SBE19 Graz

SUSTAINABLE
BUILT ENVIRONMENT
D-A-CH CONFERENCE 2019
TRANSITION TOWARDS
A NET ZERO CARBON BUILT
ENVIRONMENT

11–14 September 2019
TU Graz, Austria
> sbe19.tugraz.at

Influence of cross-passages temperatures on the life-cycle cost of technical equipment in a railway tunnel

IN CO-OPERATION WITH

Baltic-Adriatic Corridor of the trans-European-road and railway axes in Central Europe (**1.800 km**)

From the **Baltic seaports** to the **Adriatic ports**

Industrial regions of Central and Southern Poland

Czech Republic, Slovakia, **Austria**, Slovenia and Italy

Key railway projects Semmering Base Tunnel and **Koralm Railway Line**

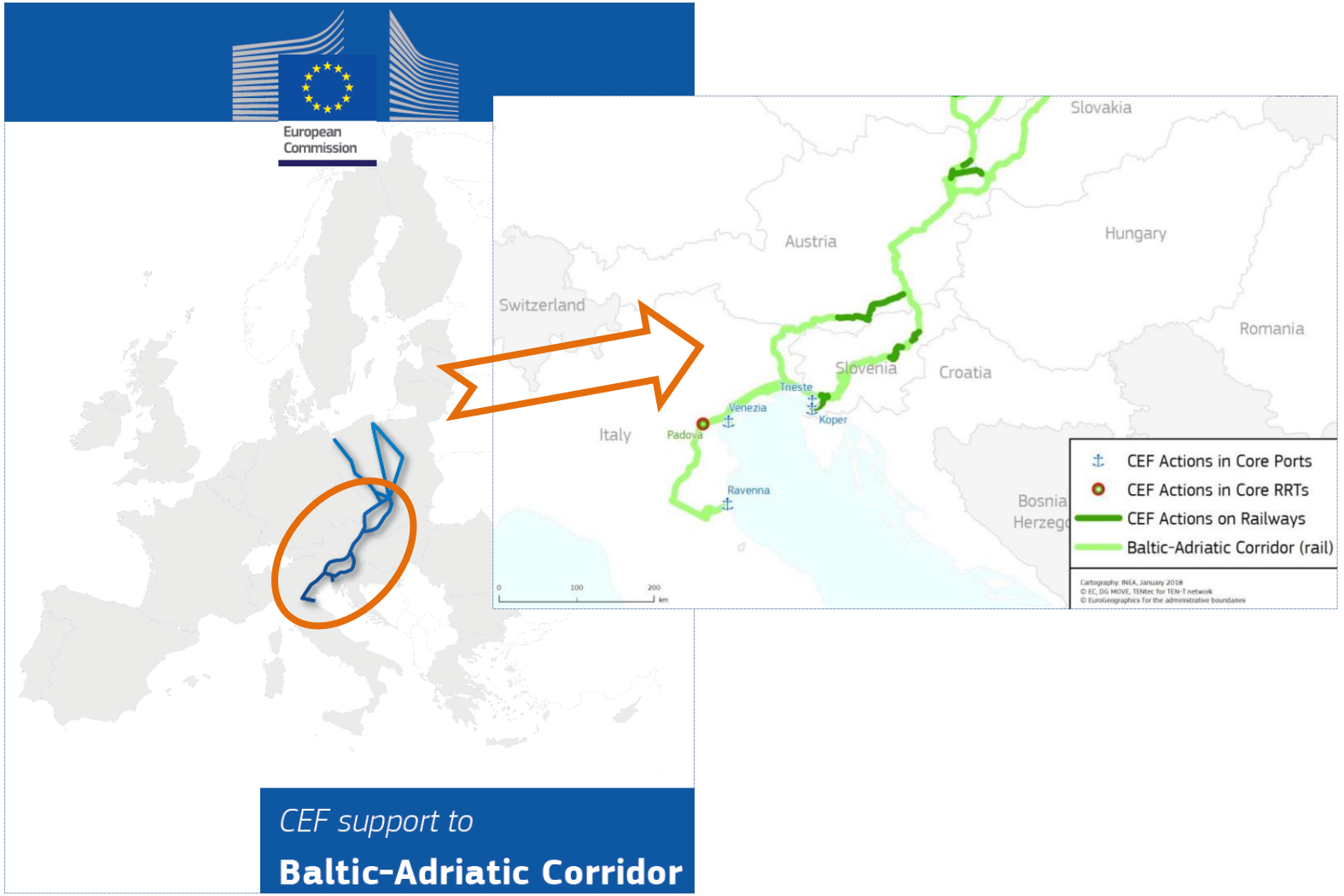


Figure: European Commission, Brussels, Belgium, Baltic-Adriatic Corridor, February 2018

Koralm Tunnel is the **sixth-longest** railway tunnel in the **world**

Wettmannstätten to **St. Andrä** (33 km)

Travel time will be **reduced** for more than **2 hours** (Graz-Klagenfurt)

Two tunnel tubes (external diameter of around ten meters)

Connected with **68 cross-passages** (interval around 500 m)

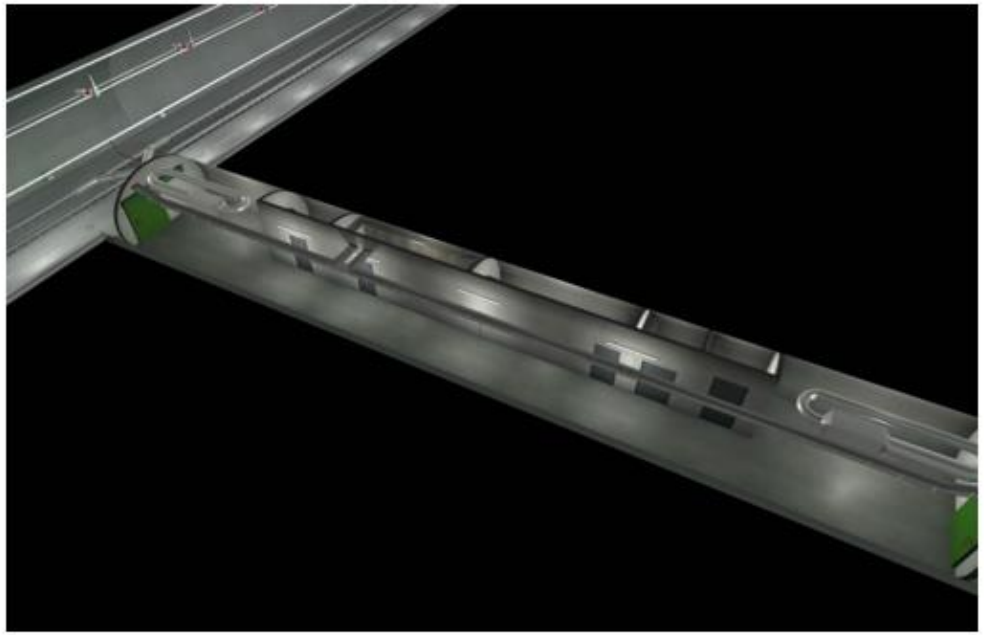
Figure: Austrian Federal Railways - ÖBB

Cross-passages serve as

- escape-ways and
- utility rooms

Technical equipment

- low voltage systems
- medium voltage systems
- transformer systems
- **telecommunication systems**



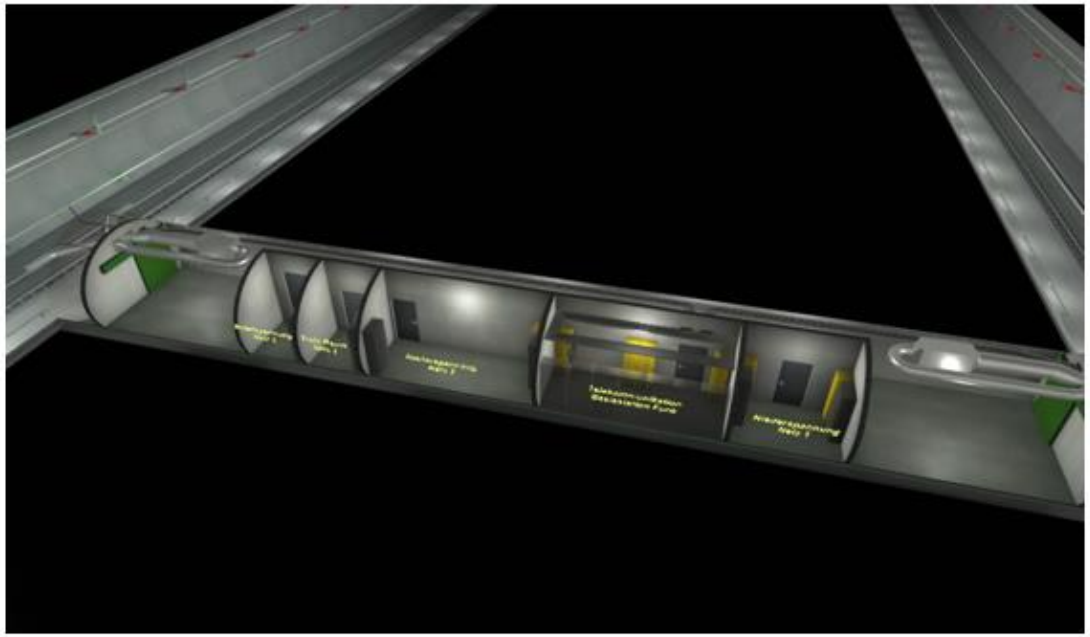


Figure: Austrian Federal Railways - ÖBB

Thermal simulations revealed **indoor air temperatures** up to **85°C**

Heat release of the **technical equipment**

Limited heat transfer with the surrounding rock and with the adjacent running tubes

