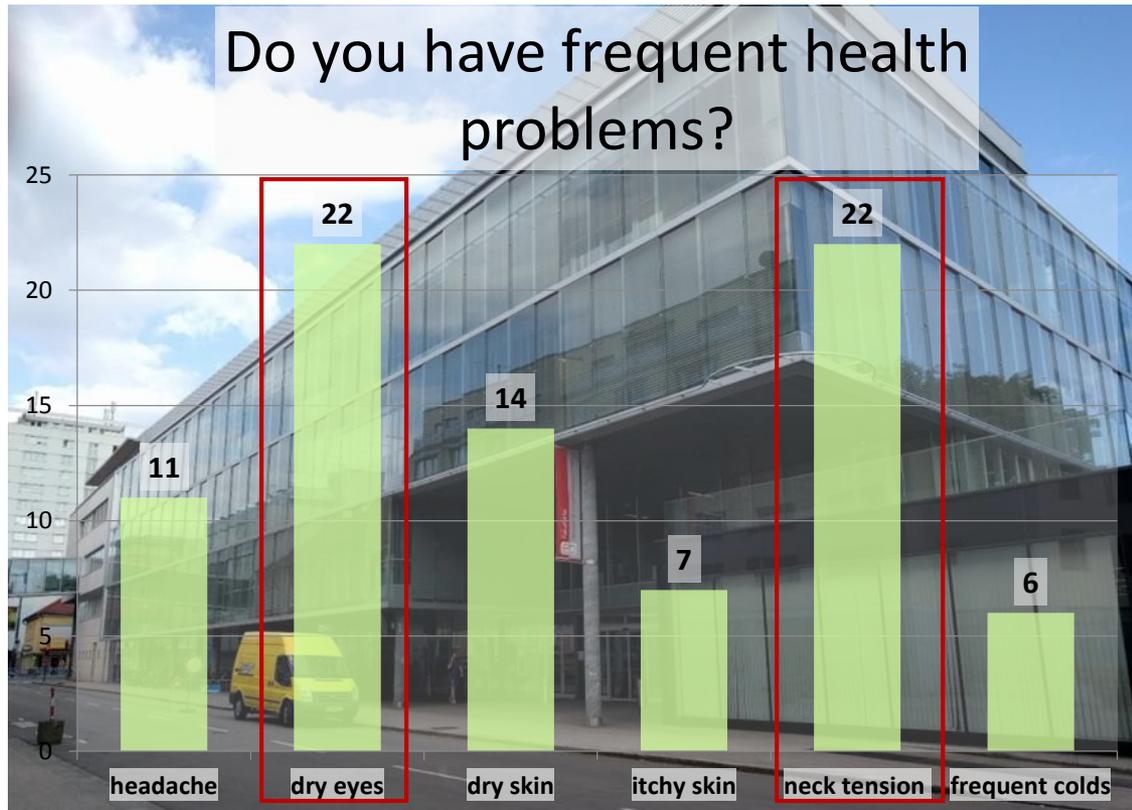
3.1 Wie würden Sie die typischen Arbeitsbedingungen an Ihrem Arbeitsplatz beurteilen?

3.1 Temperatur

|                       |                       |                       |                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1                     | 2                     | 3                     | 4                     | 5                     | 6                     | 7                     |
| <input type="radio"/> |
| unbegl. / zu kalt     |                       |                       | begl. / zu warm       |                       |                       |                       |
| 1                     | 2                     | 3                     | 4                     | 5                     | 6                     | 7                     |
| <input type="radio"/> |
| stabil                |                       |                       | variabel (unter Tap)  |                       |                       |                       |

