Riv
Bevar
Gjenbruk

Viktig problemstilling i dagens BAE-næring

31.Oktober 2023

Professor emeritus, FoU-leder Svein Bjørberg

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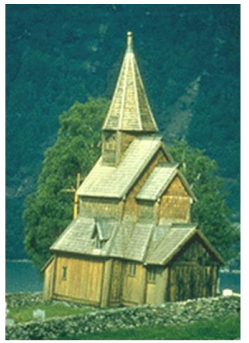
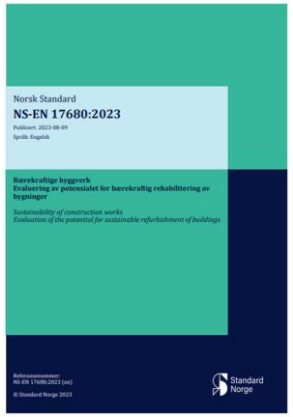
Fra Høvik Verk via en rekke aktiviteter til **Bærekraftig ombygging**

- «Bevar» startet lenge før med Magnus Lagabøter i 1274
  - OBS: 750 års jubileum i 2023
- Utvikling av «Bygningsforvaltning» som fagområde
  - Fra punktforelesninger i 1975 til egne studieretninger
- Spesielle prosjekter på veien
  - Victoria Terrasse, Byfornyelse, Den Gamle Logen, Norges Bank
  - UNESCO i Nepal, Aga Khan Trust for Culture Kabaul, RA i Laza, Studenter i Asmara
- Utvikling av standarder: NS, NEN og ISO
  - Fra Tilstandsanalyse og LCC til FM og Ombygging
- FoU-aktiviteter
  - Byggskader (RUB), Bygningssakkyndige, Hurtig-Erfa, Effektive helsebygg, OSCAR Verdi for eier og bruker
- Professor II ved NTNU
  - 1992 – 2019 (Ombygging, BEF) på bygg fakultetet
  - 2010 - 2019 (Eiendomsutvikling) på arkitekturfakultetet
- Noen spennende verv er det blitt, bla
  - Leder av eiendomsutvalget i Fortidsminneforeningen, Styremedlem i NBEF, medlem av statens byggeskikkutvalg og byggeskikkprisjuryen i Forsvarsbygg



Urnes stavkirke, ca. 1130
UNESCOs verdensarvliste



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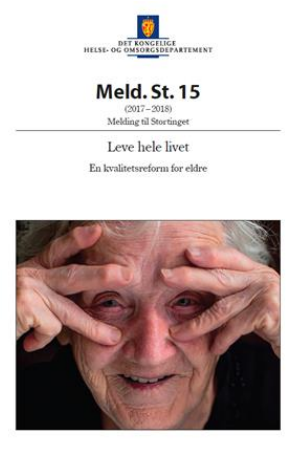
Viktige (noen) signaler fra Regjeringen(e)

- 3 viktige dokumenter
  - «Gode bygg for eit betre samfunn» (Stm 28: 2011-2012)
  - «Leve hele livet» (Stm 15:2017-2018)
  - «Forsvarlig byggkvalitet» (Rapport til KMD 2020)
- Tilsammen handler dette om
  - **livsløpsplanlegging, well-being over totalt livsløp, kvalitet i bygninger, folk og samfunn**
- Daværende minister Nikolai Astrup
  - Nytt regjeringskvartal skal planlegges for livsløp på 300 år
  - Nøkkelord må da bli:
    - **Tilpasningsdyktighet for å opprettholde well-being**
    - **Dekonstruksjon og sirkulær økonomi**
  - Etterslep bør fremkomme som gjeld i balanseregnskapet



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Eksisterende bygningsmasse har potensial til å tilfredsstille nye krav

- **Bygningsmassen**
  - ca 400 millioner m2 bygg (ca 2/3 er boliger) + ca 40 millioner m2 hytter: Stort etterslep (GJELD!!)
- **Demografisk utvikling:**
  - 80% av verdens befolkning ender i byer / tettsteder: sosial utfordring
  - Økende antall enslige husholdninger: ca 55% i Oslo
- **Klimaendringer** (påvirkning på bygg og områder)
- **Sirkulær økonomi** (Gjenvinning, gjenbruk, lang levetid på hele bygg gir stor gevinst), OBS TEK § 9-5
- **Taksonomi** (grønne bygg, brune bygg)
- **Vedtak i EU**:
  - Ombygging av 35 millioner bygg 2020 – 2030 (stor gevinst i bygg med gener for et langt liv)
  - Energidirektivet: strenge krav
- **Utfordring**
  - Fra versting (40% bransjen) til forbilde gjennom livsløpet

RESULTATER

Tabellen oppsummerer de ulike områdenes samlede hovedkonklusjoner.

OMRÅDE	ESTIMERT VERDI (gjenanskaffelses-verdi eks kjøp av eiendom)	TILSTANDS-KARAKTER (1-5 der 5 er best)	ESTIMERT KOSTNAD, OPPGRADERING TIL KARAKTER 4 – Dagens anlegg (eks kjøp av eiendom)	FREMTIDS-UTSIKT
	mrd. NOK		mrd. NOK	
Kommunale bygg	1200	3	160	
Helsebygg (statlige)	400	3	40-55	
Andre statlige bygg	360	3	11	
Jernbane	600	2	600	
Lufthavner	100 – 140[1]	4	0	
Riksveier	1000	3	1000-1100	
Fylkesveier	700	2	700[2]	
Kommunale veier	500	3	300	
Vannforsyningsanlegg	719	3	250[3]	
Avløpsanlegg	1067	3	320[3]	
Energiproduksjon	500 – 550	4	0	
Energidistribusjon	380 – 500[4]	4	0	
Sum	7180 – 7390	3	3221 - 3336	