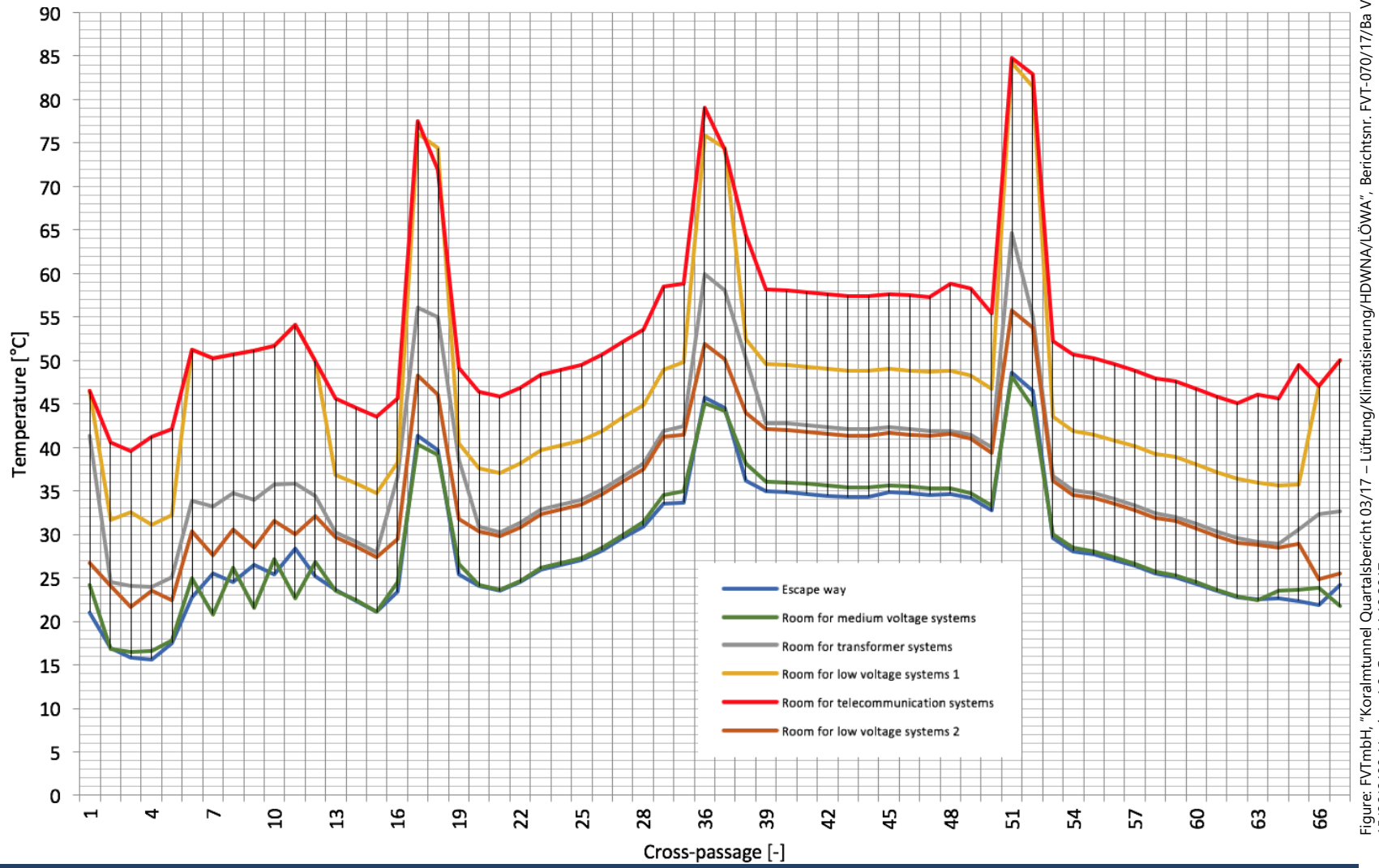


Figure: FVTmbH, "Koralmtunnel Quartalsbericht 03/17 – Lüftung/Klimatisierung/HDWNA/LÖWA", Berichtsnr. FVT-070/17/Ba V&U 15/06/6400, Version 1.0, Graz, 14.10.2017

Reduced service life of telecommunication systems

Arrhenius equation determine the expected lifetime of telecommunication systems

Utility room temperature	Service life	Replacement cycle
22 °C	16 years	3
25 °C	13 years	3
30 °C	9 years	5
35 °C	6 years	8
40 °C	4 years	12
45 °C	3 years	16

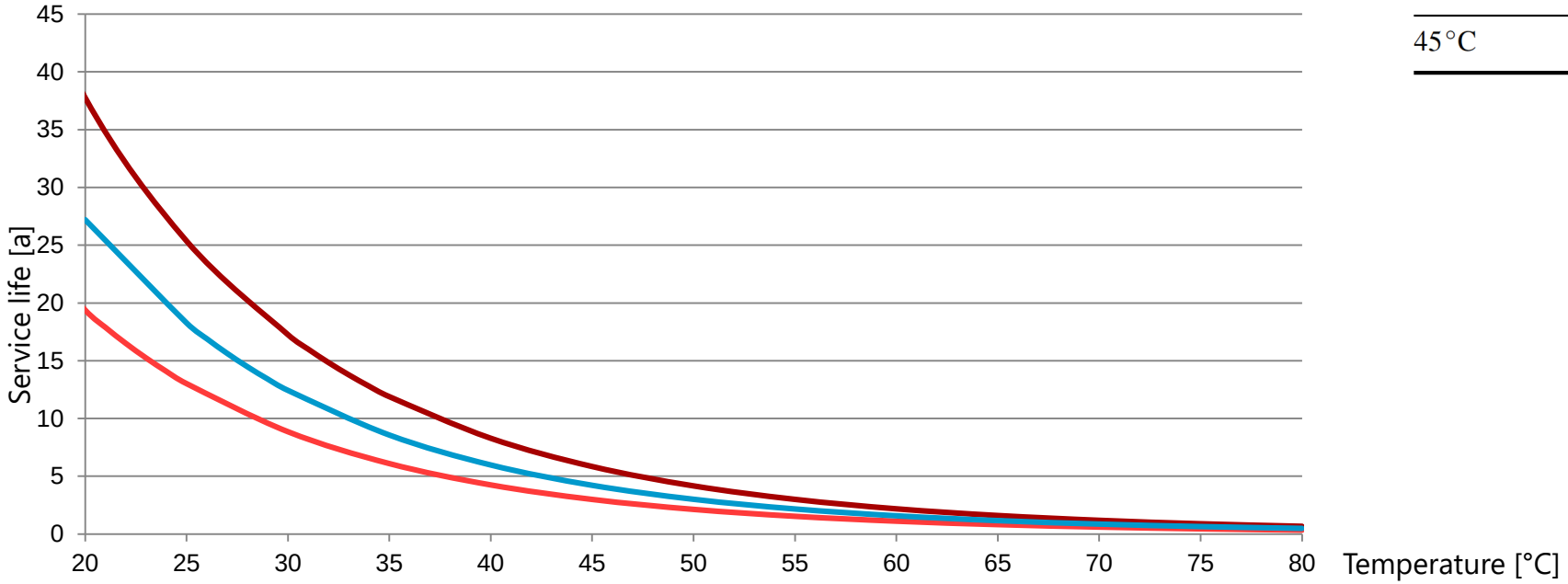
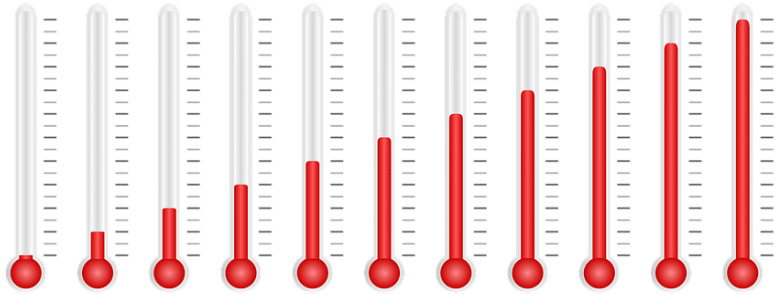


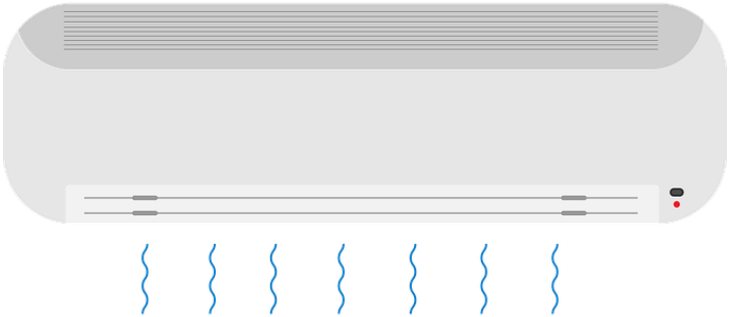
Figure: ACTES Ingenieure



Should the telecommunications systems be **exposed to higher room temperatures** and thereby **exchanged** at **short replacement cycles**

or

is there an economic advantage if the **utility rooms** are **cooled** (ventilated or active cooled) to reach **longer replacement cycles** of the telecommunications systems