Source: Dornigg, 2014

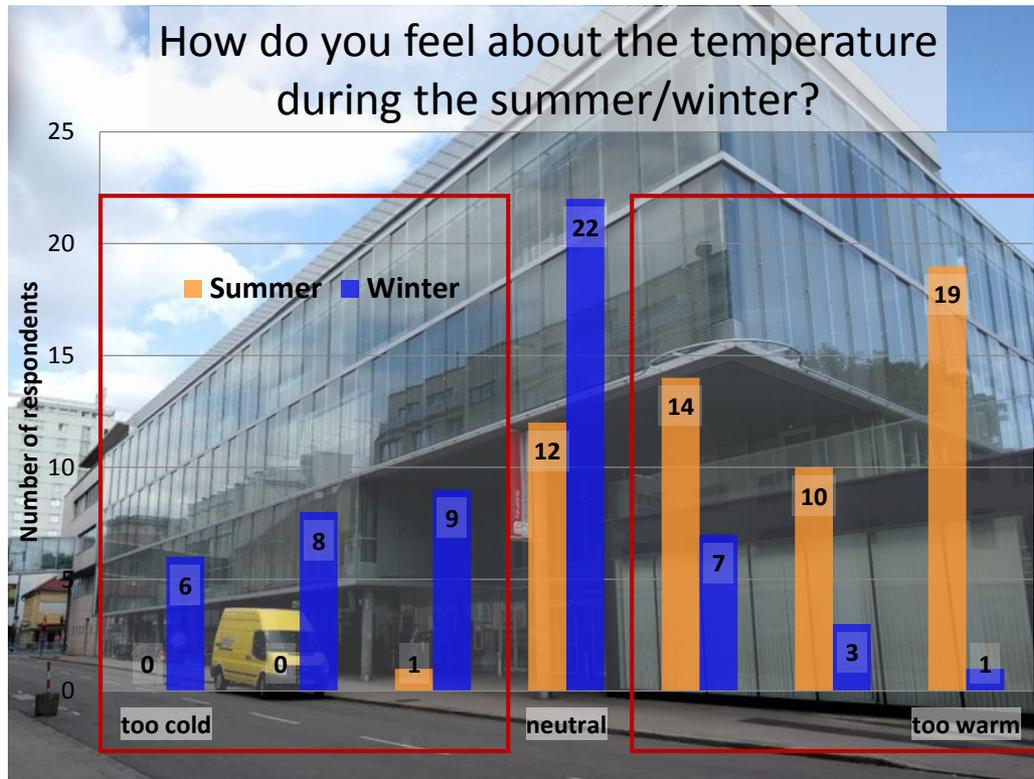
# 1a Health Problems of Care Staff at Work



- 79 respondents
- University buildings in Wels
- Dry eyes and neck tension

Source: Mittermaier, 2016

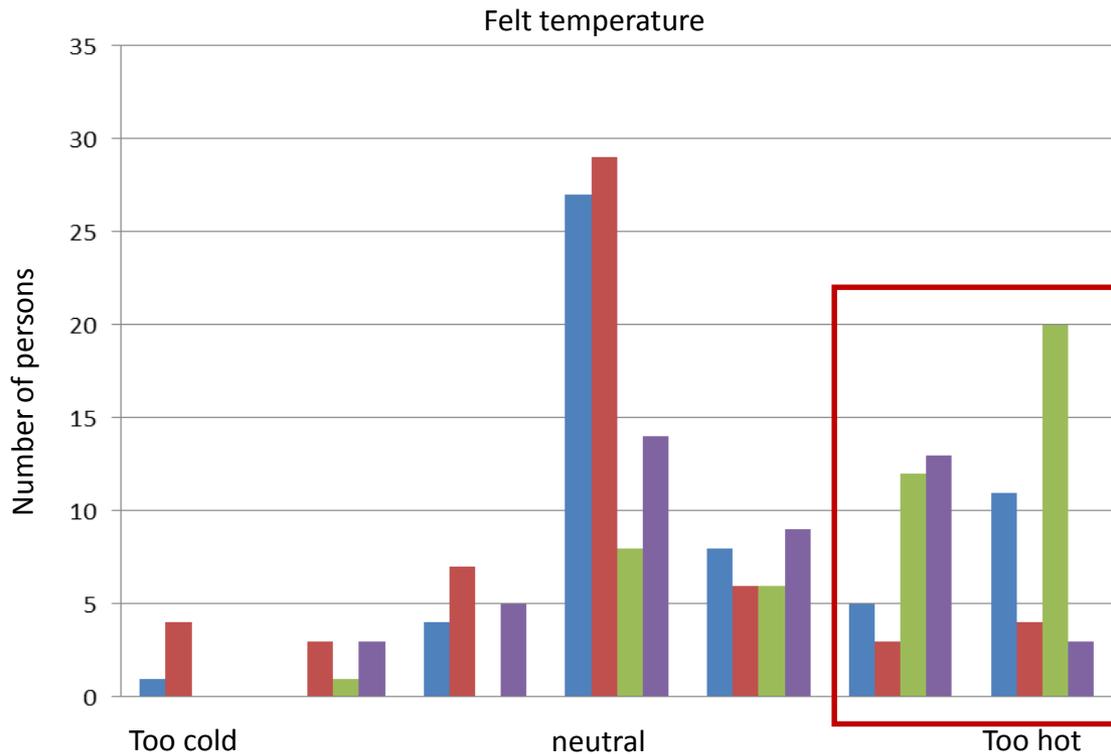
# 1b Perceived Temperature Split up into Summer and Winter



