

Smart Technology in Indoor Air Quality management

Exploratory research to help Facility managers of Dutch universities



Aaditi Singh

P5 Presentation | 21.06.24



Table of Contents

- 01** | Context
 - 02** | Research aim
 - 03** | Methods
 - 04** | Theoretical Research
 - 05** | Empirical Research
 - 06** | Discussion and Conclusion
 - 07** | Limitations & Further research
- Questions?

A modern office interior with a warm, industrial aesthetic. The ceiling features exposed wooden beams and white pipes, with several pendant lights hanging down. The walls are covered in light-colored wood paneling. In the foreground, three people are seated around a white circular table, working on laptops. In the background, there's a lounge area with a purple sofa and a person standing near a desk. The overall atmosphere is bright and collaborative.

People spend **90%**
of their time indoors

(European Union, Environment protection agency, National Institute of Health, 2023)



A polluted Indoor air



Health hazards

- Viral transmissions
- Respiratory problems
- Cardiovascular diseases

A high-angle, wide shot of a modern office space. The office is open-plan with several cubicles separated by low, dark-colored dividers. Desks are equipped with computers, printers, and office supplies. People are seen working at their desks and walking through the aisles. The lighting is bright, with large windows on the left side of the frame. The overall atmosphere is professional and active.

“The level of indoor air pollutant concentrations can be up to 5 times higher than outdoor levels”

(Environment protection agency, 2023)

Despite this fact, the scientific community has put more emphasis on studying solutions to outdoor air pollution as compared to indoor



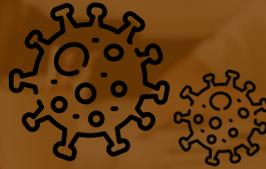
Impact on student's performance and productivity

The effect of indoor air quality in Dutch higher education classrooms on students' health and performance

“High CO₂ levels negatively impacted students' attention and concentration level”

- (Brink, 2019)

COVID 19 Pandemic



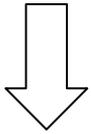
- *Heightened public awareness*
- *New guidelines and regulations*



01 | Context



Facility Manager



Smart tools



Healthy & productive IAQ

Global Corporate Survey

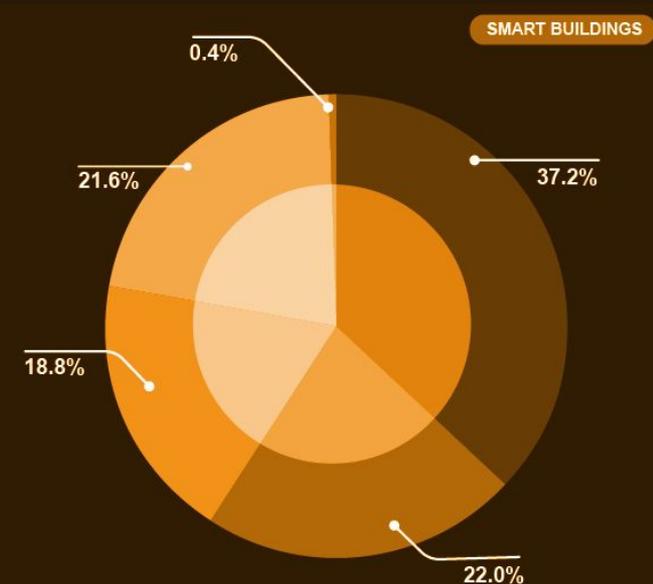
VERDANTIX



Will Covid-19 Drive New Investment In Air Quality Sensors?

- New investment at all relevant sites
- New investment at a few sites
- Evaluating or trialling
- No further investment
- Don't know

Source: Verdantix



N=250

“Use of smart IAQ technology by facility managers is underexplored”

- *Exploratory interview: Ding (2023)*

“Although there is information available on the potential benefits of smart tools in IAQ monitoring, there is a need for data-driven IAQ management models”

- *Zhang et al. (2022), Dai et al. (2023)*



02| Research aim

MAIN RESEARCH QUESTION

How does the adoption of smart IAQ technologies help the facility managers of Dutch universities and what are the barriers to it?



SUB RESEARCH QUESTIONS

[SQ1] What is the **role** of facility managers in creating healthy indoor air quality?

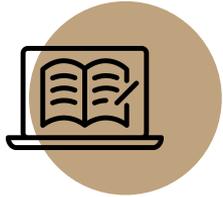
[SQ2] What is the **current status** of smart technologies available in indoor air quality management?

[SQ3] What are the **benefits** of smart IAQ technologies for the facility managers of Dutch universities?