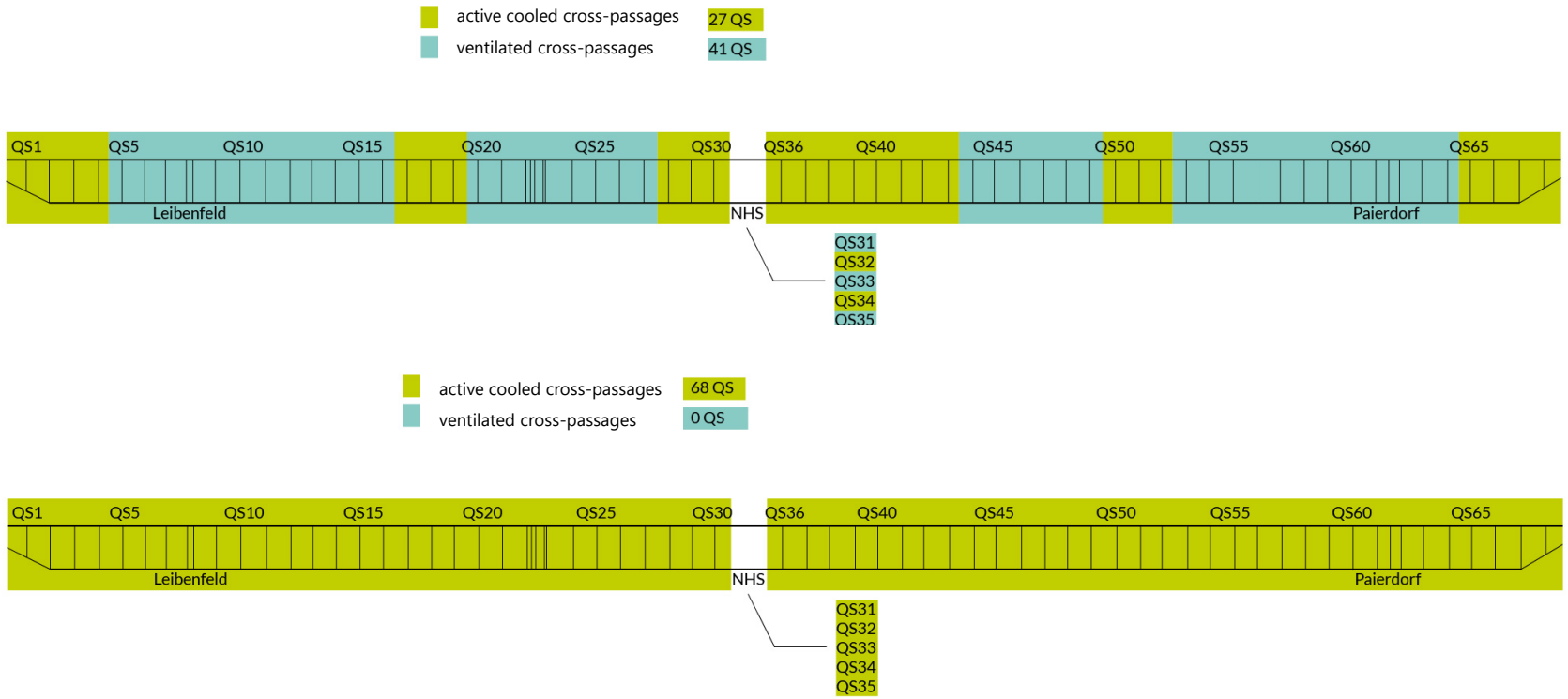
First classification for 22°C

27 active cooled cross-passages and

41 ventilated cross-passages

First approach for LCCA

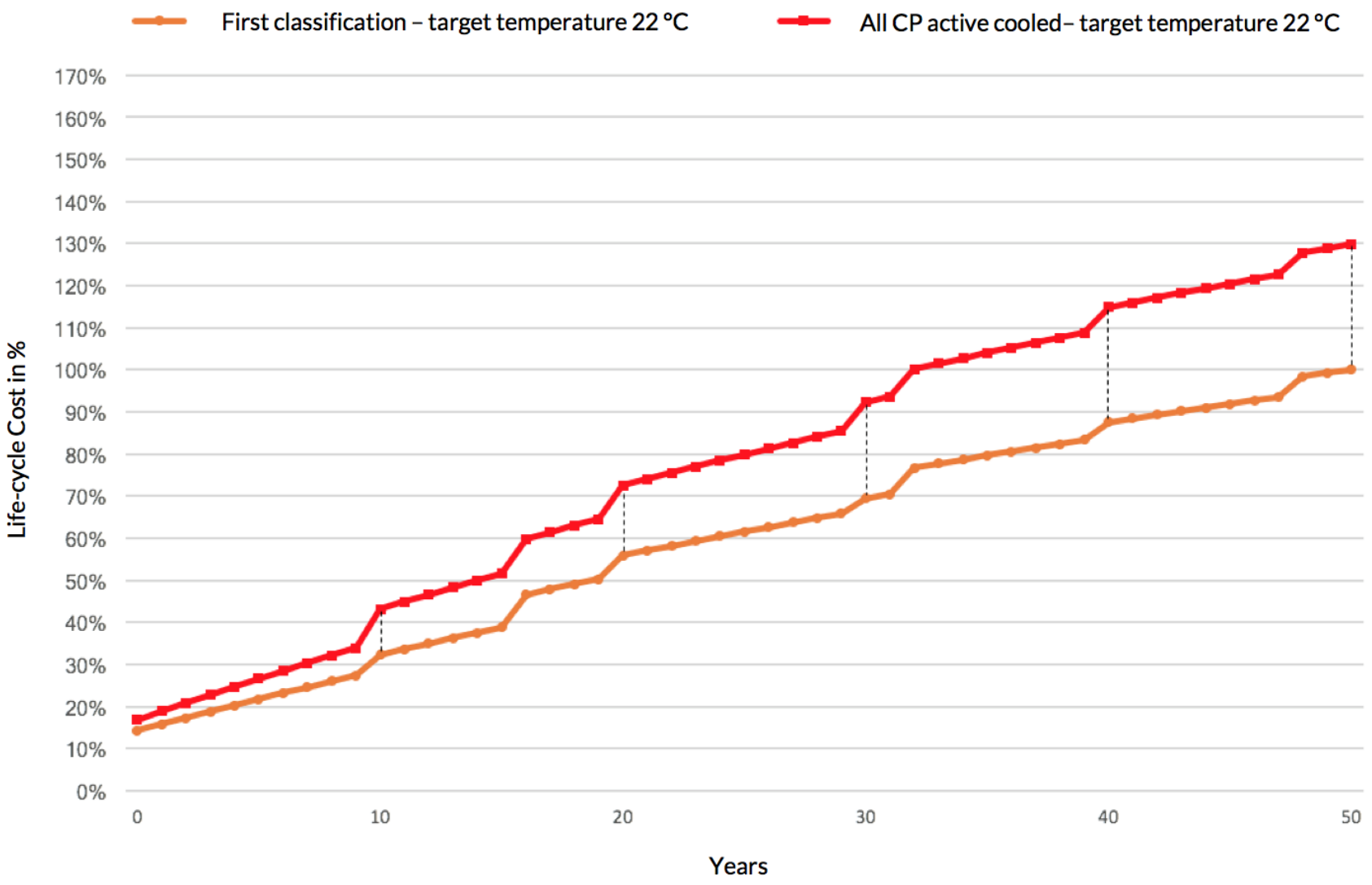
active cooling of all cross-passages with air-conditioning systems

