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SE applied in the construction industry to achieve a BREEAM certification

Introduction

- Buildings have a high environmental impact
  - 1/3 of global resources
  - 40% of all raw materials
  - 40-50% of all energy usage and anthropogenic greenhouse gas emissions globally
- Long useful life span
- Wasteful end-of-life handling

BREEAM

Building Research Establishment Environmental Assessment Method

- Building assessment methods
  - Green constructions are gaining increased attention
  - More than 600 building certification methods globally
  - Documented qualities provide evidence of compliance
  - Measures to lower the environmental impacts from buildings

- BREEAM
  - Established in 1990
  - Five different rating benchmarks
  - BREEAM-NOR

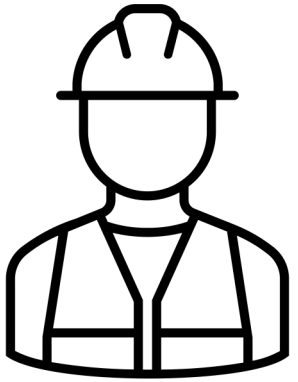
BREEAM Rating	% score
OUTSTANDING	≥ 85
EXCELLENT	≥ 70
VERY GOOD	≥55
GOOD	≥ 45
PASS	≥ 30
UNCLASSIFIED	< 30

Illustration source: https://www.breeam.com/BREEAM2011SchemeDocument/Content/03_ScoringRating/scoring.htm

Systems Engineering

- Systems Engineering
  - Sillitto et al. (2019, p. 3) suggest defining Systems Engineering as a "*transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods*".

- Systems Engineering in Construction
  - Traditionally driven by the project management triangle
  - Regulations are becoming increasingly performance based
  - More ambitious
  - Growth in number of requirements and stakeholders
  - Construction industry - increased interest in SE