[SQ4] What are the **barriers** encountered in adoption of smart IAQ technologies in Dutch universities and how can they be overcome?

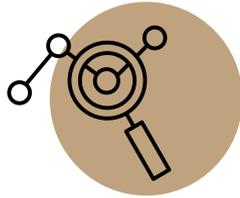


03 | Methods



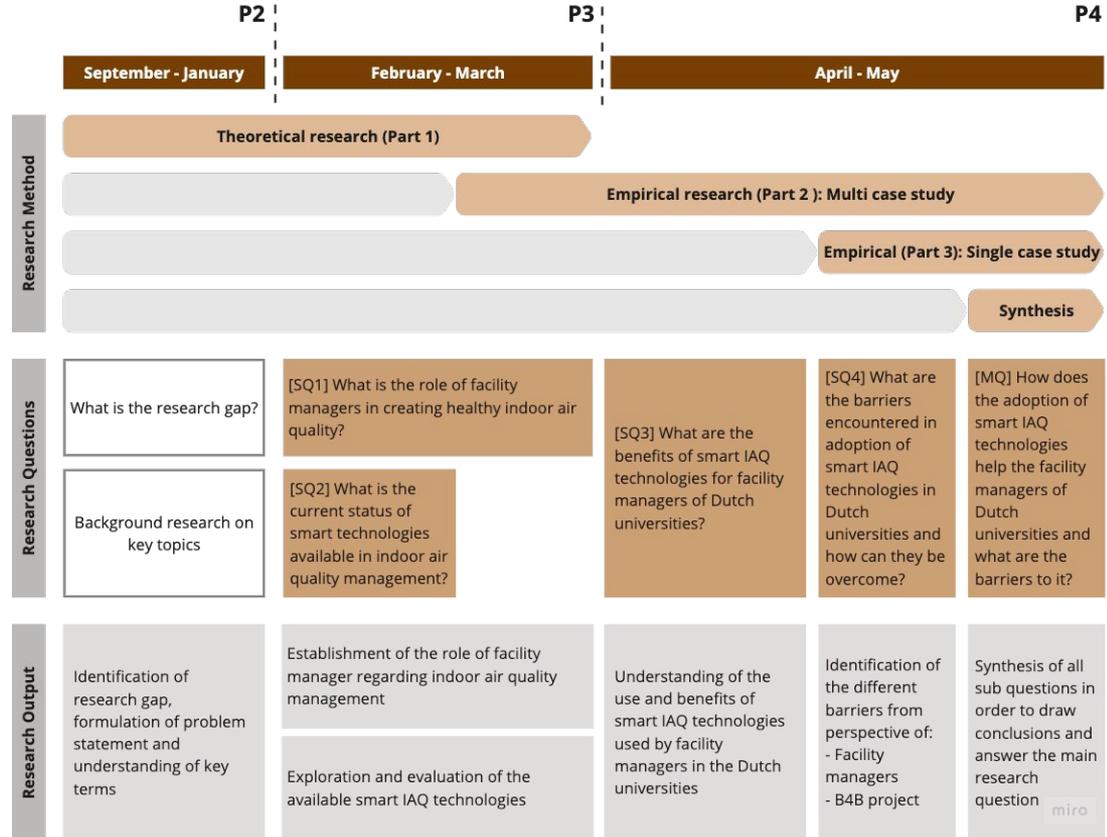