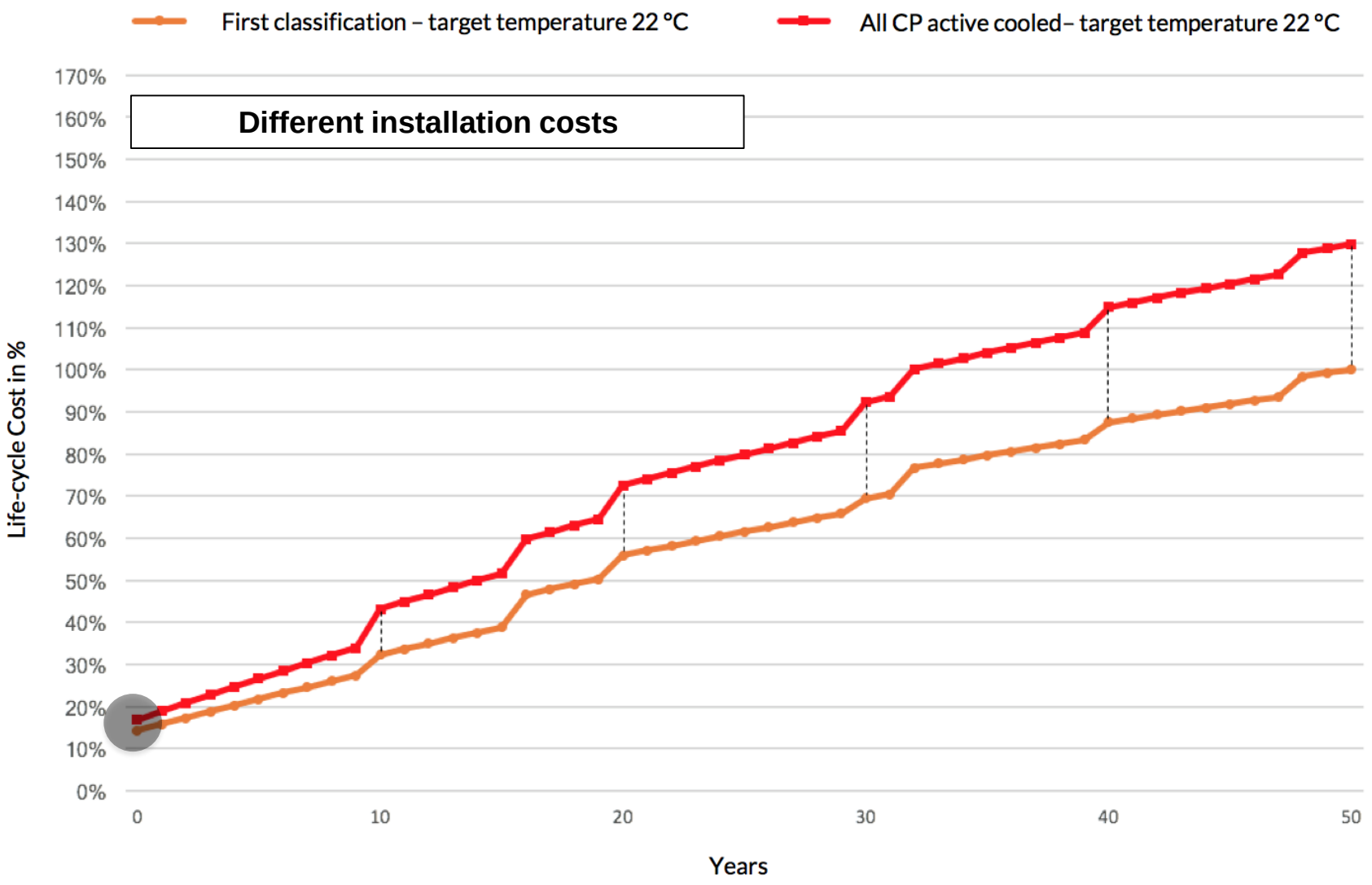


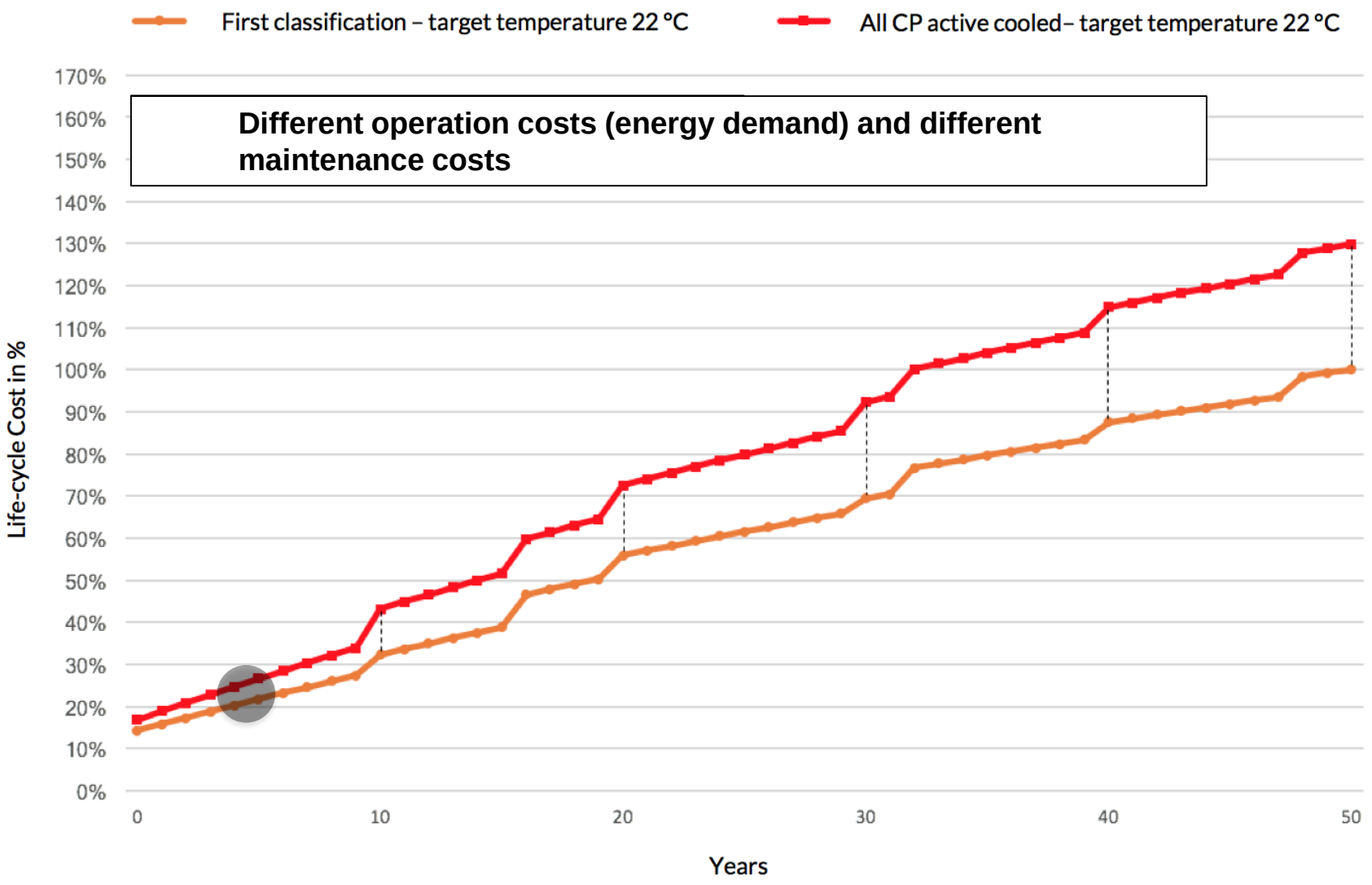
Terms:

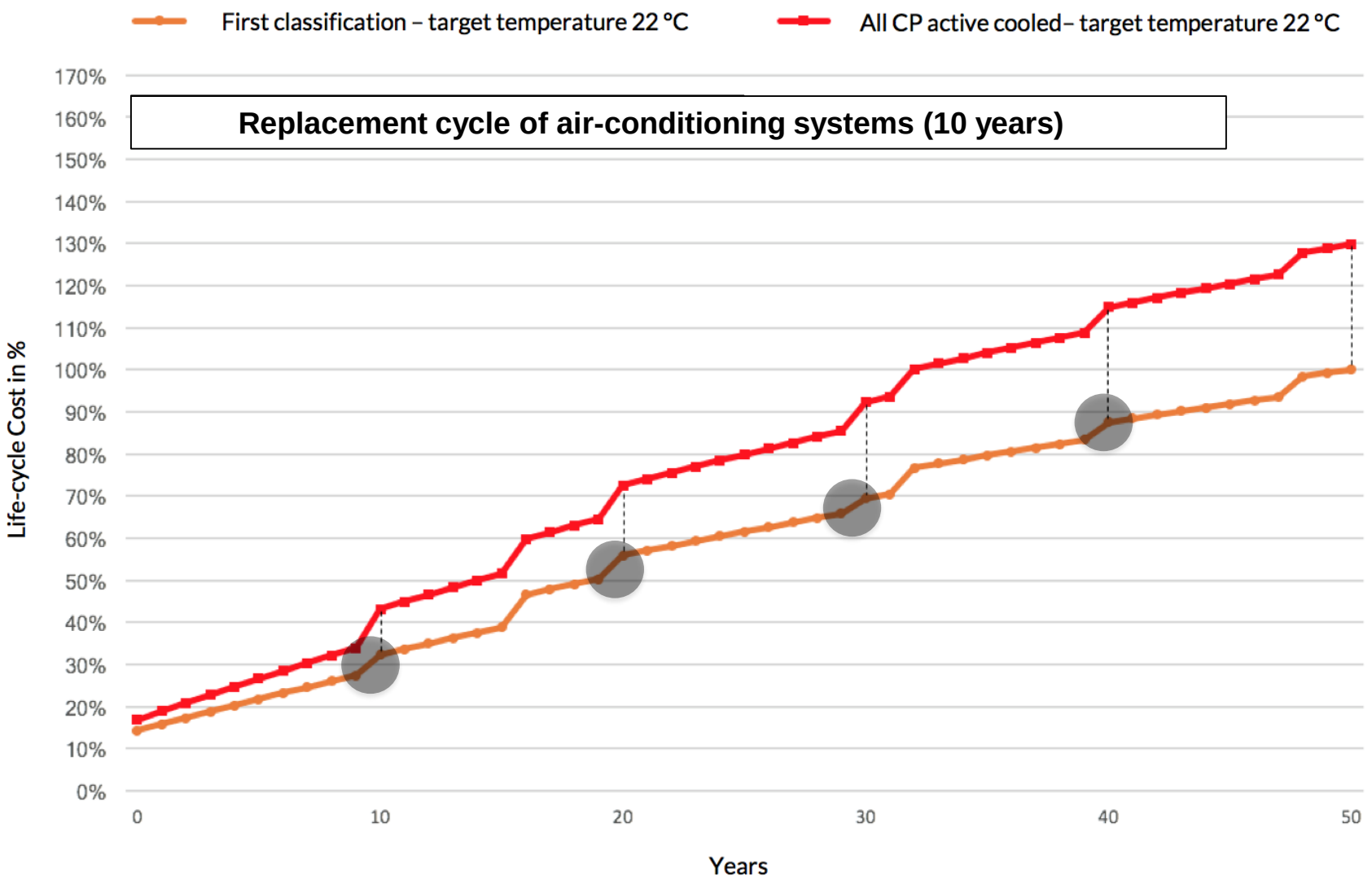
Active cooled = air-conditioning system

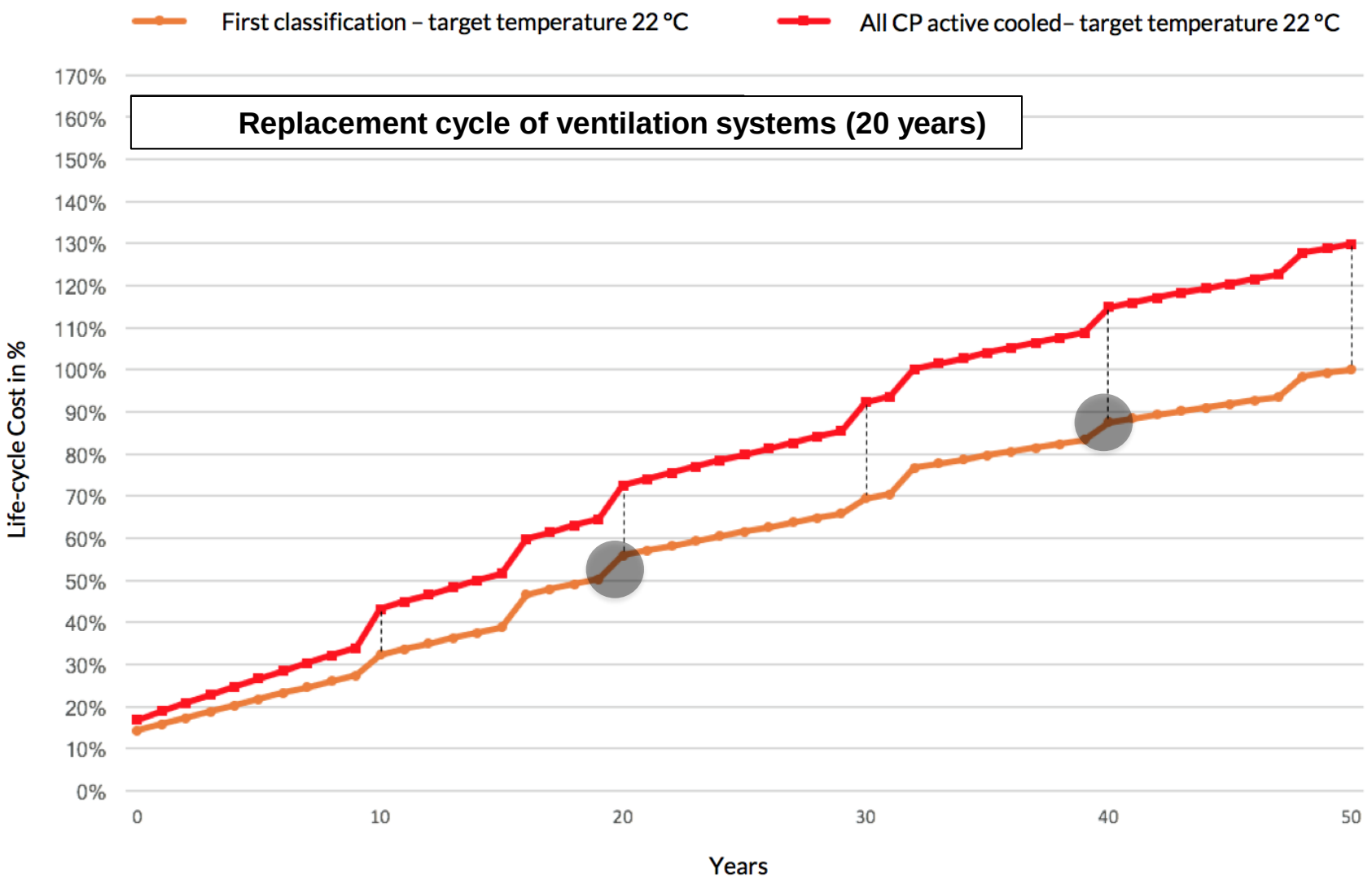
Ventilated = ventilation systems

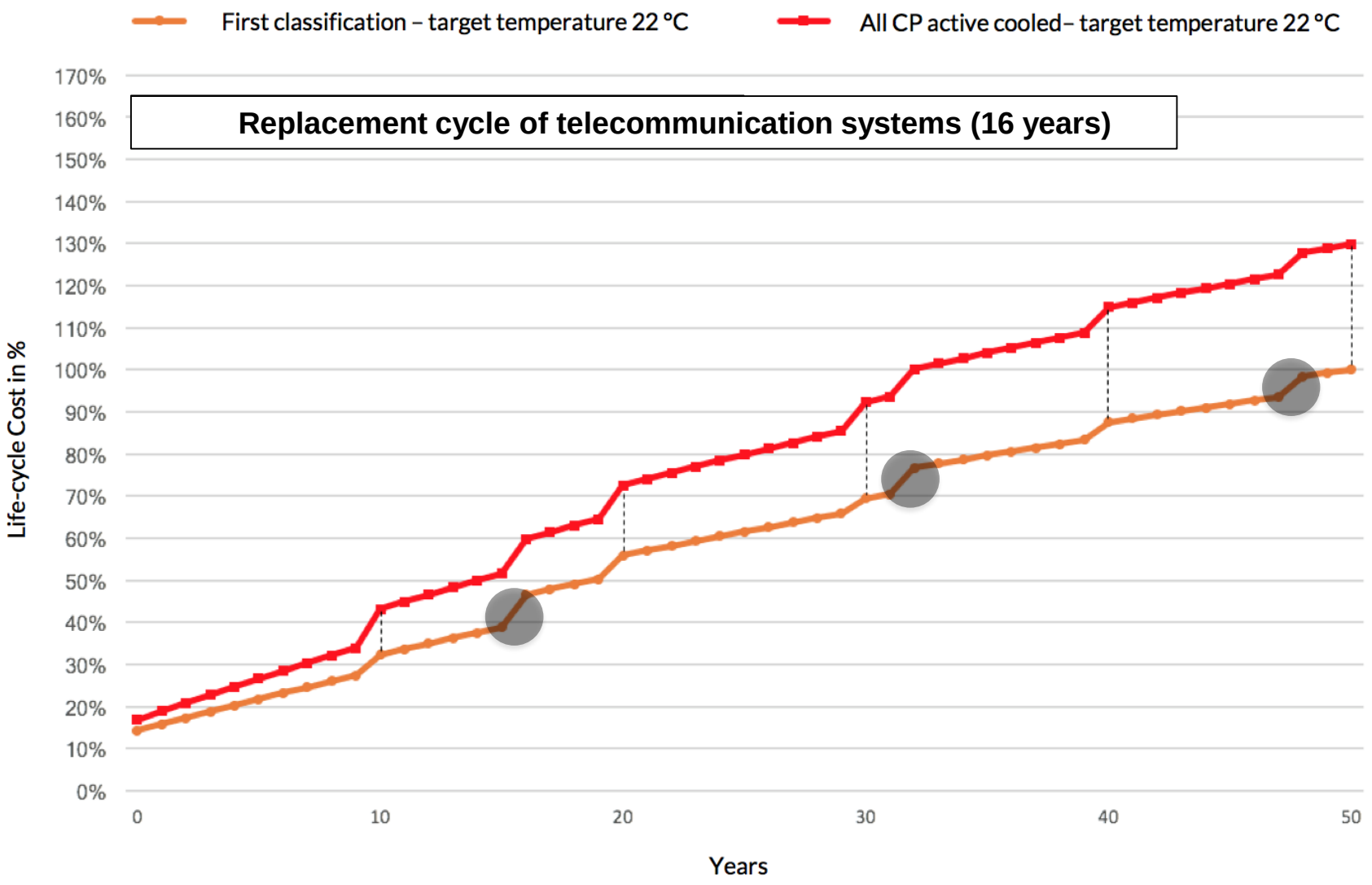

First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years


First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Different installation costs
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years

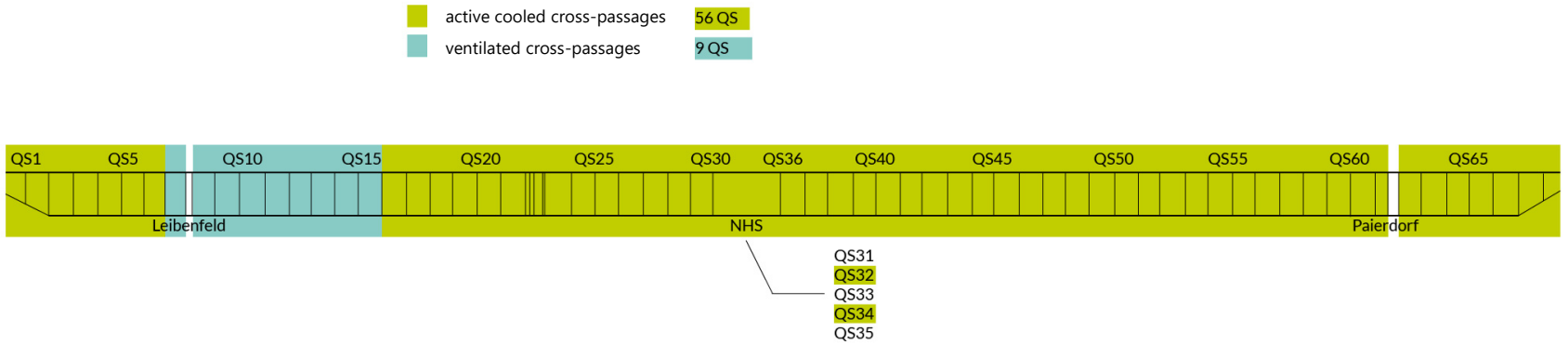

First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Different operation costs (energy demand) and different maintenance costs
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years


First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Replacement cycle of air-conditioning systems (10 years)
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years

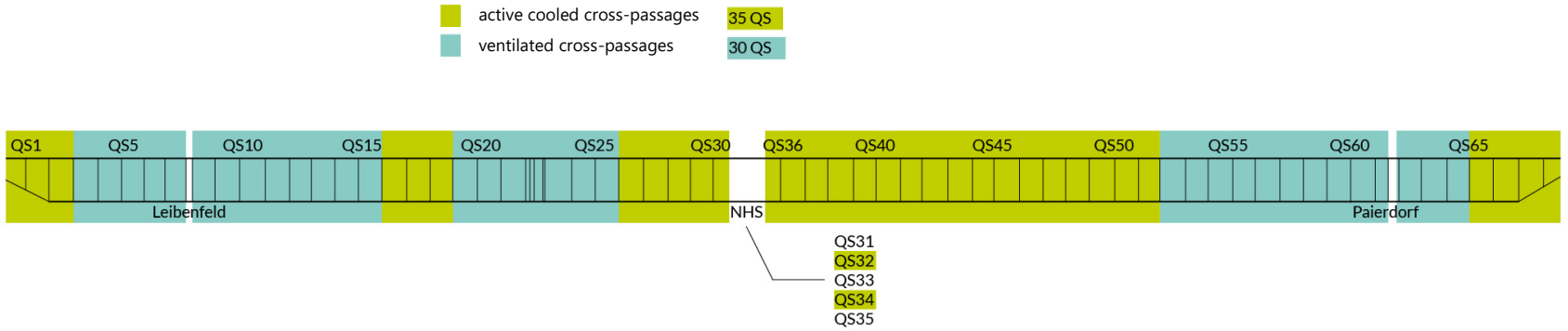

First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Replacement cycle of ventilation systems (20 years)
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years


First classification – target temperature 22 °C
All CP active cooled– target temperature 22 °C
Replacement cycle of telecommunication systems (16 years)
Life-cycle Cost in %
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
Years