- 79 respondents
- University buildings in Wels
- Problems with overheating in Summer
- Temperature could be higher in Winter

Source: Mittermaier, 2016

# 2 Retirement home: Felt Temperature of Caregivers and Residents



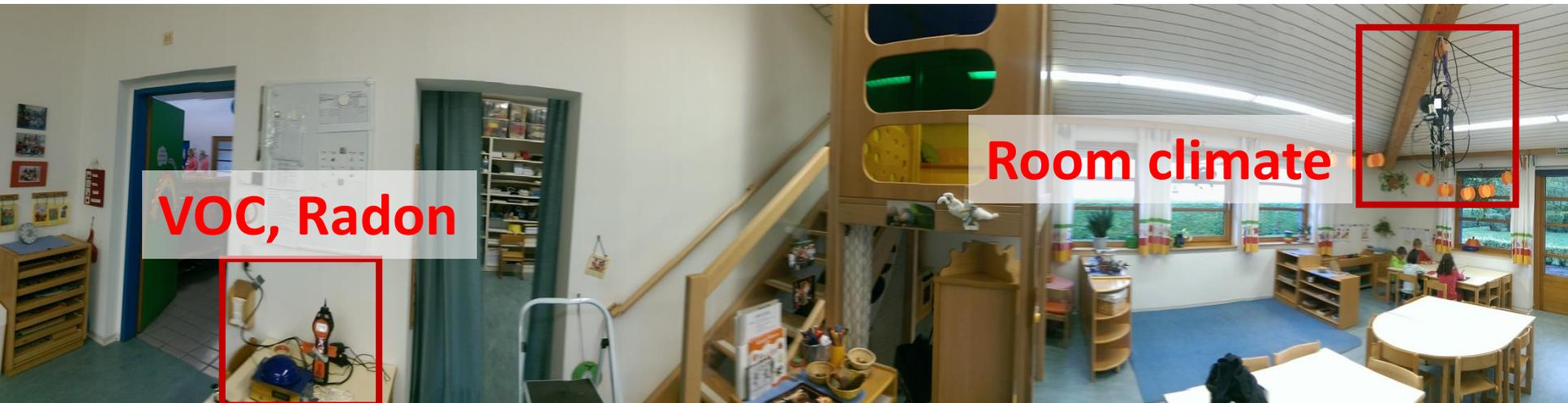
- Residents in Summer
- Residents in Winter
- Caregivers in Summer
- Caregivers in Winter

- Difference in activity levels of caregivers and residents
- Residents claim for higher temperatures while caregivers