Systems Engineering continued

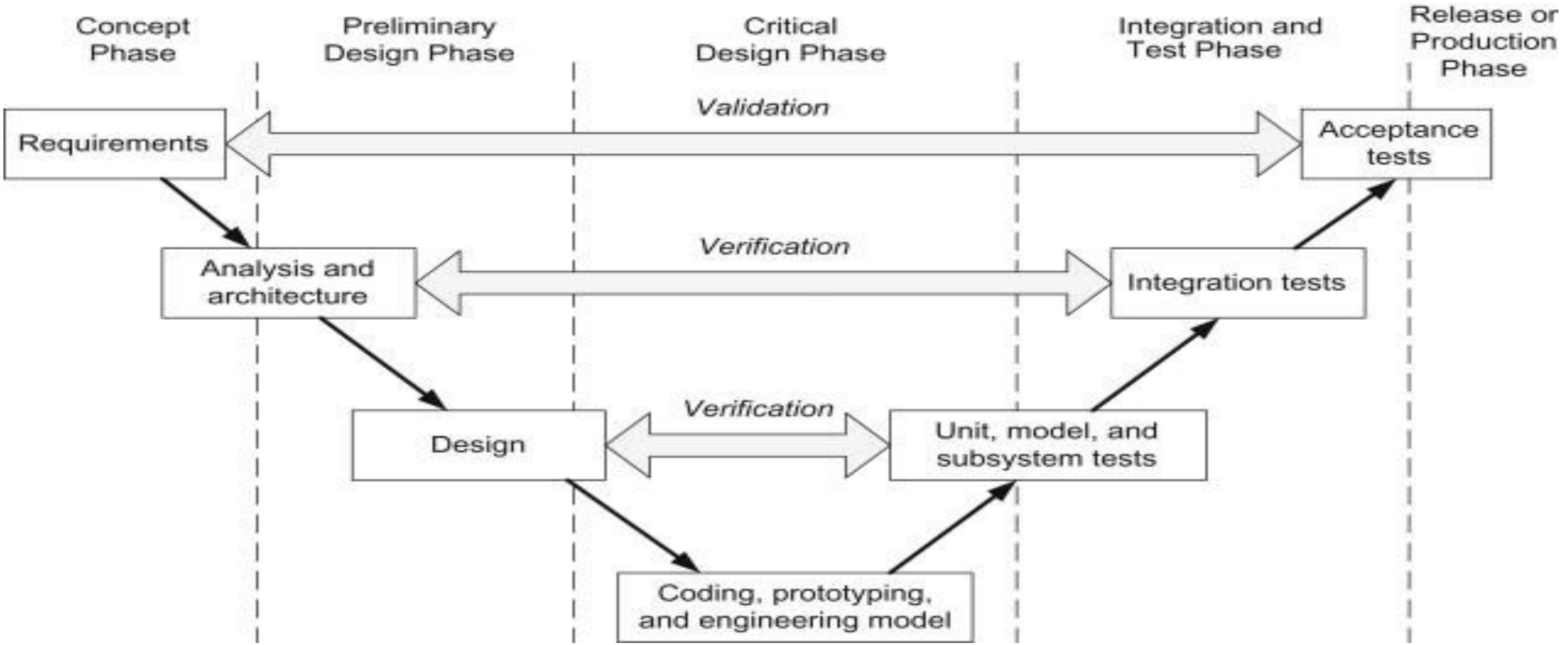
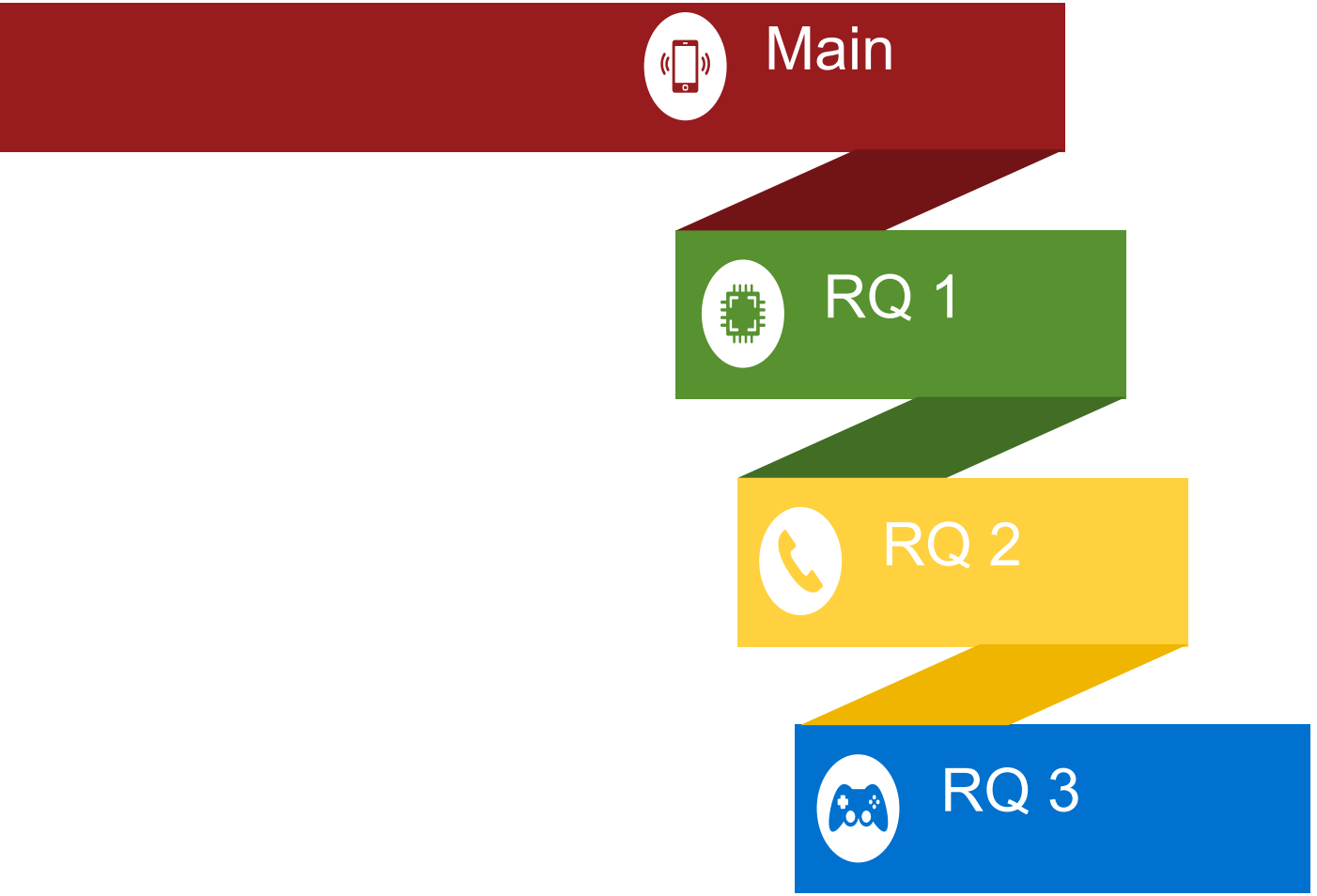


Illustration source: Fowler, K. 2014. *Developing and managing embedded systems and products: methods, techniques, tools, processes, and teamwork*, Elsevier.