Theoretical

Literature Review
Desk Research



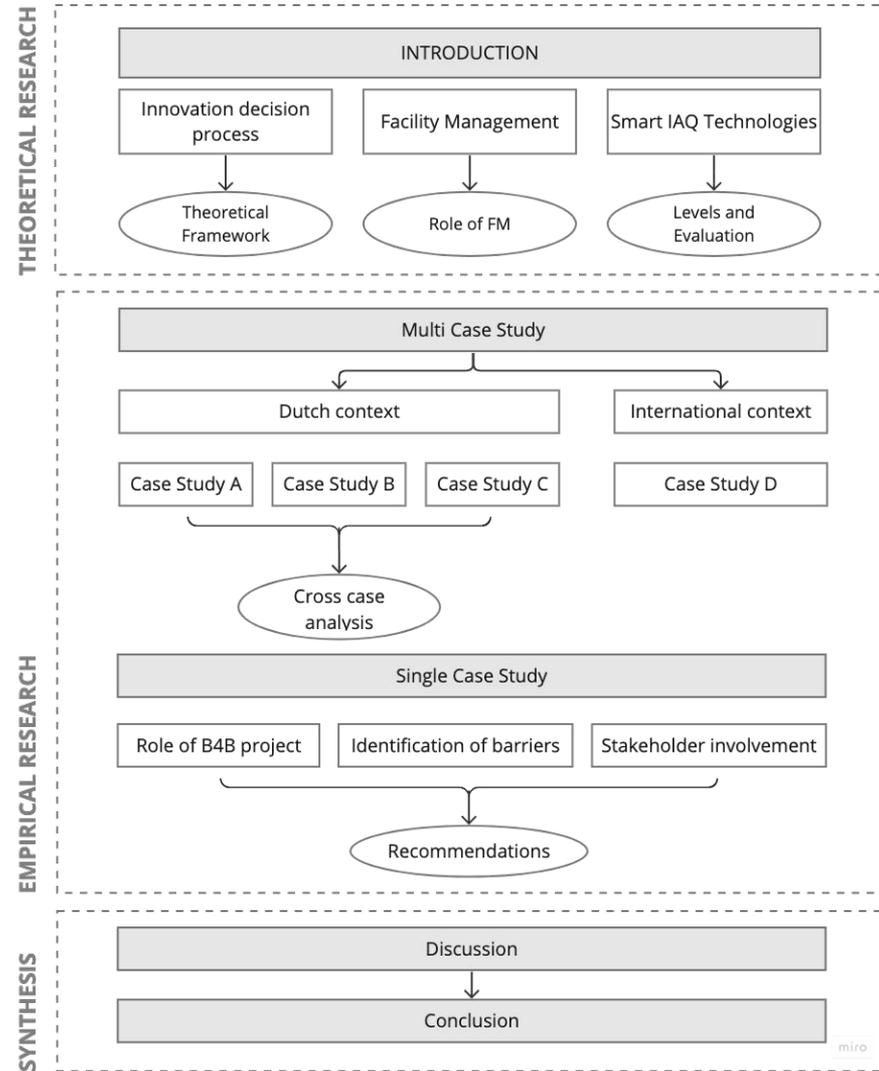
Empirical

Case Studies
Interviews



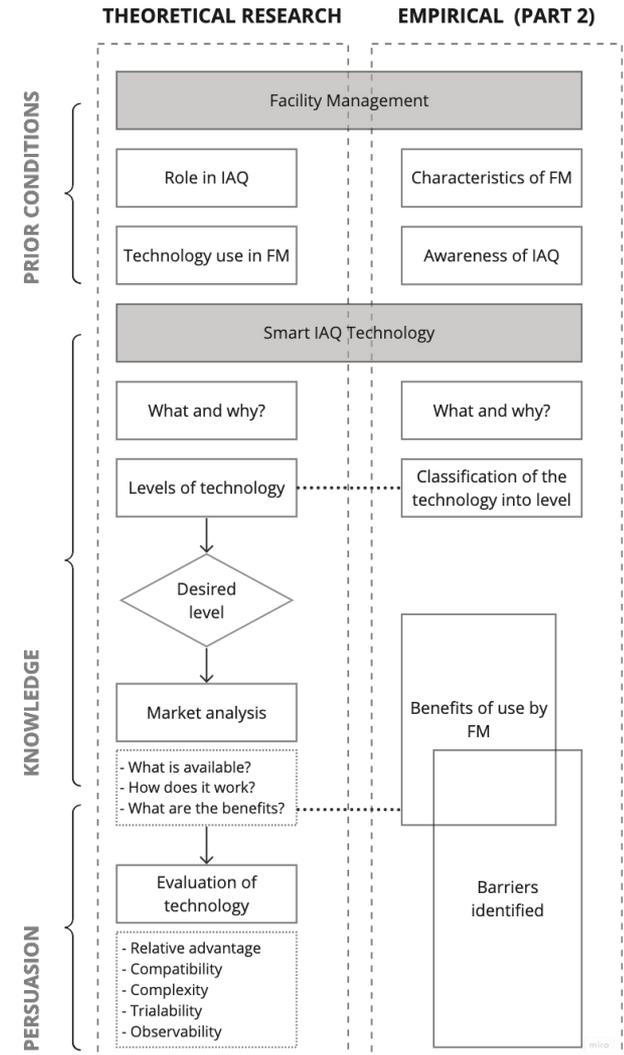
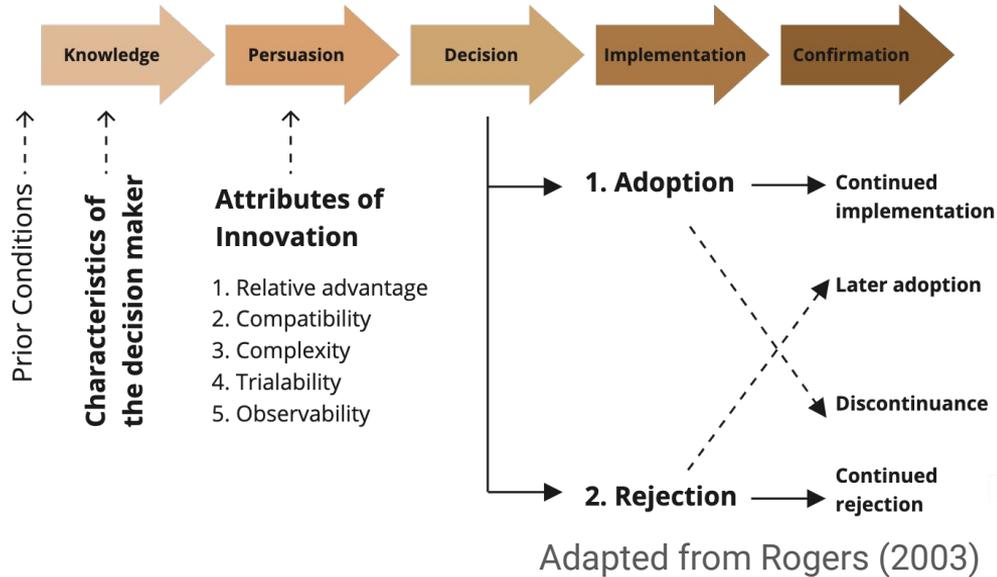
03 | Methods