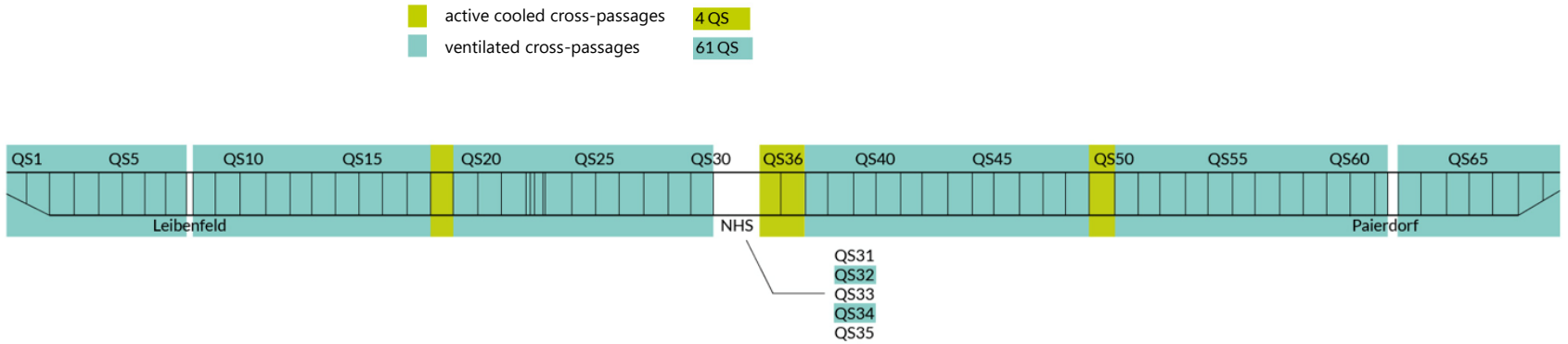
Target temperature 22 °C



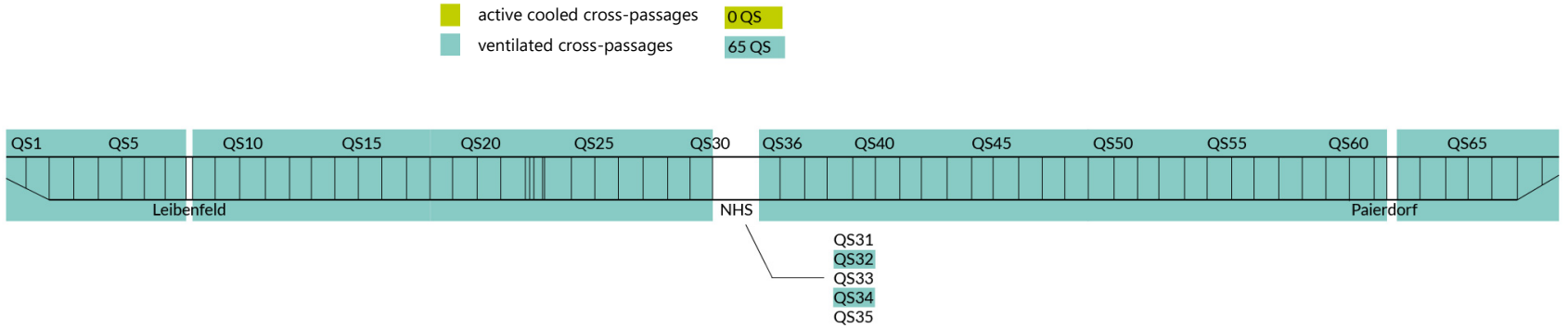
Target temperature 25 °C

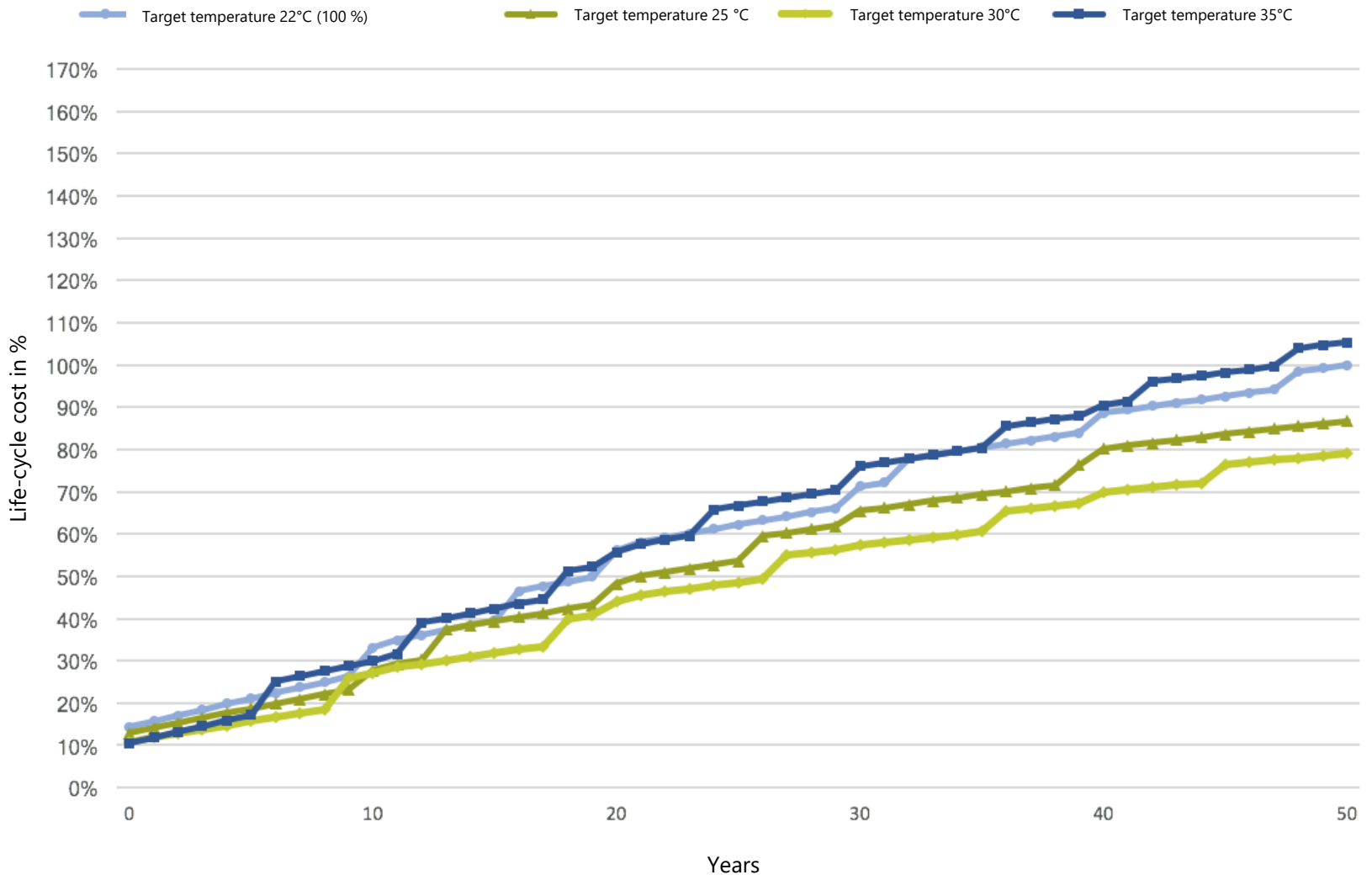


Target temperature 30 °C

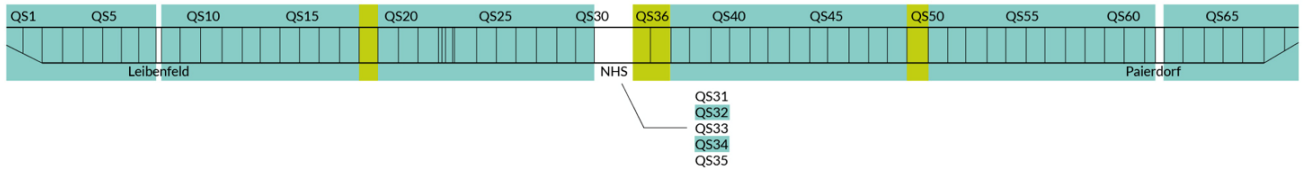


Target temperature 35 °C




Target temperature 22°C (100 %)
Target temperature 25 °C
Target temperature 30°C
Target temperature 35°C
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Life-cycle cost in %
0
10
20
30
40
50
Years