Research Questions



How can SE processes help achieve a BREEAM certification?

Why is BREEAM important to the construction industry?

What are the barriers to a BREEAM certification, i.e., why do not more buildings qualify for certification?

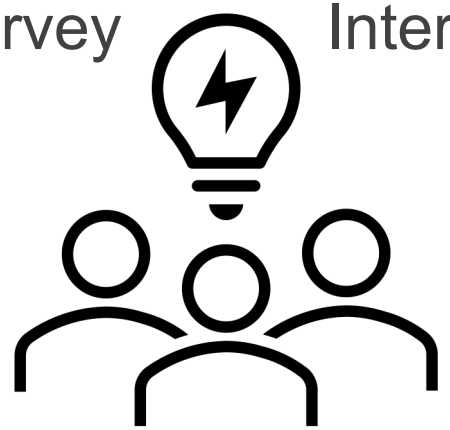
What SE activities are recommended for the construction industry?

Research Methods

1 → 2 → 3 → 4 → 5

Literature Review

Survey



Interview

Analysis

Ethical and validity concerns

Literature review results

- About 65 articles
- Barriers to BREEAM
  - Cost and time
  - Early phase consideration
- Drivers to BREEAM
  - Reputation, social responsibility and rental possibilities
  - Discourages greenwashing, document based
- BREEAM and the SDGs

Example of barriers to BREEAM

- One example of a barrier is the passive-house Miljøhuset (The Environmental House), that is the own-built headquarter of the company GK. According to GK the building could have reached a “Very Good” BREEAM rating.
- In personal email correspondence, GK states that as they did not consider a BREEAM certification until the construction was underway, by then it was too late for much of the work to be documented. This includes missing documentation on the cleaning and waste plan through the first part of the construction phase.
- Since it could not be documented that this was in place from the start, these points could not be obtained. Thus, the building could not be certified to achieve the certification ambitions, even if the building met the other points necessary.
- This is consistent with literature reports on the observation that operational buildings are less likely to undergo the certification process (Ding et al., 2018).