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Bærekraftig ombygging

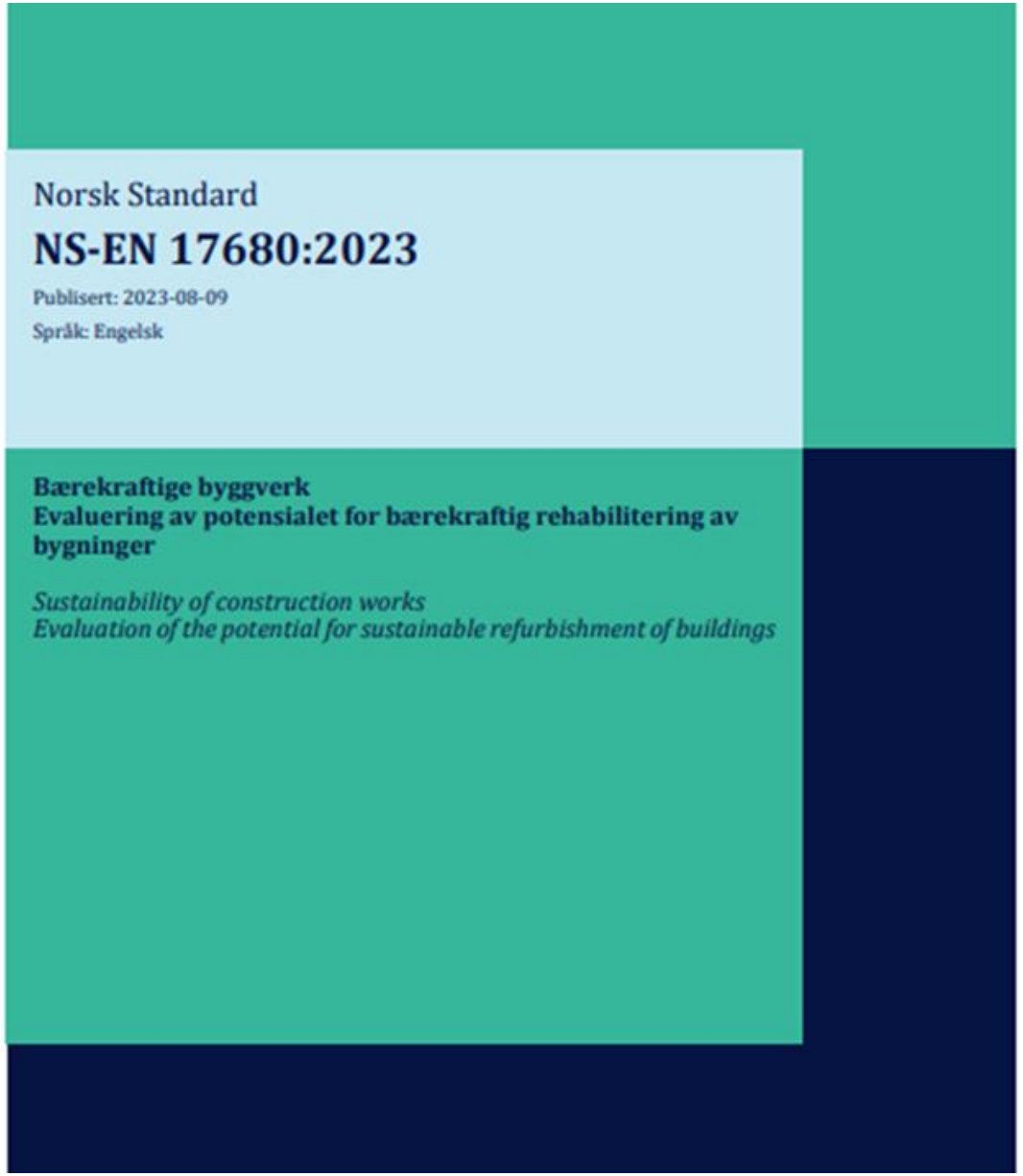
NS-EN 17680:2023
Sustainable Construction

“Evaluation of Sustainable Refurbishment potential”