RESEARCH FRAMEWORK



04 | Theoretical research

INNOVATION DECISION PROCESS (ROGERS, 2003)



Facility Management

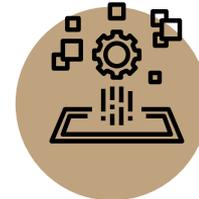
ROLE OF FACILITY MANAGER IN IAQ MANAGEMENT

[SQ1] What is the **role** of facility managers in creating healthy indoor air quality?

Key responsibility of FM: **Ensure occupant health & comfort**

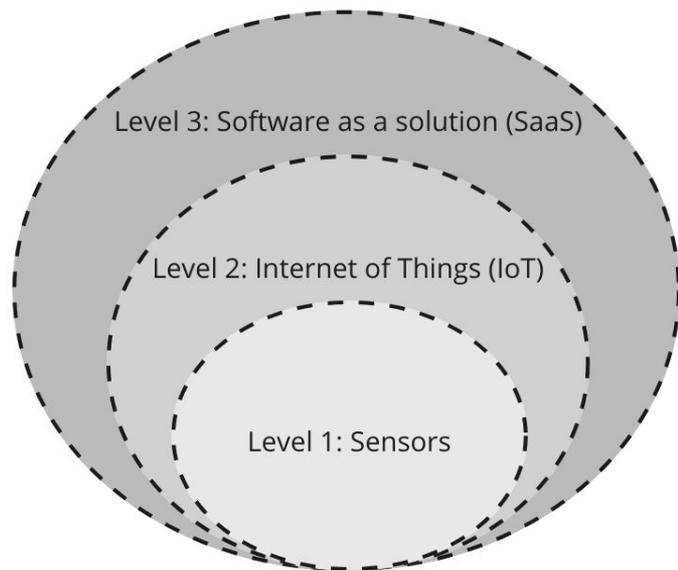
Important role in IAQ management as they:

- Check the conditions of HVAC systems
- Control ventilation rates
- Solve occupant complaints
- Use smart tools to monitor and manage IAQ