BREEAM and the SDG

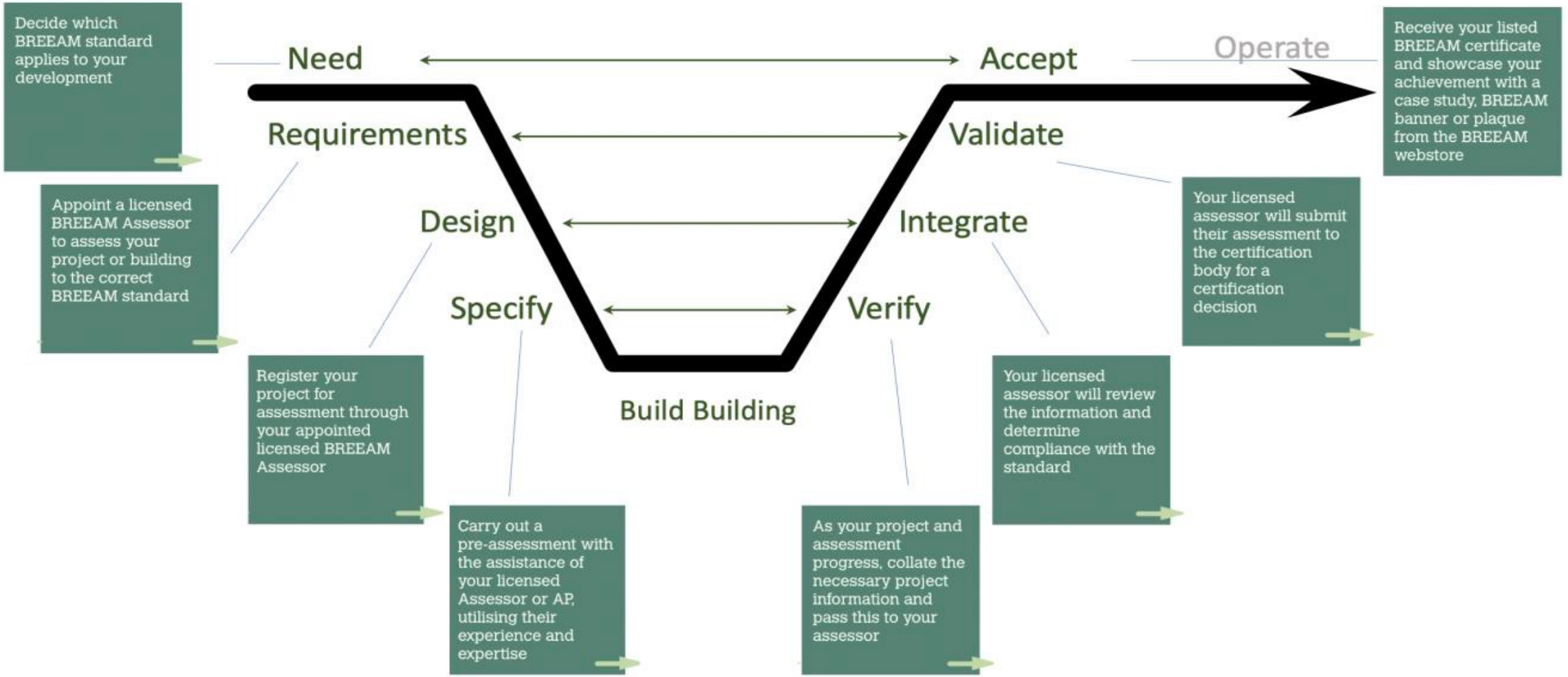
- The UN Agenda 2030 ratified in 2015
- 17 sustainable development goals (SDG) and respective targets have been established to help policy makers, industry, and individuals work toward a more sustainable future.
- BREEAM New Construction has a significant contribution to goals 3, 6, 7, 9, 11, 12, 13 and 15 (respective targets.

Sustainable Development Goals	Relevant targets
Goal 3: Ensure healthy lives and promote well-being for all at all ages	3.4, 3.6, 3.9
Goal 6: Ensure availability and sustainable management of water and sanitation for all	6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.a, 6.b
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	7.1, 7.2, 7.3, 7.a, 7.b
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	9.1, 9.4, 9.5, 9.a
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	11.1, 11.3, 11.5, 11.6, 11.7, 11.a, 11.b, 11.c
Goal 12: Ensure sustainable consumption and production patterns	12.1, 12.2, 12.4, 12.5, 12.6, 12.7, 12.a
Goal 13: Take urgent action to combat climate change and its impacts	13.1, 13.2. 13.3
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1, 15.2, 15.3, 15.5, 15.9

Literature review results continued

- V-model mapping
  - Parallels with BREEAM steps
  - Systemize the certification steps and organize required artifacts and documentation
  - Focus on early phase investment