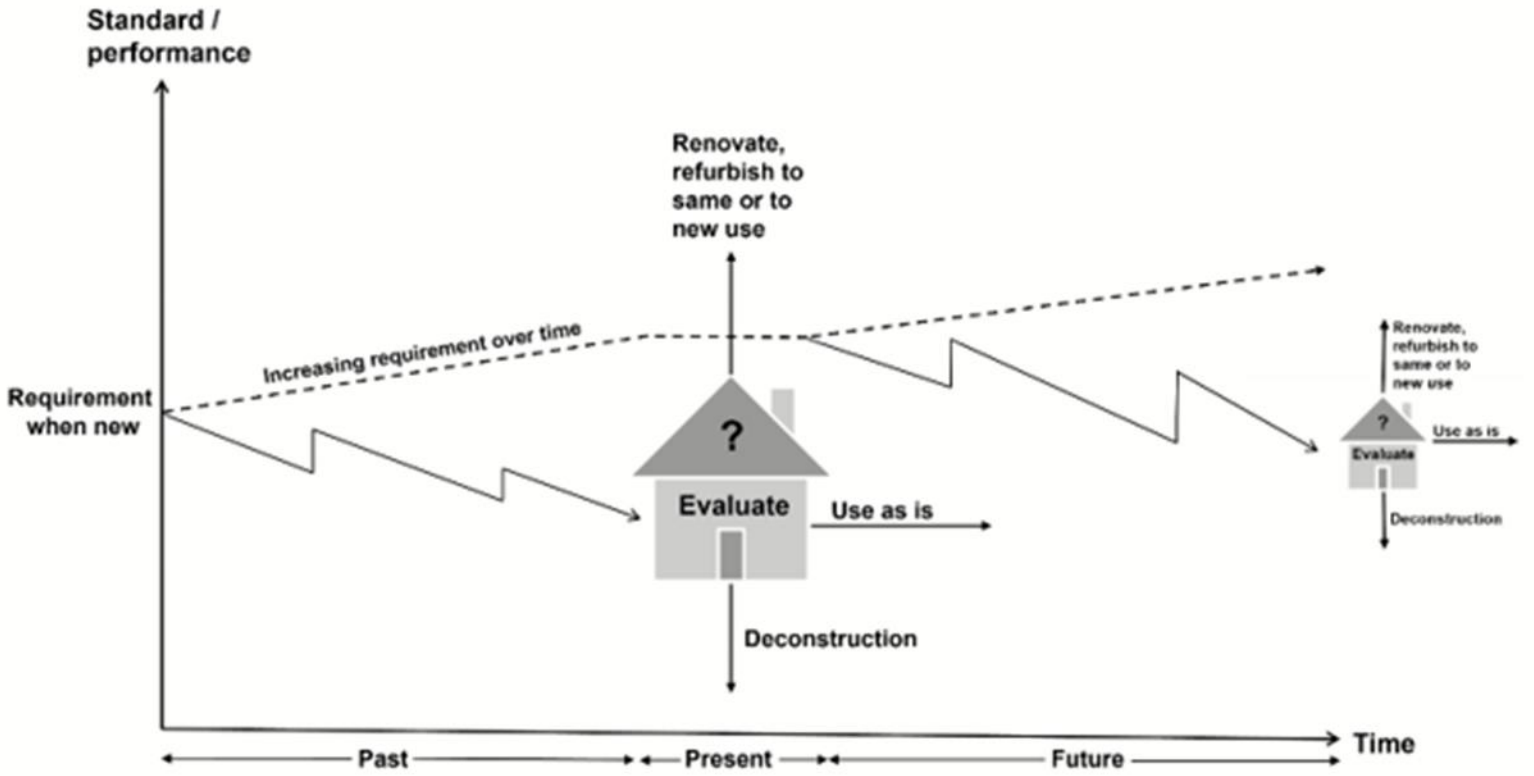
Påbegynt november 2017

Godkjent i EU juni 2023

Lansert av Standard Norge (SN) 8. august i Norge



Decision methodology process



(Ref.: NS-EN 17680:2023, figure 2)

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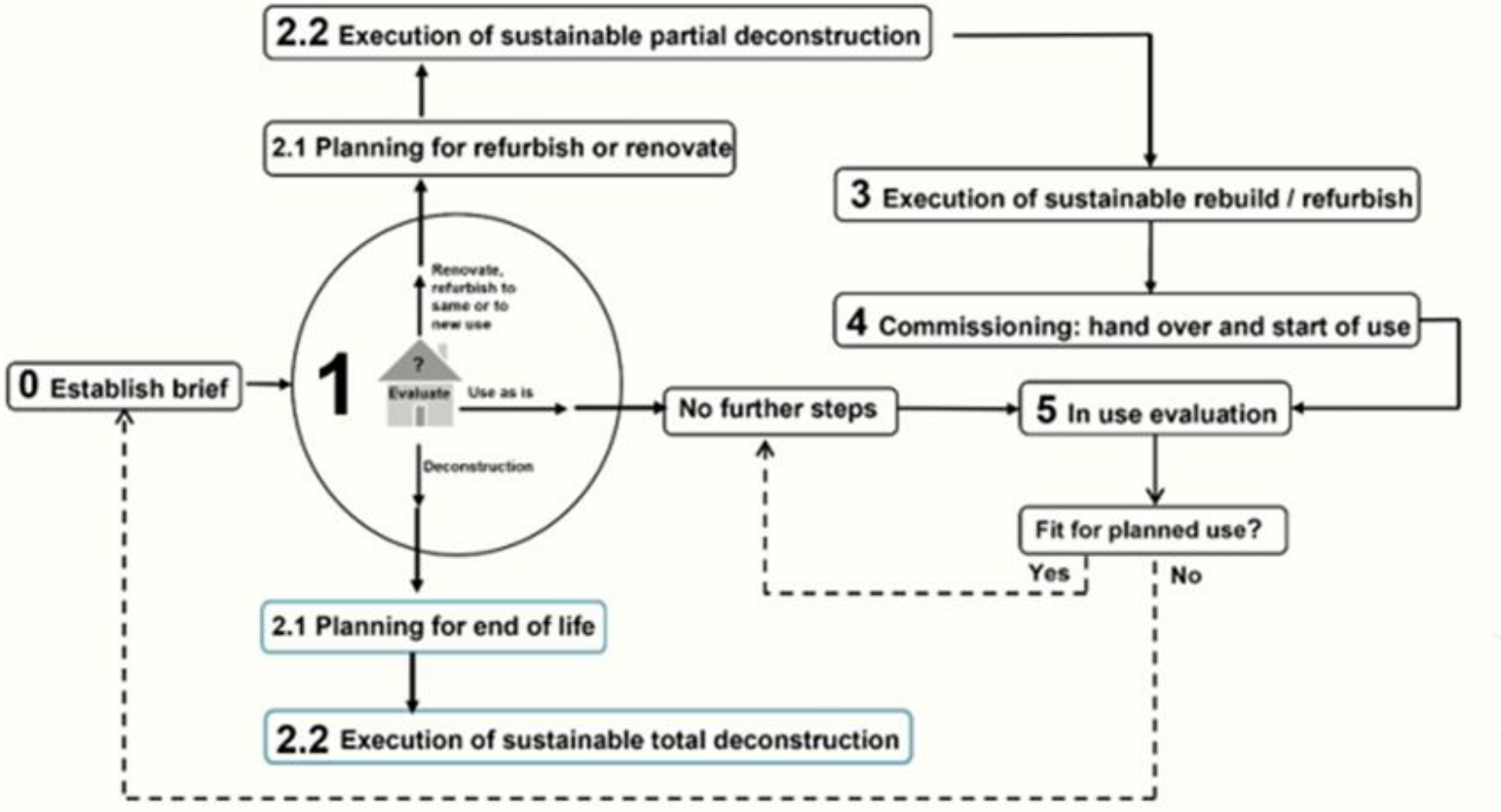
Decision flowchart



(Ref.: NS-EN 17680:2023, figure 6)

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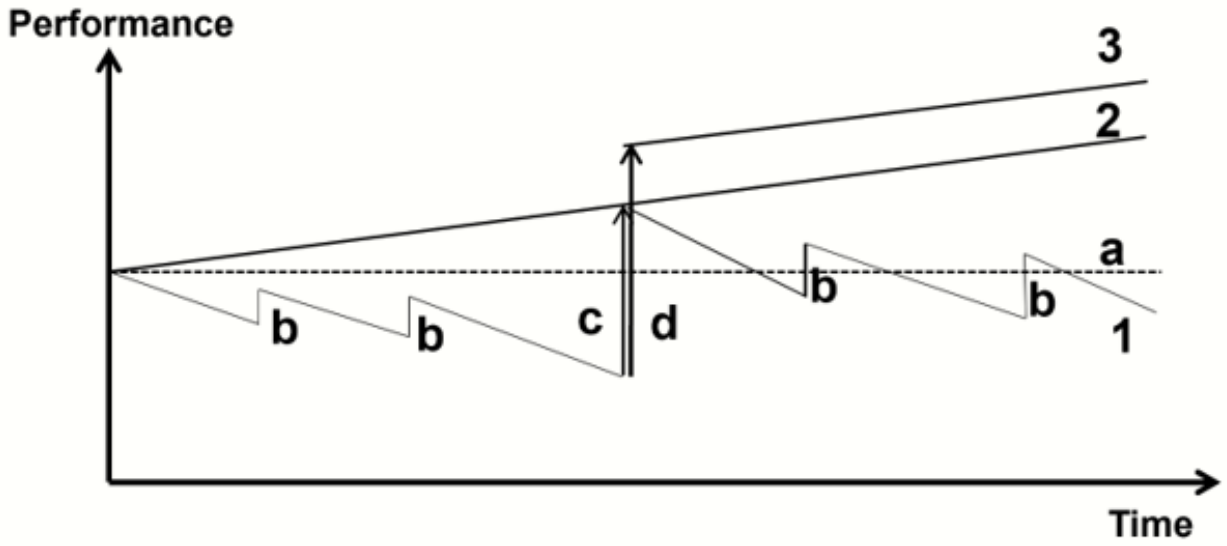
Renovation and refurbishment