Target temperature 30 °C



Target temperature 35 °C

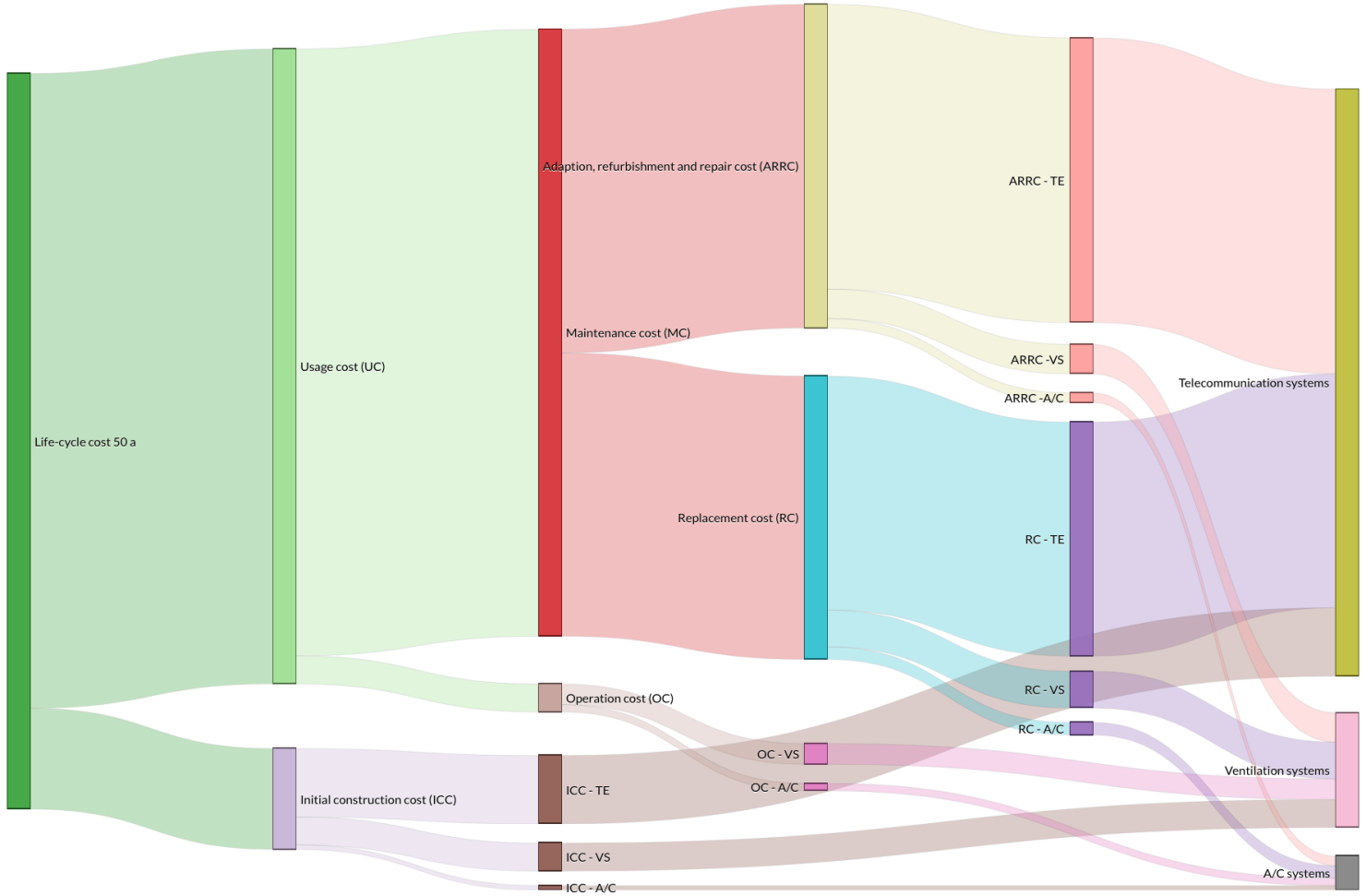
Target temperature 35 °C:

Replacement cycle every 6 years instead of 9 years

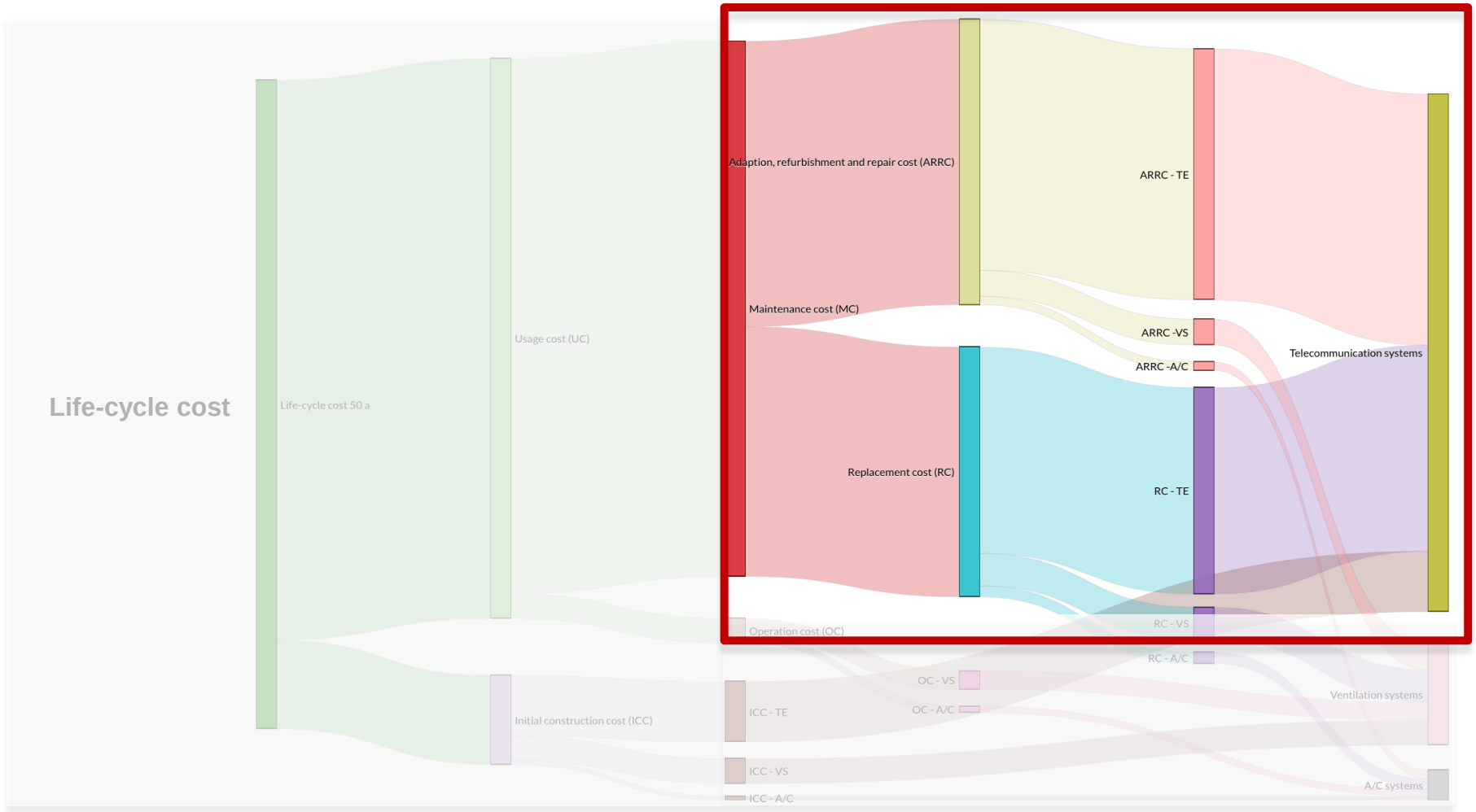
Higher maintenance costs at higher temperatures