Smart IAQ Technologies

LEVEL OF SMART IAQ TECHNOLOGIES



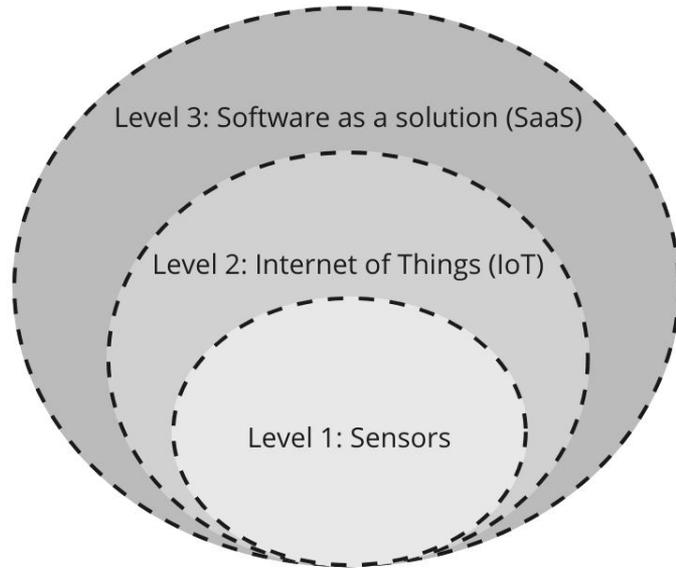
Level 1: Sensors

- Measure temperature, humidity, CO2, PM and other air pollutant levels



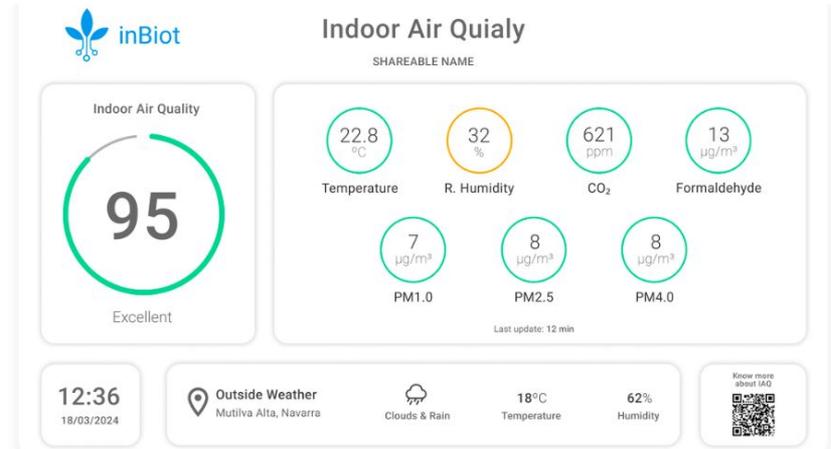
Smart IAQ Technologies

LEVEL OF SMART IAQ TECHNOLOGIES



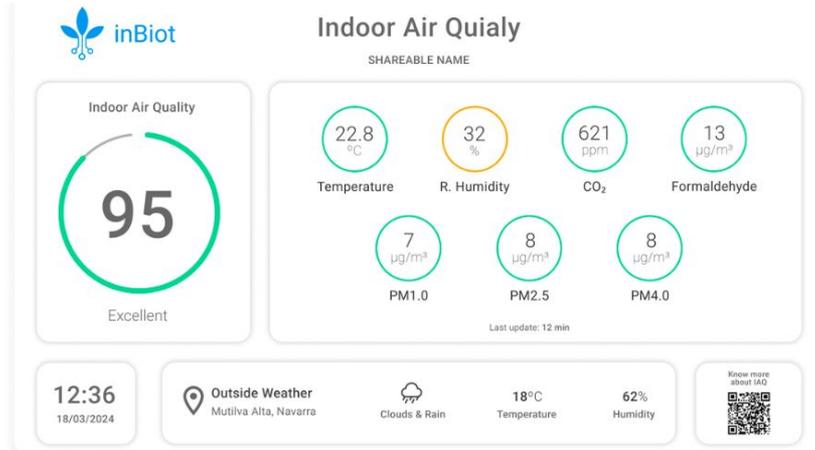
Level 3: SaaS

- Online platforms and dashboards
- Visualise data for easy interpretation



Smart IAQ Technologies

LEVEL OF SMART IAQ TECHNOLOGIES



Why SaaS chosen for evaluation?

- Sensors and IoT used since a long time (Numerous literature available)
- SaaS digital platforms relatively new
- Directly used by the facility managers without any involvement of data/technical experts
- Evaluation from FM perspective