Key

a Requirement at construction time as **new building**

b **Maintenance**

Note 1: Only maintenance will lead to some repaired and replacements in the future

c **Renovation:** Upgrading the fabric/material, components and energy retrofit

Note 2: For listed buildings, renovation (c) may only reach line (a) depending on national regulations.

d **Refurbishment**: Major renovation that can also include change of space distribution in connection with construction activities

Note 3: Fulfil new requirements on performance from core business

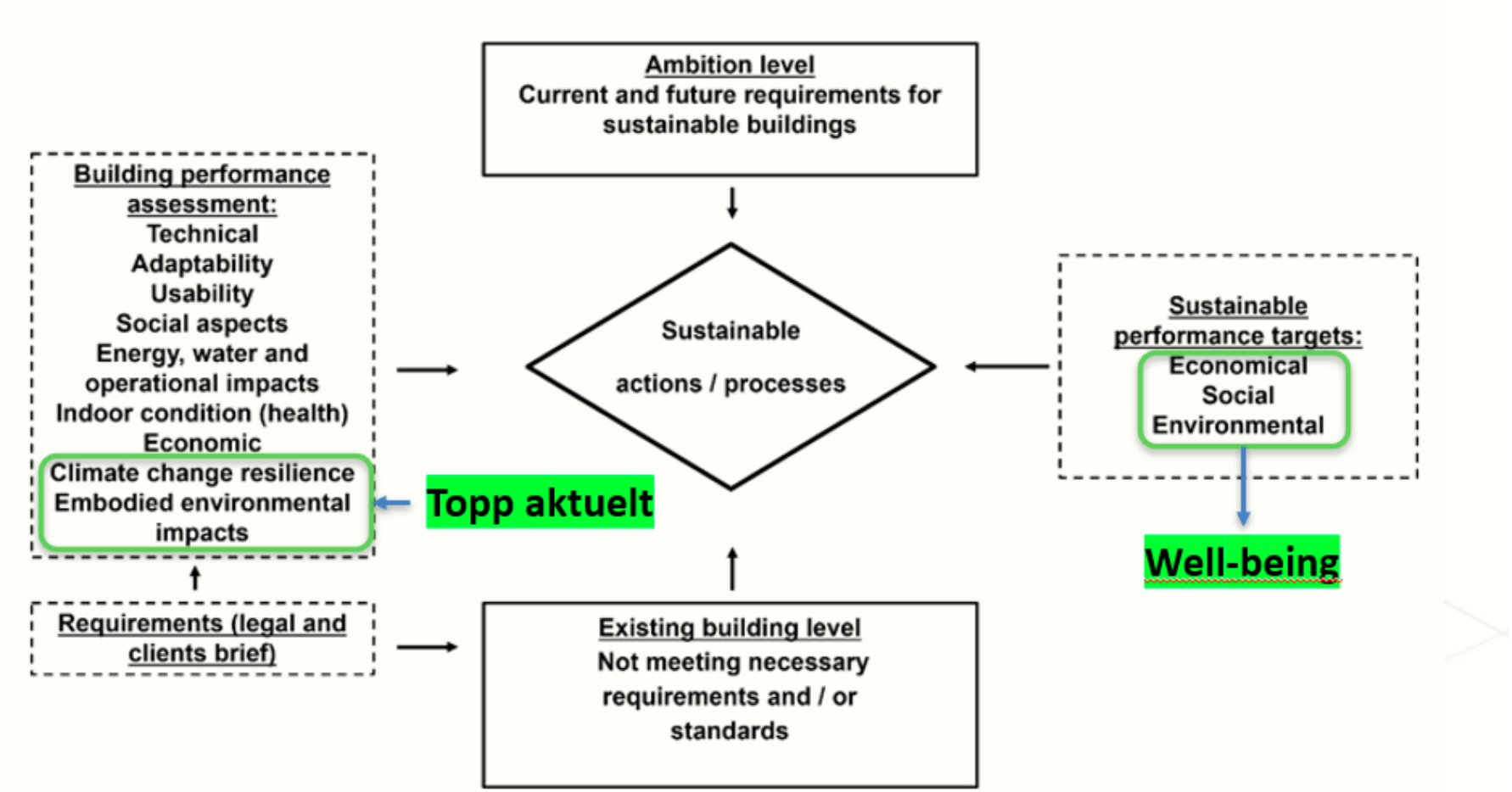
Note 4: In certain circumstances refurbishment measures may not reach sustainability requirements

Note 5: Requirements to space distribution and renovation and change of use

1. Performance level with just maintenance and replacement of components, elements and systems, including new energy efficiency upgrade
2. **Upgrading level**: Technical upgrade to today's performance demands.
3. **Sustainability level**: New demands related to sustainability performance. (Renovation that also includes change space distribution)

(Ref.: prEN 17680 fig 5)

Bridging (closing) the gap



(Ref.: NS-EN 17680:2023, figure 3)

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Main categories for assessment

My point of view:
Important starting point

Main categories	Numbers of indicators	Exemplified description
Technical	18	The costs for upgrading a building which has not been well maintained, and/or has significant failures may be very high in relation to both payback and sustainability.
Adaptability	14	Adaptability should allow for changes in circumstances, either within the building (such as change of use), or its local environment (urban planning, climate change), flexibility (possibility to change space distribution), generality (possibility to change the function of building) and expandability (possibility to change volume). The cost of adaptability can be decreased where it has been factored into the design of walls, floors, and other load bearing elements to allow for potential future changes in use or layout.
Usability	7	Poor usability levels will lower productivity of building user(s).
Social aspects	4	Poor architectural and urban quality can have a long-lasting negative effect on social and cultural value of space.
Energy and water (operational impacts)	4	Overuse of resources can have negative impact on efficiency and environment.
Indoor environment (including health aspects)	12	A poor indoor environment and/or poor indoor air quality can have a negative impact on the efficiency, productivity, creativity, comfort, and general health and wellbeing of the building occupants.
Economic	5	Total costs for refurbishment should be estimated as a consequence of performance classes found for technical, usability, adaptability and indoor climate related to possible income.
Climate change resilience	6	The design of the building, construction works, and materials used should attempt to mitigate the negative impacts of climate change, rising sea levels, flooding, avalanche, seismic activity, and extreme weather events.
Embodied environmental impacts	1	Assessment method shall be in accordance with EN 15978.