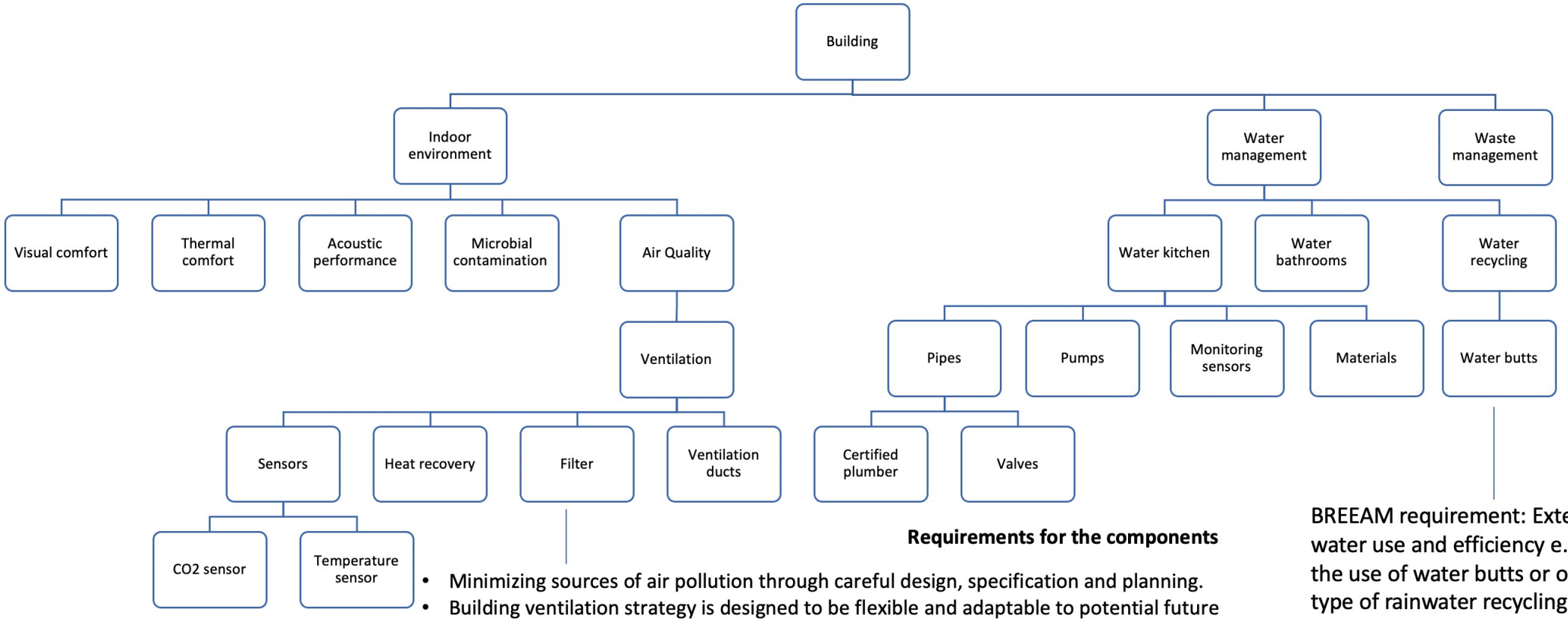
Literature review results continued



Literature review results continued

- Hierarchy diagram
  - Link BREEAM requirements to the various parts of the system
  - Outsource the design process
  - Model-based system technology
    - Set up the model
    - Identity traceability