Smart IAQ Technologies

SERVICE PROVIDING COMPANIES



Open Blue Enterprise Manager



Workplace solution

Dexma

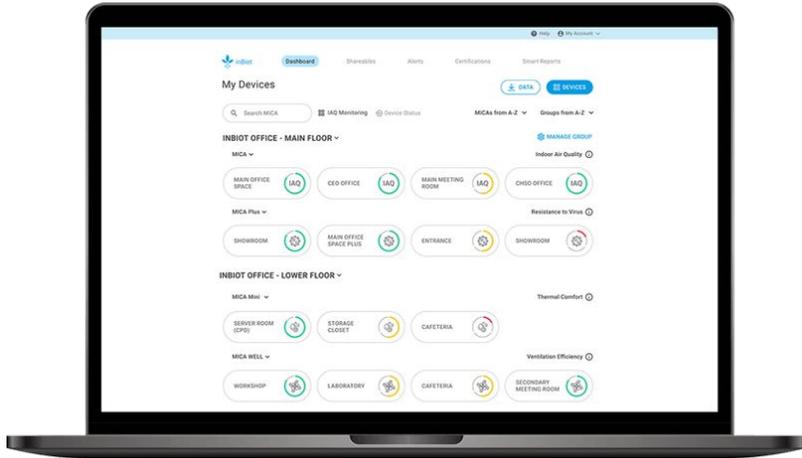


Inbiot Business Intelligence

My Inbiot Platform

Evaluation

EVALUATION OF SAAS (DIGITAL PLATFORMS)



Attributes of Innovation Rogers (2003)

Relative Advantage	Cost effective, scalable, remote access to real-time data
Compatibility	User-friendly interfaces and customizable dashboards Integrated to Building Management systems (BMS)
Complexity	Easy to understand , require minimal technical expertise
Trialability	Trials and demos available
Observability	Better decision making and proactive role of facility managers

04| Theoretical research

SUB QUESTION 2

[SQ2] What is the **current status** of smart technologies available in indoor air quality management?

- Different levels of smart IAQ technologies available
- New emergent technology: smart dashboards
- Identify and tailored to the needs of the facility managers



05| Empirical research (Multi case study)

CASE SELECTION

Criteria	Case A	Case B	Case C
Located in the Netherlands	✓	✓	✓
Use of the building: University (Mainly educational/office)	✓	✓	✓
Uses smart technology to monitor/manage indoor air quality	✓	✓	✓
A responsible facility manager is present who manages the indoor air quality	✓	✓	✓

Brains 4 Buildings



Make buildings intelligent by BMS and IoT

Mission: Aid building managers in improving health and comfort inside institutional buildings



05| Empirical research (Multi case study)

CASES



CASE STUDY A

School of Business & Economics
MAASTRICHT UNIVERSITY



CASE STUDY B

Building 28
TU DELFT



CASE STUDY C

The Delft Branch
The HAGUE UNIVERSITY

CASE STUDY A



CASE STUDY A

School of Business & Economics
MAASTRICHT UNIVERSITY

Level of smart IAQ technology used	Level 1 and 2 Sensors + IoT based BMS
Benefits of use for FM	<ul style="list-style-type: none">- Adjust educational and work space to the post pandemic situation- Meet new government regulations and standards of Dutch building decree
Barriers identified	Costs Reliability Regulations: monumental buildings

CASE STUDY B



CASE STUDY B

Building 28

TU DELFT

Level of smart IAQ technology used	Level 2 IoT based BMS
Benefits of use for FM	- Fix equipment malfunction - Solve comfort complaints
Barriers identified	Complexity Lack of knowledge

CASE STUDY C



CASE STUDY C

The Delft Branch
The HAGUE UNIVERSITY

Level of smart IAQ technology used	Level 3 - Digital platform + BMS
Benefits of use for FM	- Identify trends, use historical data to make long term strategies for the campus
Barriers identified	Stakeholders not agreeing



CASE A: Maastricht university



CASE B: TU Delft



CASE C: The Hague university

CROSS CASE ANALYSIS DISCUSSION

[SQ1] What is the **role** of facility managers in creating healthy indoor air quality?

- Reactive or proactive role → depending on the level of awareness
 - Follow regulations
 - Comfortable environment
 - Understand the impact on concentration levels





CASE A: Maastricht university



CASE B: TU Delft



CASE C: The Hague university

CROSS CASE ANALYSIS DISCUSSION

[SQ3] What are the **benefits** of smart IAQ technologies for the facility managers of Dutch universities?

- Provides alerts if thresholds are exceeded
- Remote access to solve comfort complaints of occupants
- Identify and rectify installation malfunctioning
- Make long term IAQ strategies by using historical data

} Reactive measures

} Proactive measures



CASE A: Maastricht university



CASE B: TU Delft



CASE C: The Hague university

CROSS CASE ANALYSIS DISCUSSION

[SQ4] What are the **barriers** encountered in adoption of smart IAQ technologies in Dutch universities and how can they be overcome?

- Cost
- Regulations
- Reliability
- Stakeholder collaboration
- Lack of knowledge



CASE A: Maastricht university



CASE B: TU Delft



CASE C: The Hague university

CROSS CASE ANALYSIS DISCUSSION

[SQ4] What are the **barriers** encountered in adoption of smart IAQ technologies in Dutch universities and how can they be overcome?