Source: Ruschak, 2016

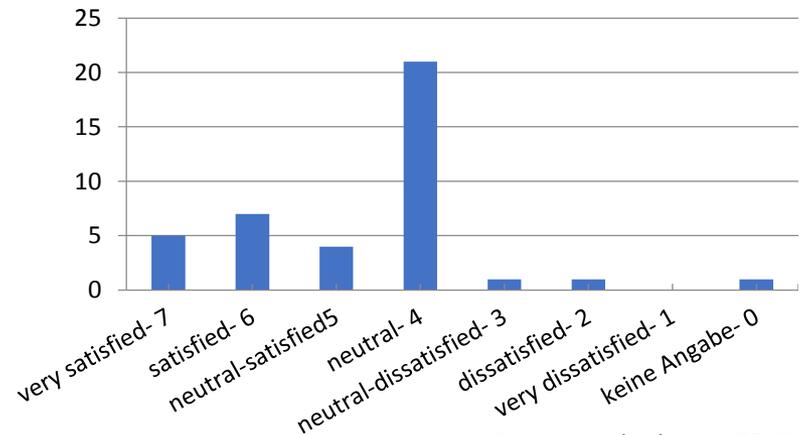
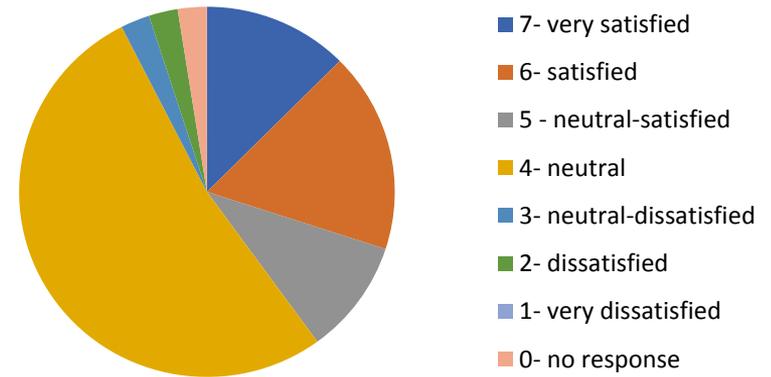
# 3a Air Quality in Kindergartens

- 7 different Kindergartens in Upper Austria
- 17 different rooms have been measured
- 40 interviewed educators



# 3b Air Quality in Kindergartens

- Question: Altogether, how satisfied are you with the room climate?
- Answers: predominately neutral
- Average: 4.8 (positive)



Source: Weberberger 2017

# CONCLUSION



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# General Conclusion

- Quality optimization has to be measurable.  
There exist already **quality assessment tools**, which however have been rarely used (expensive → ....?)
- **klimaaktiv**: Austrian self-declaration system, **low level with high quality, open system**

**klimaaktiv**



- **Cooperation** between universities offers numerous benefits



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# klimaaktiv projects



Vogelweide Nord, Wels  
klimaaktiv GOLD



Office Autonom  
B14, Wels  
Klimaaktiv Gold



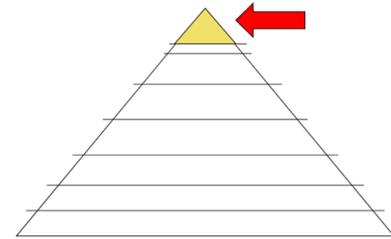
Sanierung  
Schule  
Rainbach  
Klimaaktiv Gold



# Conclusion of LQG and MOFNUG

## LQG

- Life cycle orientation is indispensable
  - The highest goal of quality optimized constructing must be **user satisfaction**



## MOFNUG

- **User satisfaction** is very complex, subjective and **just partially measurable**
- Thermal comfort is one of the best explored area, however, there are still outstanding issues

# “Special Conclusion”



**Only 2 questions lead to all the answers:**

- 1. Where do the children play?**
- 2. How do the elderly people live?**

Leindecker, H.C. (2004):  
„Condensed building structures  
as child-friendly living environment  
in the city“

Herbert Claus Leindecker

Verdichtete  
Bebauungsstrukturen als  
kinderfreundliche  
Wohnumwelt in der Stadt



Centaurus

# Thank you

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