(Ref.: NS-EN 17680:2023, table 2)

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Examples on indicators

Topp aktuell etter «Hans»

Technical 18		Foundation-load bearing system. Windows/doors in facades Balconies Roof Indoor surfaces (ceilings, floors, walls) Inventory (fixed)sanitation Heating Ventilation system/ventilation rate Air-conditioning Fire protection (active and passive) Security Electrical system lighting IT-Communication Lifts Waste handling in use Outdoor technical systems Ground-drainage Seismic behaviour
Climate change adaptation and resilience 6	Extreme weather conditions (wind load, rain, ...) Materials and details of buildings envelope Increase of sea level Flooding Landslide Avalanche	The building The site
Adaptability 14	**Flexibility / generality:** Net floor to ceiling height Load bearing capacity (floors) Vertical space for installations Possibility for holes in slabs Amount of space on each floor Possibility to open space Width of communication areas Inner walls Width of building Lift **Elasticity:** Site situation Vertical and foundations load bearing capacity	Within the building The building

(Ref.: NS-EN 17680:2023, table 3)

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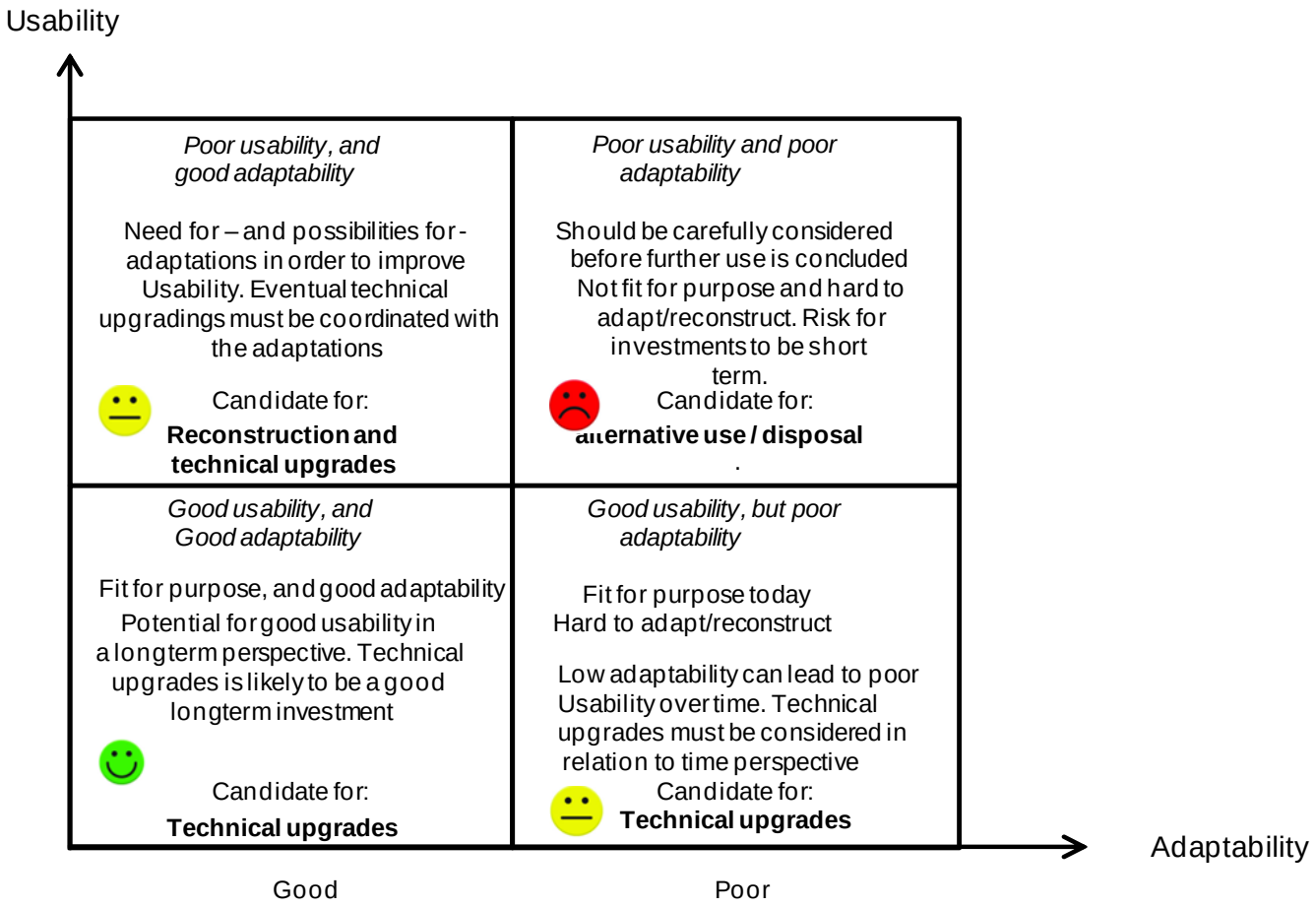
The Viability Model



The viability model ("Levedyktighetsmodellen" – the combination of usability and adaptability
(adapted from Larssen and Bjørberg, 2004)