- Cost
- Regulations
- Reliability
- Stakeholder collaboration
- **Lack of knowledge** → Building 28 TU Delft does not use the latest technology

05| Empirical research (Investigating Case Study B)

Aim: *To investigate why is the latest technology not being implemented & used in Building 28 despite being a part of the B4B project*

- Findings of research communicated with FM
- Demo of digital platform



Get confirmation



- Interview with two B4B project members

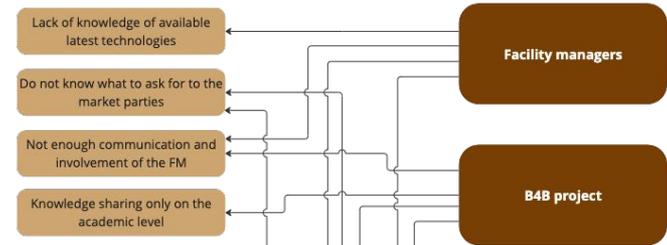


05| Empirical research

BARRIERS IDENTIFIED

Lack of knowledge	Needs of Facility manager not known Knowledge sharing & involvement of FM Market research: University demand?
Stakeholders	Difficult to convince Split incentive
Lack of resources	B4B: Only pilot projects Need to train employees
Safety and security	Vendor lock in: Loss of data if external party leaves the contract

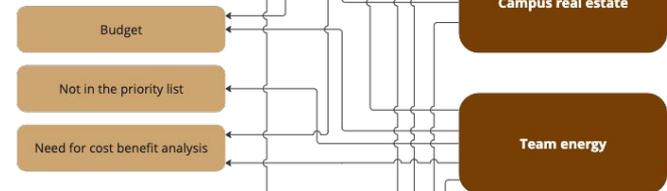
KNOWLEDGE



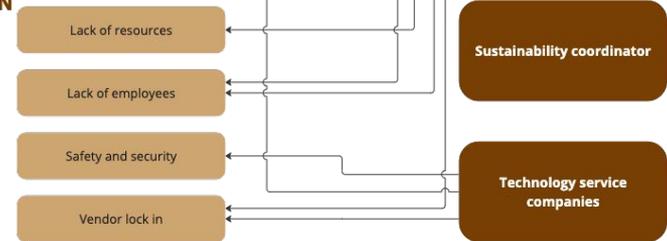
PERSUASION



DECISION

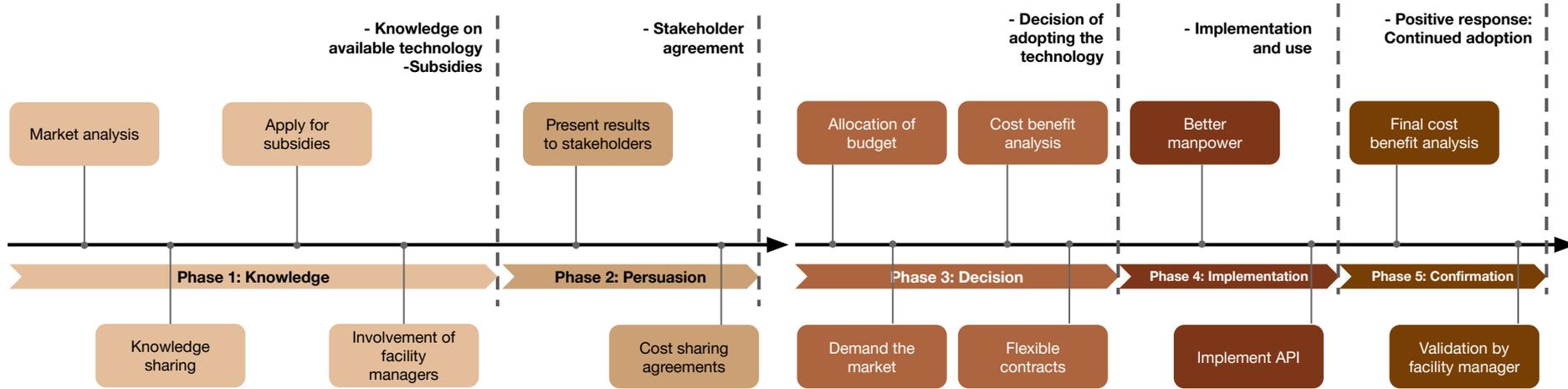


IMPLEMENTATION



CONFIRMATION

RECOMMENDATIONS



[SQ4] What are the **barriers** encountered in adoption of smart IAQ technologies in Dutch universities and how can they be overcome?