Hierarchy diagram – partial building

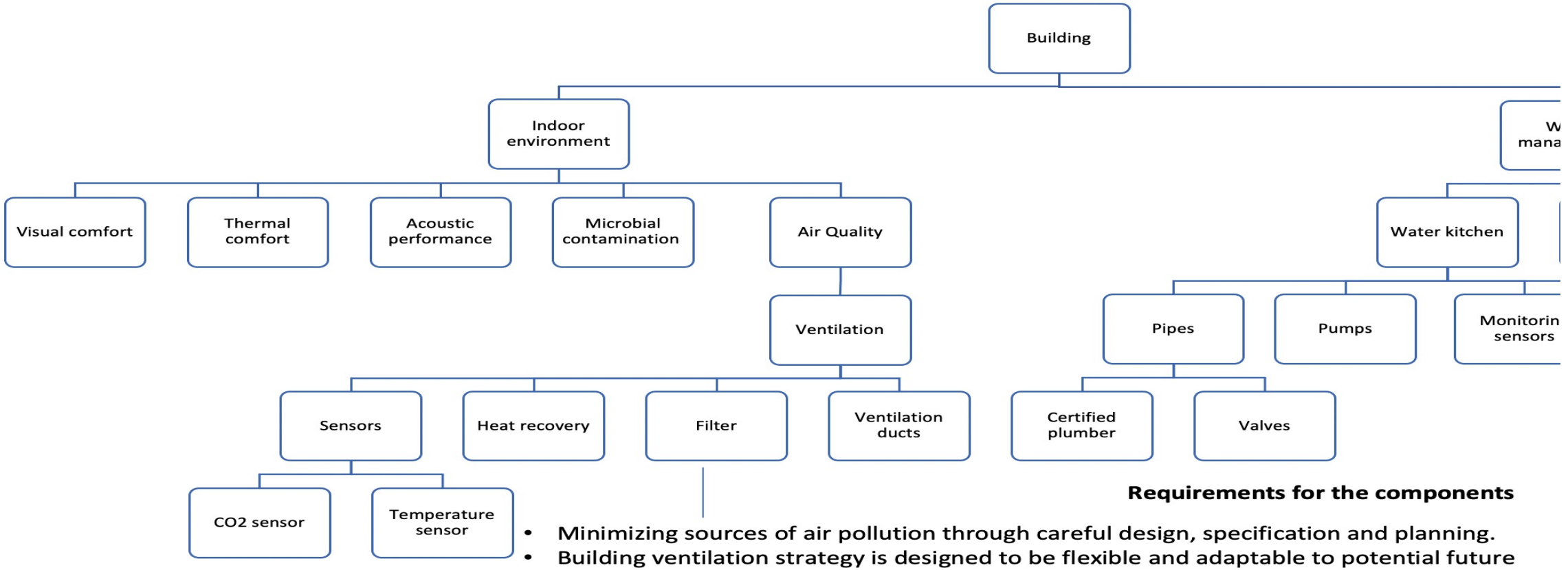


Requirements for the components

- Minimizing sources of air pollution through careful design, specification and planning.
- Building ventilation strategy is designed to be flexible and adaptable to potential future building occupant needs and climatic scenarios.
- Production of an objective risk assessment of the proposed laboratory facilities.
- Containment devices such as fume cupboards meet best practice safety and performance requirements and objectives.
- Containment level 2 and 3 laboratory facilities to meet best practice safety and performance criteria where specified.

BREEAM requirement: External water use and efficiency e.g., the use of water butts or other type of rainwater recycling systems

BREEAM requirement: Details of water saving measures and tips



Requirements for the components

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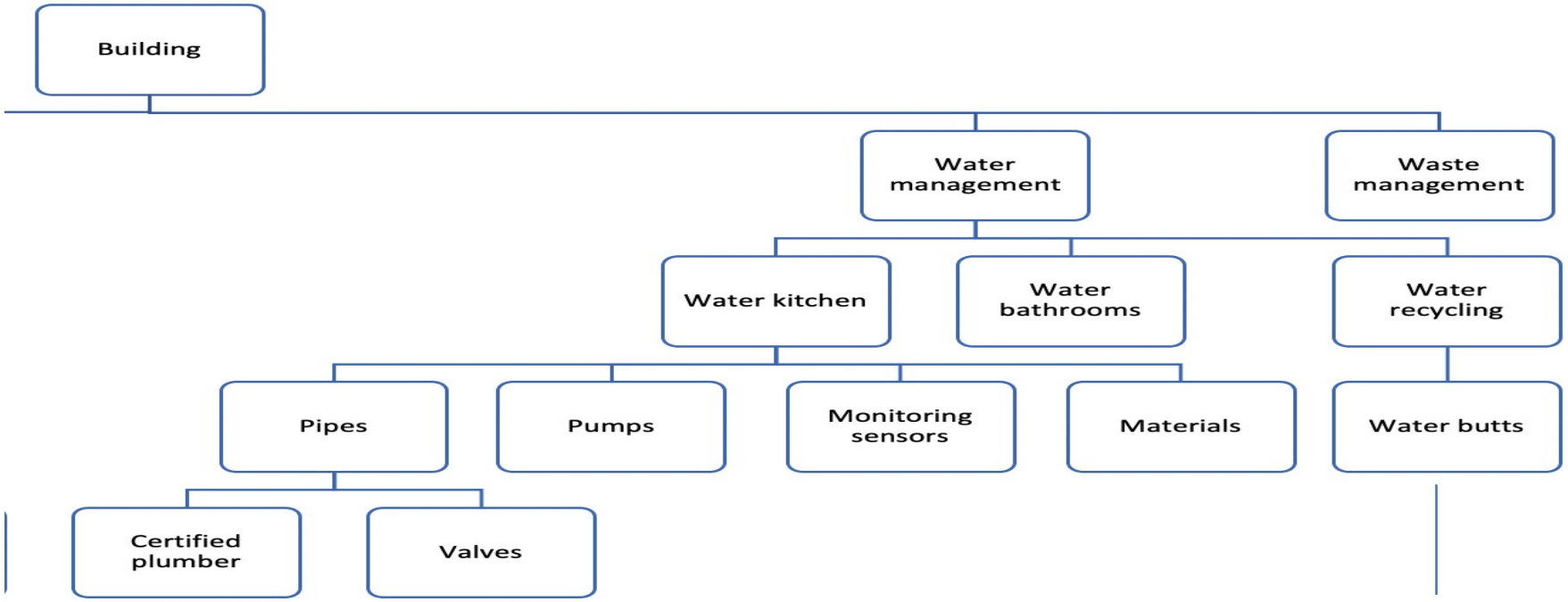
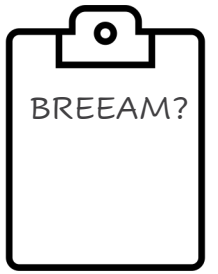