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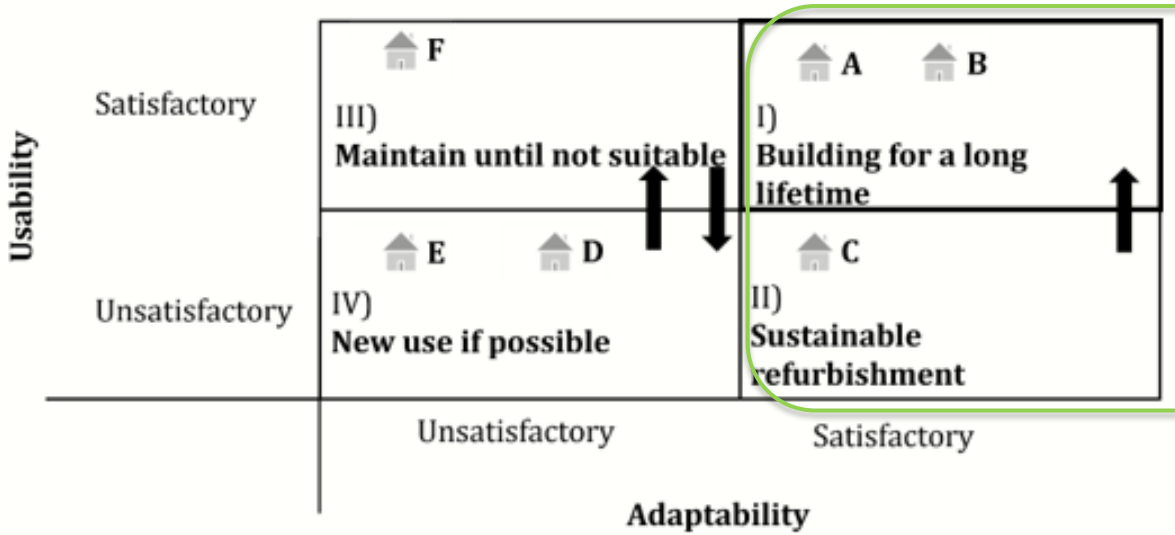
Communication results:
Which buildings are fit for a long lifetime?



Here are buildings which gives:

- long lifetime
  - adaptable
- lovest CO2 emission

Also skin genes

- materials
- details
- execution

Key

Building A and B	Valuable buildings because they have good adaptability and usability. They have the potential to stay in quadrant I) due to the ability to adapt to new demands from core business. Will keep best economy for users and owner
Building C	Can easily be moved from quadrant II) to I) when core business or owner ask for new performance demands
Building D and E	If new use is possible, they can move from quadrant IV) to III). If no new use is possible, and the building is not listed, then recommendation should be sustainable deconstruction.
Building F	Will move to quadrant IV) when core business ask for new performance demands. Recommendation is to maintain with minimum of costs until it achieves unsatisfactory usability.

Ref.: NS-EN 17680:2023 figure 9)

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Examples on indicators

Main categories	Numbers of indicators	Exemplified description
Technical	18	The costs for upgrading a building which has not been well maintained, and/or has significant failures may be very high in relation to both payback and sustainability.
Adaptability	14	Adaptability should allow for changes in circumstances, either within the building (such as change of use), or its local environment (urban planning, climate change), flexibility (possibility to change space distribution), generality (possibility to change the function of building) and expandability (possibility to change volume). The cost of adaptability can be decreased where it has been factored into the

Technical	Foundation-load bearing system. Windows/doors in facades Balconies Roof Indoor surfaces (ceilings, floors, walls) Inventory (fixed)sanitation Heating Ventilation system/ventilation rate Air-conditioning Fire protection (active and passive) Security Electrical system lighting IT-Communication Lifts Waste handling in use Outdoor technical systems Ground-drainage Seismic behaviour
Climate change adaptation and resilience	Extreme weather conditions (wind load, rain, ...) Materials and details of buildings envelope Increase of sea level Flooding Landslide Avalanche
Adaptability	**Flexibility / generality:** ← Within the building Net floor to ceiling height Load bearing capacity (floors) Vertical space for installations Possibility for holes in slabs Amount of space on each floor Possibility to open space Width of communication areas Inner walls Width of building Lift **Elasticity:** ← The building Site situation Vertical and foundations load bearing capacity

Topp aktuell etter «Hans»

(Ref.: NS-EN 17680:2023, table 3)

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Utdrag fra noen hjelpematriser for gradering av tilstand (tilstandsgrad: Condition Class from 0 (best) to 3 (dårligst)), se appendix

Table A.2 — Example of criteria for technical performance and performance classes based on technical inspection

Indicator	Class 0	Class 1	Class 2
Foundation-load bearing system (Indicator 1)	Stable foundation founded on / to rock (piles). No risk or sign of settling damages. No sign of weakening of the structural system.	Small signs of settlement cracks, but stable	Stable foundat few signs of increasing stru damages. Smal of weakening (spalling, crac
Windows, exterior doors (Indicator 2)	No damages, only minor wear on windows/doors of new built standard. Good air tightness	Visual impairments, stiff casements/sash. No signs of decay.	Loose / torn g small air leaks Def Sta glas coa for ren ent
		Chipping or spalling of minor extent. No signs of decay or corrosion	Join pla of d Sig and

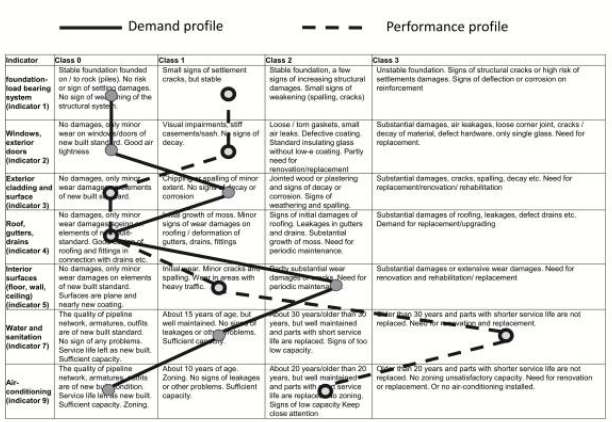

Figure A.1 — Example on plot of demand and performance profile

The plot shows negative gap for indicator 1 and 2. Another way of communicating results is shown in a spider diagram.

NOTE 2 The matrices in Figure A.1 are a copy of Table A.2.