BARRIERS



Lack of Knowledge



Stakeholders



Lack of resources



Safety and security

RECOMMENDATIONS



Research &
knowledge sharing



Joint effort and
agreement



Skill development



Subsidies

06 | Discussion and Conclusion

Comfort vs Energy



"...sustainability...It's very important in my function. We want to comply with the Paris accord of sustainability, not in 2050, but in 2030. So that's a part of my job to look for new concepts to reduce energy leakage..."

-FMC, Facility manager, Delft Branch, HHS



Climate change!

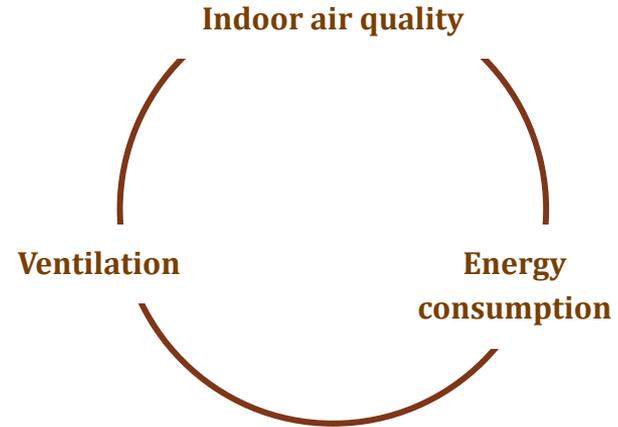
"we want to green the campus so we want to save a lot (of energy), we want to be climate neutral in 2040 so that's also why they have reserved a budget for using smart buildings"

- B4B-2, Project Coordinator, B4B



06| Discussion and Conclusion

Comfort vs Energy



Prioritise **Healthy Buildings** along with sustainable buildings!!

06| Discussion and Conclusion

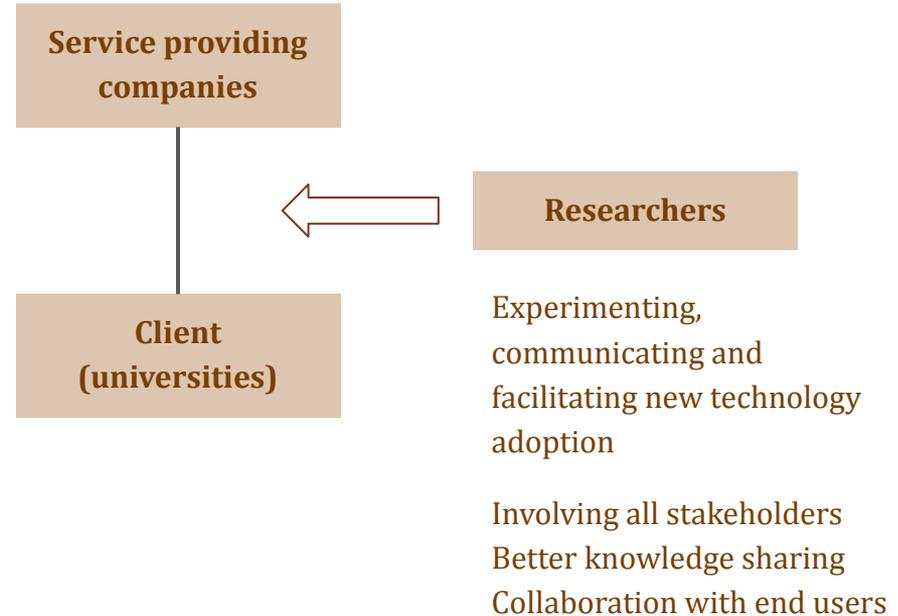
Data privacy and security



- Research did not address potential drawbacks of technology
- To use new technology ethically: need to follow regulations of data security and protect occupant privacy

06| Discussion and Conclusion

Clients, companies and researchers



MAIN RESEARCH QUESTION

How does the adoption of smart IAQ technologies help the facility managers of Dutch universities and what are the barriers to it?



Enhance IAQ



Ensure occupant
health & comfort



Make data driven
decisions



Joint effort



06| Limitations & Further research

Limitations

- Time, resource and methodology
- Case Studies
 - Limited Generalisability
 - Context specific
 - Level of technology used
 - Stages of framework
 - B4B in research stage, not implementation
- One perspective research

Further research

- Broaden geographical location
- Types of real estate (office, retail)
- Include different perspectives
 - Barriers: Internal, external stakeholders
 - Occupant-centric IAQ management model





Thank you!

Questions?

 **TU**Delft

Aaditi Singh

P5 Presentation | 21.06.24