Building
Water management
Waste management
Water kitchen
Water bathrooms
Water recycling
Pipes
Pumps
Monitoring sensors
Materials
Water butts
Certified plumber
Valves
BREEAM requirement: External water use and efficiency e.g., the use of water butts or other type of rainwater recycling systems
BREEAM requirement: Details of water saving measures and tips

Survey

- Shared by mail, linked InMail and LinkedIn
- 11 respondents
- Open text boxes - wide range of answers
- Confirmed much of what was found in the literature review
- Provided a representative overview



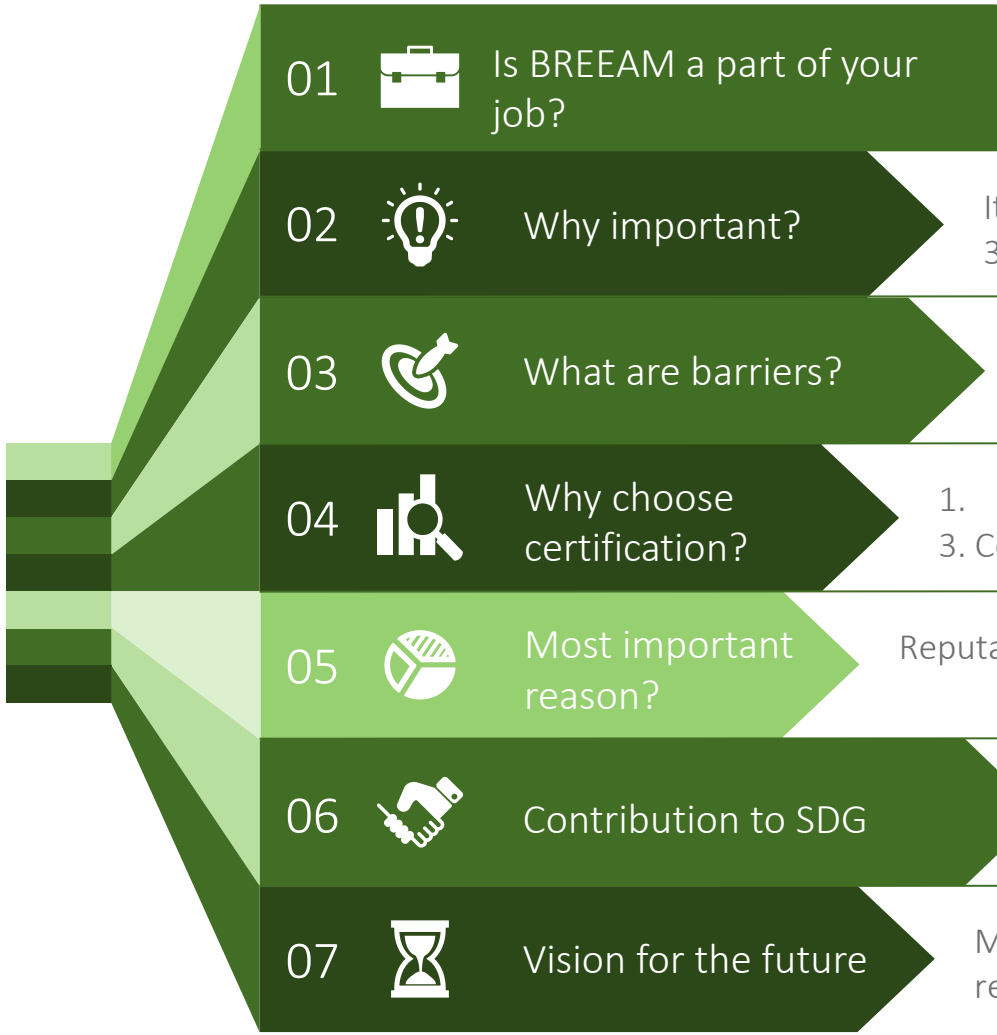
Survey participant demographics

- Head of BREEAM in Norway;
- Market manager in Grønn Byggallianse (GBA),
- A GBA employee who works with QA (approval) on projects to be certified;
- One who was a BREEAM-NOR AP (accredited professional), BREEAM-NOR Auditor, BREEAM In-Use Auditor, RIF approved environmental advisor;
- A consultant who may advise customers to use BREEAM;
- Interviewed stakeholder, works as an environmental manager;
- Remaining 5 were only aware of certification.

Survey questions

- Question 1: Is BREEAM a part of your job?
- Question 2: Why do you think BREEAM is important to the construction industry?
- Question 3: What are the barriers to a BREEAM certification, i.e., what do you think is the reason everyone (every building) does not apply for a BREEAM certification?
- Question 4: What do you experience as the reason to why people/companies choose to get a BREEAM certification?
- Question 5: Which of the following do you see as the most important reason to why people choose to get a building certification, such as BREEAM? (1. reputation and looking sustainable from the outside, 2. energy savings, 3. Sustainable Development Goals, 4. Other)
- Question 6: What do you think is the most important way a BREEAM certification contributes to the Sustainable Development Goals?
- Question 7: What changes would you like to see within the construction industry and within the execution of BREEAM assessments?
- Question 8: Anything else you would like to add? – there were no significant responses

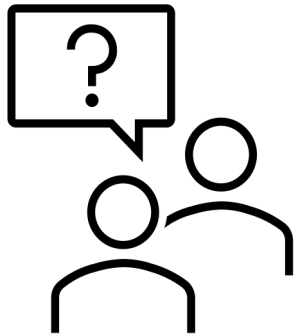
Sample Responses – respondent 6



01	Is BREEAM a part of your job?	Interviewed stakeholder, works as an environmental manager
02	Why important?	It pushes the industry towards sustainability. 2. It is unbiased and science based. 3. It offers the same framework for building projects in 80+ different countries.
03	What are barriers?	1. Awareness among landlords and investors. 2. Cost
04	Why choose certification?	1. Sustainability concerns. 2. Long-term investment benefits. 3. Corporate reporting and image.