Lower energy demand for cooling

Dominance analysis - Target temperature 30 °C



Dominance analysis - Target temperature 30 °C

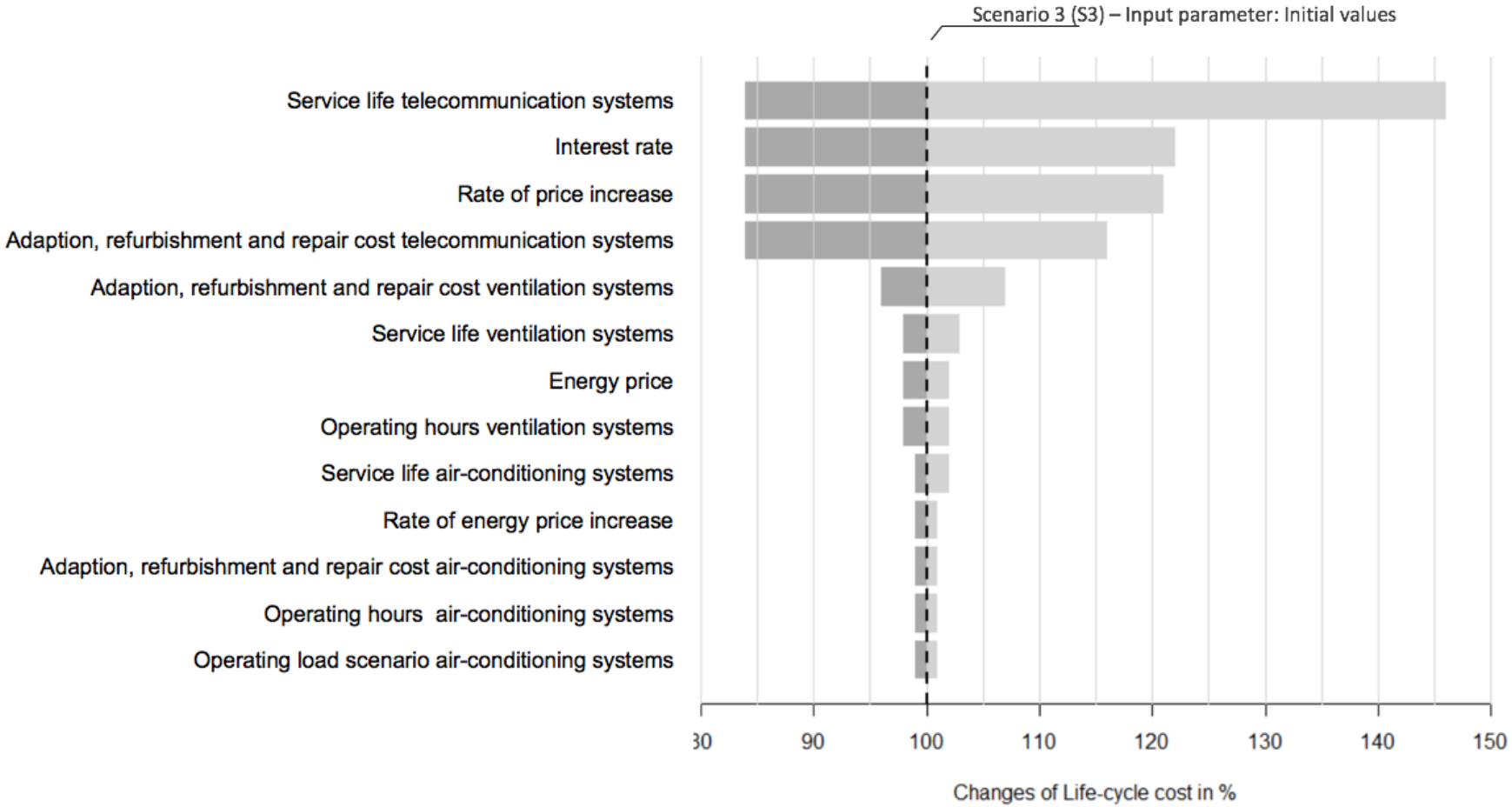


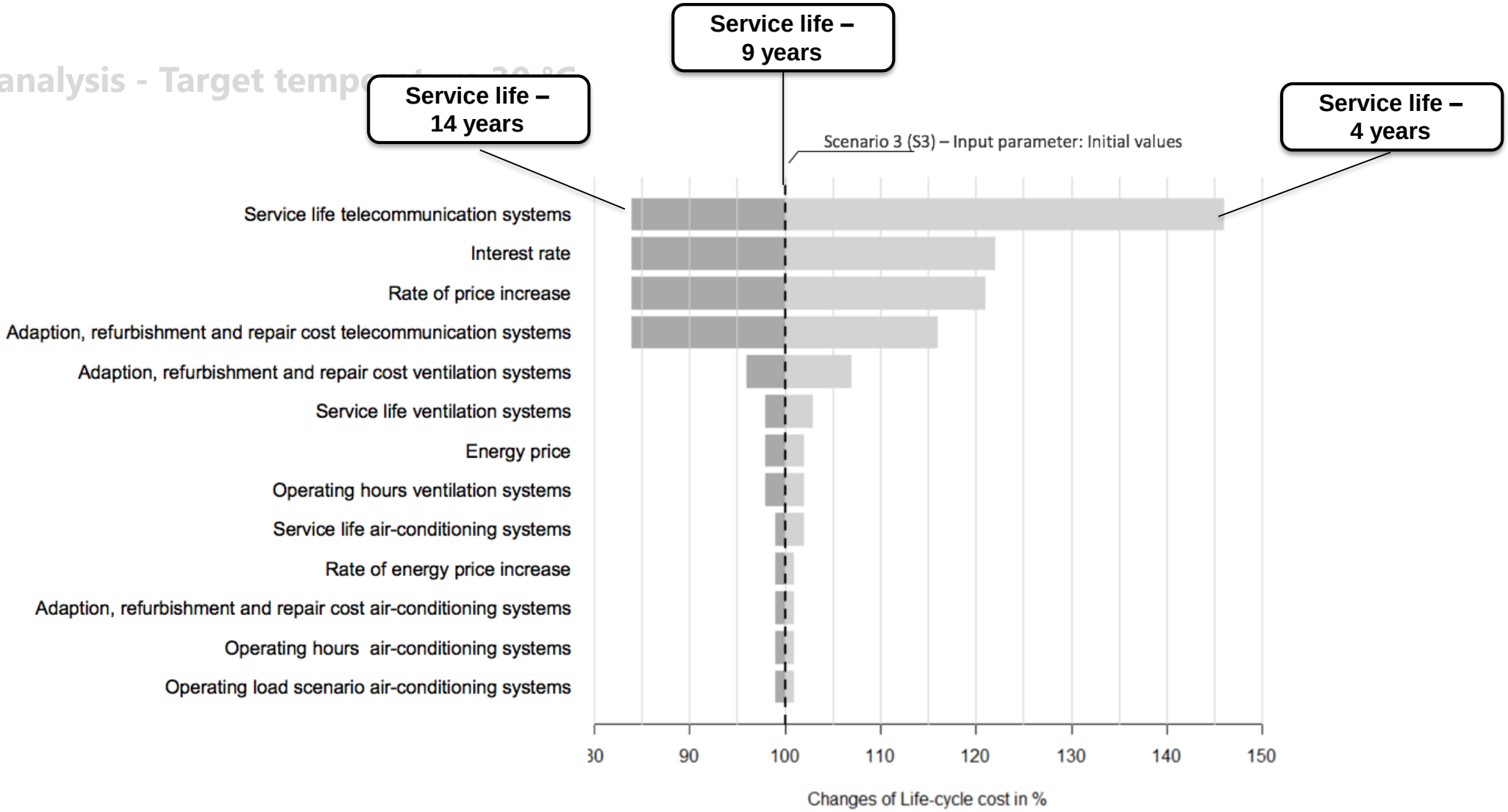
Maintenance cost of telecommunication systems

Ventilation systems

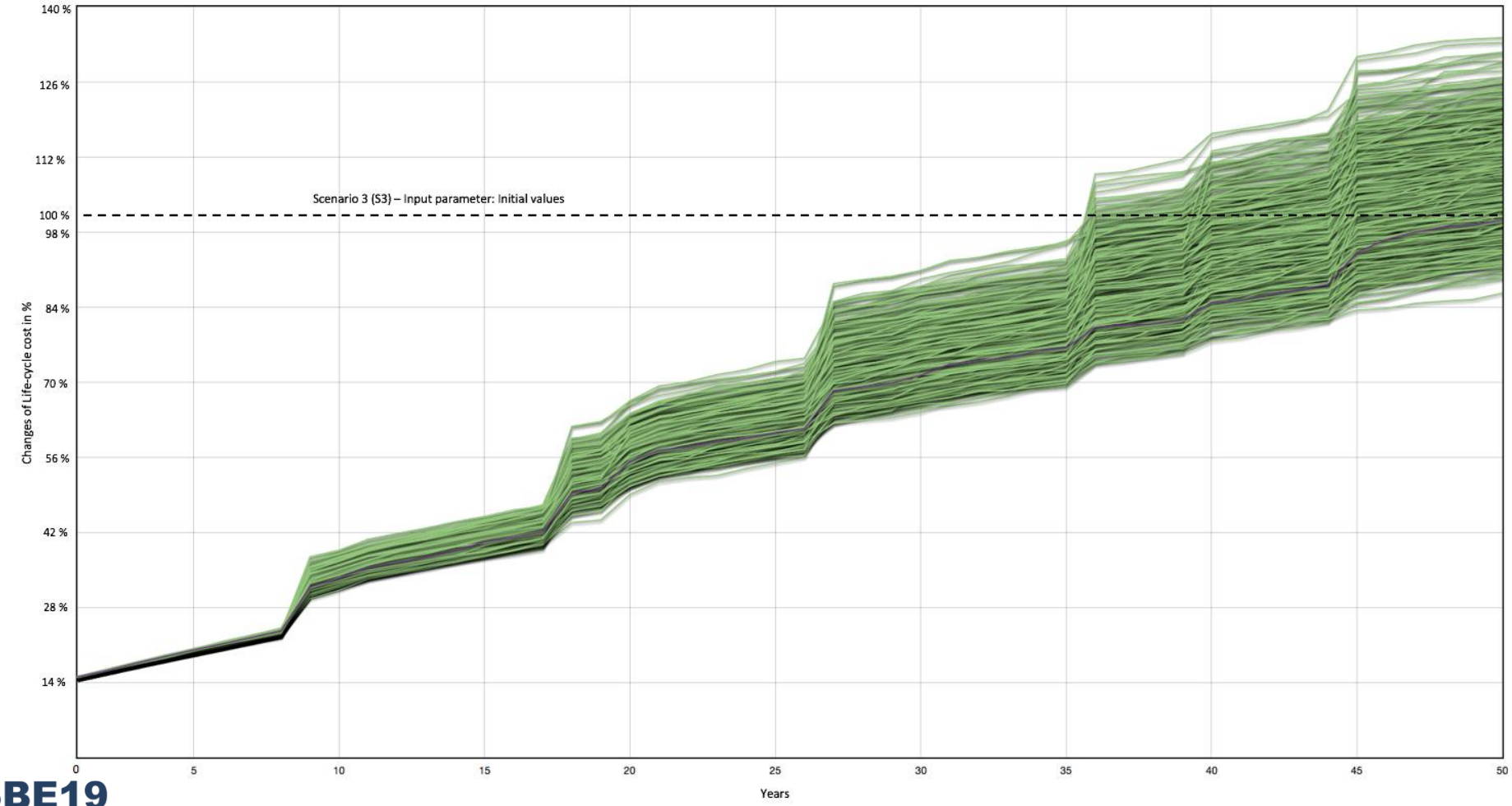
Air-conditioning systems

Sensitivity analysis - Target temperature 30 °C




Service life – 9 years
Service life – 14 years
Service life – 4 years
Scenario 3 (S3) – Input parameter: Initial values
Service life telecommunication systems
Interest rate
Rate of price increase
Adaption, refurbishment and repair cost telecommunication systems
Adaption, refurbishment and repair cost ventilation systems
Service life ventilation systems
Energy price
Operating hours ventilation systems
Service life air-conditioning systems
Rate of energy price increase
Adaption, refurbishment and repair cost air-conditioning systems
Operating hours air-conditioning systems
Operating load scenario air-conditioning systems
30
90
100
110
120
130
140
150
Changes of Life-cycle cost in %

Risk analysis - Target temperature 30 °C



Changed input parameters:

- Interest rate
- Rate of price incerease
- Energy price
- Rate of energy price increase

First calculation run has shown that the **decisive input parameters** are the required **cooling energy** for air-conditioning systems and ventilation systems.

Reduction of cooling energy by **other classification** resp. by **higher target temperatures**

Second calculation run has shown that the cross-passage classification for the **target temperature 30°C** is the **most economic** scenario over a period of 50 years

At higher target temperatures the **difference** between the **energy demand** is to **low** to compensate **the shorter replacement cycles and higher maintenance cost**

Dominance analysis has shown that the **cost drivers** are the **maintenance cost** of the **telecommunication systems**

Sensitivity analysis has shown that the **uncertainties** in the **service life** of the **telecommunication systems** affect the life-cycle cost most

Risk analysis has shown that **life-cycle cost analyzes** are subject to **uncertainties**

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THANK YOU FOR YOUR ATTENTION

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