Table A.3 — Example of criteria for adaptability performance and performance classes

Indicator	Class 0	Class 1	Class 2	Class 3
Net floor to ceiling height (Indicator 1)	x > 4,0 m (or that the over or underlying floor is a technical mezzanine)	3,5 m < x ≤ 4,0 m	3,0 m < x ≤3,5 m	x ≤ 3 m
Load bearing capacity floors (Indicator 2)	x >5 kN/m²	4 kN/m² - 5 kN/m²	3 kN/m² - 3,9 kN/m²	< 3 kN/m²
Vertical space for installations (Indicator 3)	Large and/or several shafts providing large space for expansion and/or new vertical transmissions (alternatively technical towers	Shafts size and/or several shafts providing possibility for expansion and /or vertical shafts	Shafts size and/or several shafts providing a limited / remote for expansion and /or vertical shafts	Small shafts and / or number of shafts providing a very little space for expansion and /or new vertical shafts. No residual capacity
Create openings in	Well adapted for	Adapted for creating	Restricted	Not / very

Table A.5 — Example of criteria for indoor climate performance and condition classes based on survey (users) and measurements

Indicator	Class 0	Class 1	Class 2	Class 3
Thermal comfort a	Ventilation system and windows in good working order	System and provision in need of repair and/or renewal	Limited extract fans and/or inadequate natural ventilation	No existing mechanical ventilation and natural ventilation inoperable
	Good levels of thermal comfort to local standards without exceeding a normal heating demand	Adequate levels of thermal comfort	Some provision of heating but not adequate to maintain good comfort	Inadequate heating provision with significant air leakage
	Few complaints from occupants (<x % of occupants)	Some complaints (<y % of occupants)	Many complaints (<z % of occupants)	Considerable number of complaints (>v % of occupants)
CO_2 levels Also check Carbon Monoxide monitors are installed	CO_2 levels never exceed x ppm	CO_2 levels occasionally exceed x ppm	CO_2 levels frequently exceed x ppm	CO_2 levels generally exceed x ppm

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Further steps in the life cycle of the building(s)

Table 4 — Indicators for sustainable deconstruction

Categories	Indicators for step 2 (2.1 planning related and 2.2 execution related)
Reuse	Components for re-use on site or offsite Materials for recycling Materials for recovery
Waste disposal	Energy recovery from building materials Hazardous waste disposed (safe destruction or deposit/landfill) Non-hazardous waste disposed (safe destruction)
Social (Neighbours, users and workers)	Dust and particles Noise Traffic Vibrations Light pollution Health and safety of workers Health and safety of users in the case of refurbishment in-use conditions Accessibility
Process	Energy for deconstruction Energy for transport

Step 2
Deconstruction

Step 4
Commissioning

Step 5
Indoor climate

Table 5 — Indicators for commissioning-stage

Categories	Indicators for step 4 Commissioning
Documentation	As Built documents Digital model of the project Guidelines for operation and maintenance[2] Documentation on adaptability Manuals for IT-systems Simple user's manual
Technical Systems	Functionality of integrated systems Airflow proved requirements Security and safety systems Outdoor systems[1]
Operational Competence	Training program fulfilled Organization of MOM (Management, Operation, Maintenance) defined
Approval of the building	Inspection of completion totally finished Surfaces are as described Indoor climate as described (example on criteria for indoor climate is given in table A5)

Table 6 — Indicators for in use-stage

Categories	Indicators for step 5
Social	Indoor climate
	Aesthetic environment Acoustic environment (for users of the building and neighbours) Actinic (light conditions) environment (for users of the building and neighbours) Accessibility and Universal Design, see EN 17210:2021 Usability Safety Thermal comfort (for users of the building and neighbours)
Environmental	Material and chemical usage Waste treatment Energy source Energy demand Electricity usage Energy management Water consumption Ecology Nature conservation
Economy	Adaptability Level of Maintenance (technical condition) Location Building certifications Value Life cycle costs

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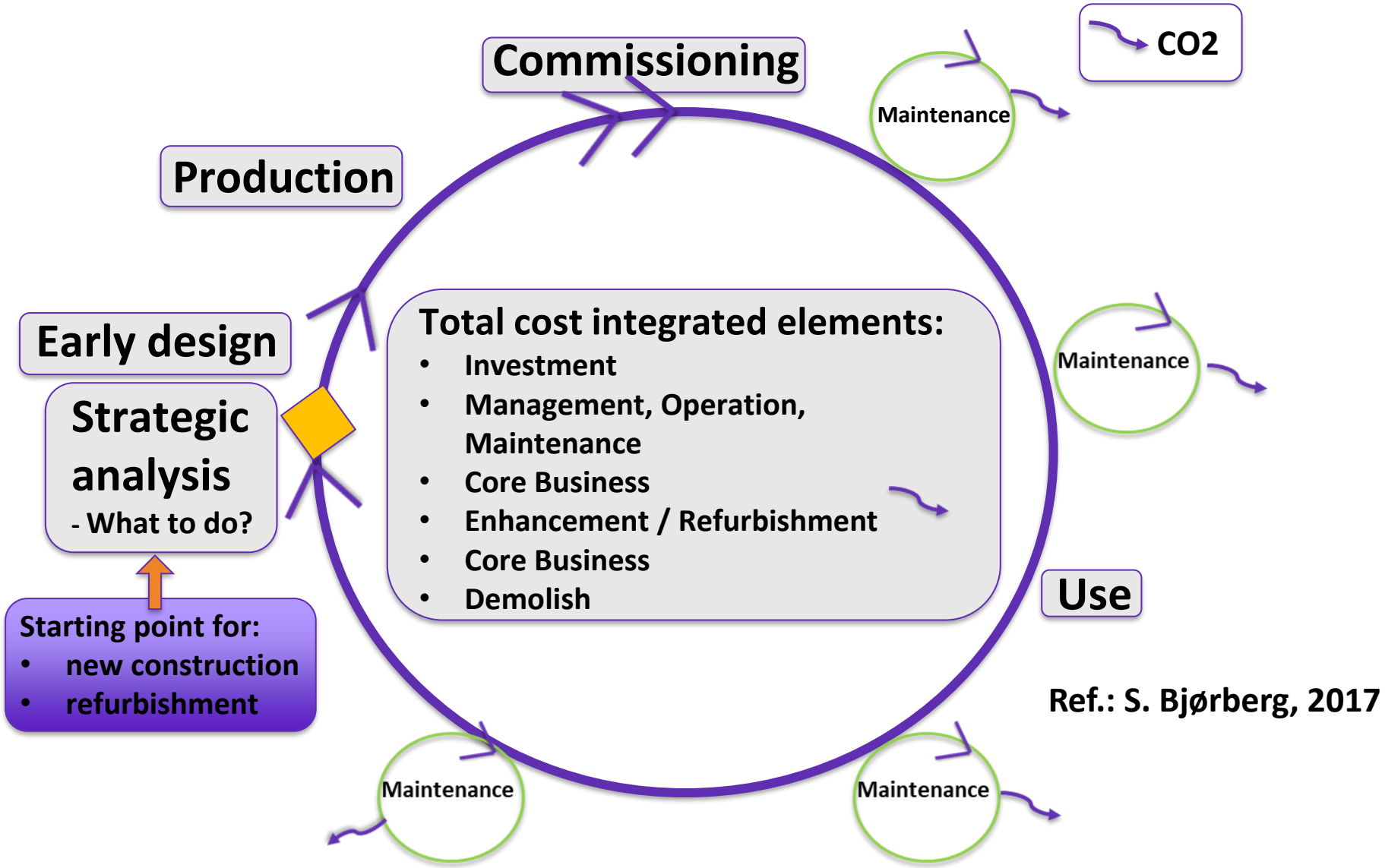
Oscar generic phaseplan = circular phaseplan (analysis-design-production-commission-use- maintain - refurbishment-demolish)