05	Most important reason?	Reputation and “looking sustainable” from the outside.
06	Contribution to SDG	BREEAM projects are often energy efficient and use renewable energy, they do more for biodiversity and circularity, and facilitate cooperation towards sustainable development.
07	Vision for the future	More digitalized processes related to sustainability, lower cost on sustainability-related measures.

Interview with respondent #6

- Environmental manager who has previously worked closely with BREEAM
- Semi-structured interview
- Two parts:
  - After her survey response
  - Reaction to SE propositions
    - Agrees that a digitalization/systematization is desirable
    - No experience with SE, but interested in any approach that could systemize BREEAM while still retaining its values



Discussion

- **Why is BREEAM important to the construction industry?**
  - Management tool and guidelines for more sustainable buildings
  - Allows for innovation
  - Reputation and social responsibility
  - Rental opportunities

- **What are the barriers to a BREEAM certification, i.e., why do not more buildings qualify for a BREEAM certification?**
  - Cost
  - The documentation is too valuable to be incomplete
  - The measures can be done without achieving the certification

Discussion continued

- **What systems engineering activities are recommended for the construction industry?**
  - Address the increased complexity of modern buildings
    - The V-model helps organize the processes
    - The Hierarchy Diagram helps organize the requirements
- **Main research question: How can systems engineering processes help achieve a BREEAM certification?**
  - Use of SE models
  - Early life cycle phase investment
  - Systematization and digitalization

Conclusion

- Limited literature on this topic
- The construction industry is constantly evolving
- Increased systematization with the help of systems engineering could help the industry cope with the increasing complexity of buildings and organize the many disciplines that must cooperate in construction projects

Future work

- Creation and testing of prototype software to digitize the certification process
- Populate a hierarchy diagram with the BREEAM requirements and make it available in the software
- To be able to fully implement the processes discussed in this thesis it will require testing, adaption and time
- Support validation with stakeholders within the BREEAM environment
- It will take time to engage an entire industry

Thank you for your attention!

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www.incose.org/symp2022