Ref.: S. Bjørberg, 2017

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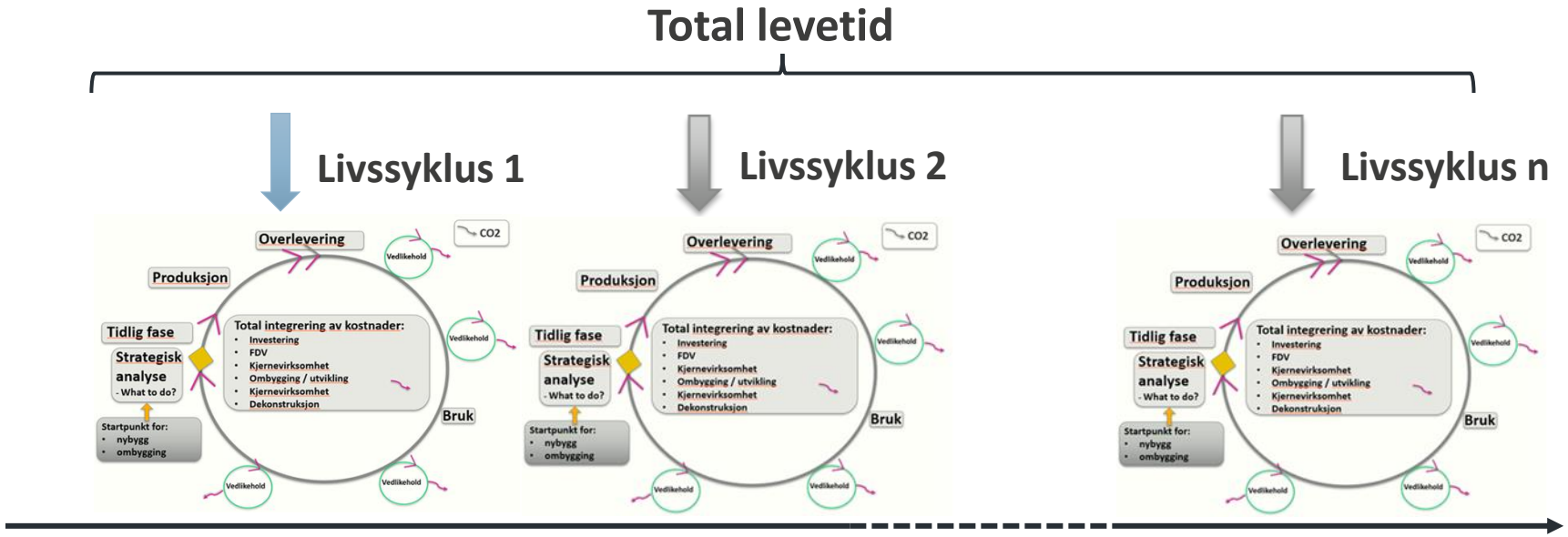
Ny model:
Total levetid er en sum av n antall livssykluser



Design for nytt bygg
Gener for et langt liv besluttes i tidligfase

Design for ombygging
Genene må kartlegges

Design for dekonstruksjon

Hvordan kartlegge gener for ombygging?

Ref.: S. Bjørberg, 2023

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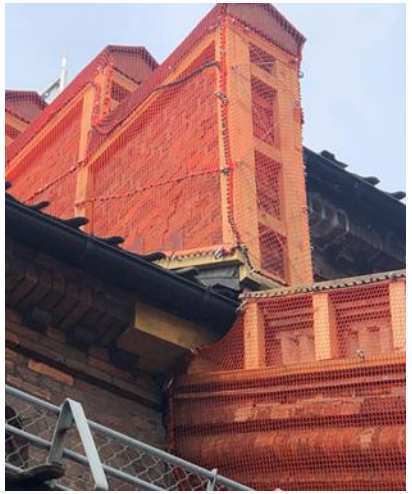
De gode gener

- Usability: possibility to satisfy new demands:
  - Adaptability
    - Flexibility: possibility to change space distribution
      - » Ex.: from cell offices to open landscape
    - Generality: possibility to change functionality
      - » Ex.: from office to school
    - Elasticity: possibility to change volume
      - » Ex.: extra floor or/and horizontal extension

- Skin: possibility for a long technical lifetime
  - Maintenance friendly
    - Materials, details and execution that together provide maximum resistance to degradation
      - » Long intervals for maintenance and replacements

Noen erfaringer

- Første rehabiliteringslov
  - Jo mer du river desto mer må du rive
- Topp utgangspunkt ved eksisterende bygg
  - Modell i 1:1, jobb på modellen
- Fredede / vernede bygg
  - Start på modellen sammen ved antikvariske myndigheter
- Kostnadsestimering 1:
  - Ikke lett å sette kostnad på tanker som ikke er tenkt
  - Funksjon av tilstand før og etter
  - Det er forskjell på udefinerte - og uforutsette arbeider
- Kostnadsestimering 2 (fredede / vernede byggverk):
  - Trinn 1: kostnader for å bringe opp til overlevelsesnivå
  - Trinn 2: hva koster det å holde det der
  - Trinn 3: tillegg for spesiell bruk (OBS konsekvenser av ny bruk)



BAE-næringen trenger å styrke kompetanse innen livsløpsplanlegging

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