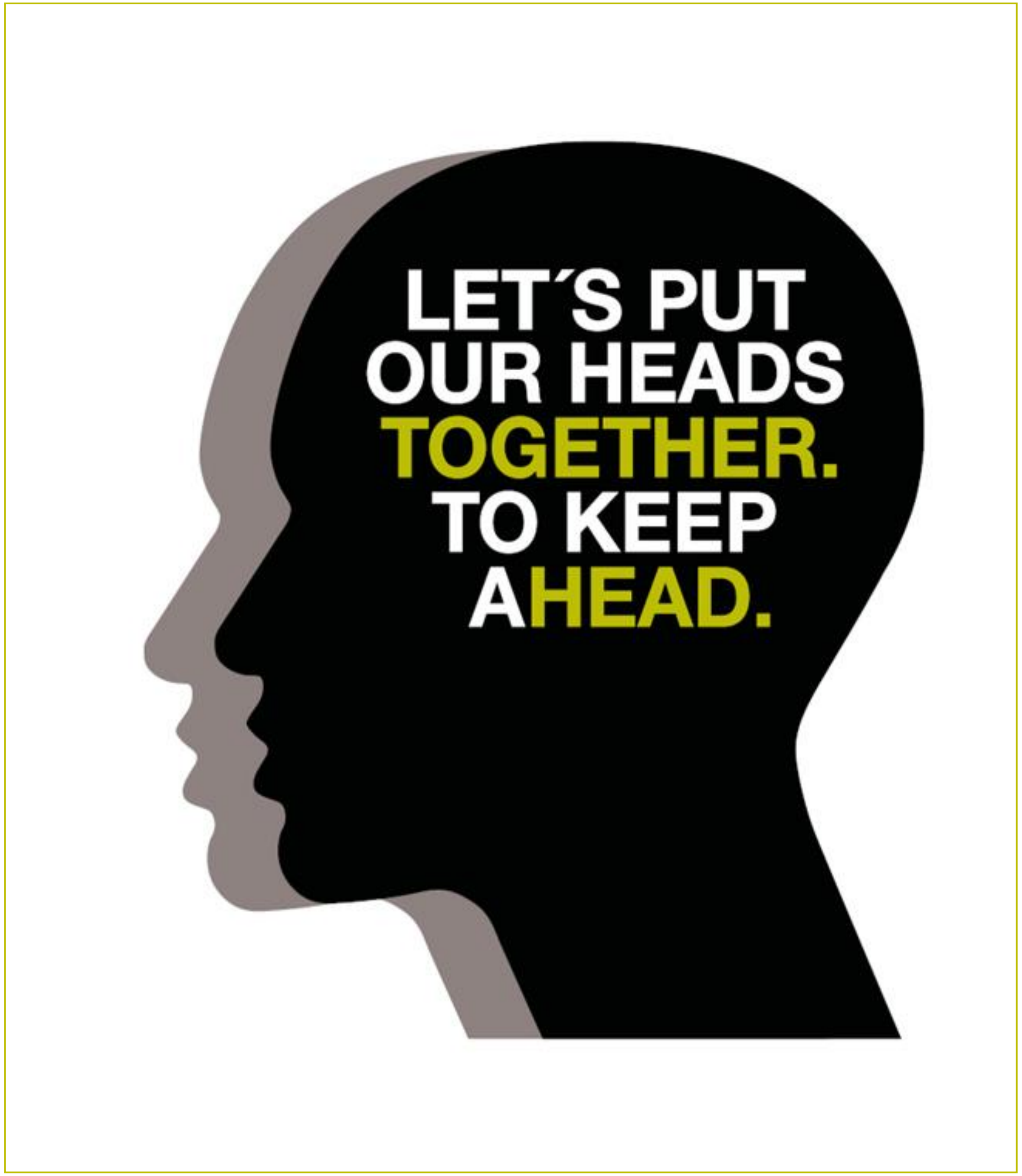
OPTIMAL MAINTENANCE OF HOT DIP GALVANIZED STEEL STRUCTURES

Ytskydd 1 jan 2023

Björn Tidbeck



RISE Research Institutes of Sweden

Division: Material & Production
Corrosion Protection and Surface Technology

Optimal Maintenance of HDG structures

- The aim of the project is to compare different methods of maintaining Hot Dip Galvanized steel
- Compare different pretreatment methods for in-field use
- Compare different coating products
- Inspection of reference objects
- Life Cycle Analysis (LCA) and Life Cycle Cost analysis (LCC) will be performed
- A holistic best practice will be sought

RI.
SE

Optimal Maintenance of HDG structures

Project consortium:

- Svenska Kraftnät / Swedish Power Grid
- Trafikverket/ Swedish Road Administration
- Nordic Galvanizers/ EGGA
- Svetskommissionen/ Swedish Welding Commission
- Tikkurila Sweden
- Zinga Sweden
- Agaria/ Clean Laser
- IPM Norden
- Pro Chroma/ St Control
- Dala zink

Funded by:

VINNOVA

With some help from:

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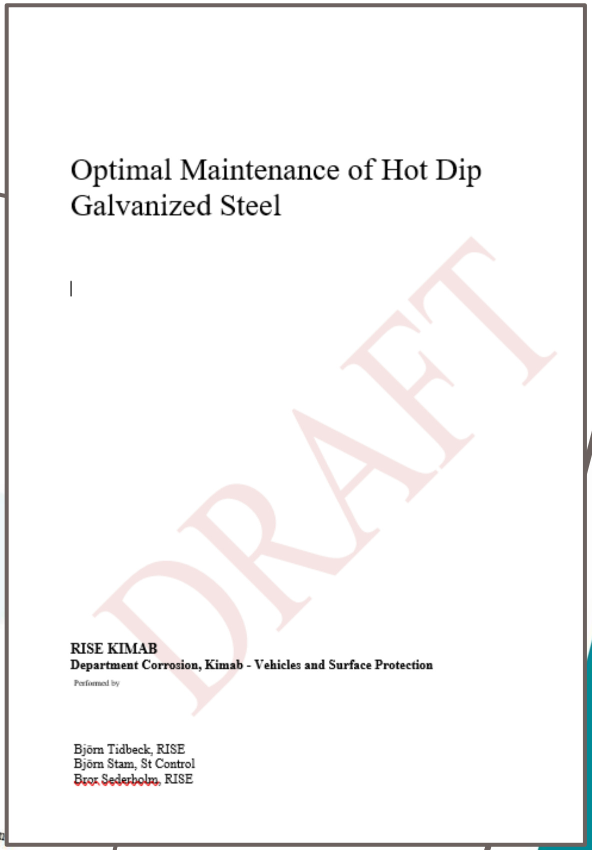
Reports


Research report
Open
Inspection of reference objects coated with various zinc rich coatings
Björn Tidbeck, Bror Sederholm
Report number. 15660-1


Research report
Open
Corrosion testing and electrochemical comparison of various alternative coatings
Björn Tidbeck, Alexi Makdesy, Viktor Fahlgren, Joachim Blomquist an
Karin Beaussant Törne
Report number. 15660-2


Optimal Maintenance of Hot Dip Galvanized Steel
DRAFT
RISE KIMAB
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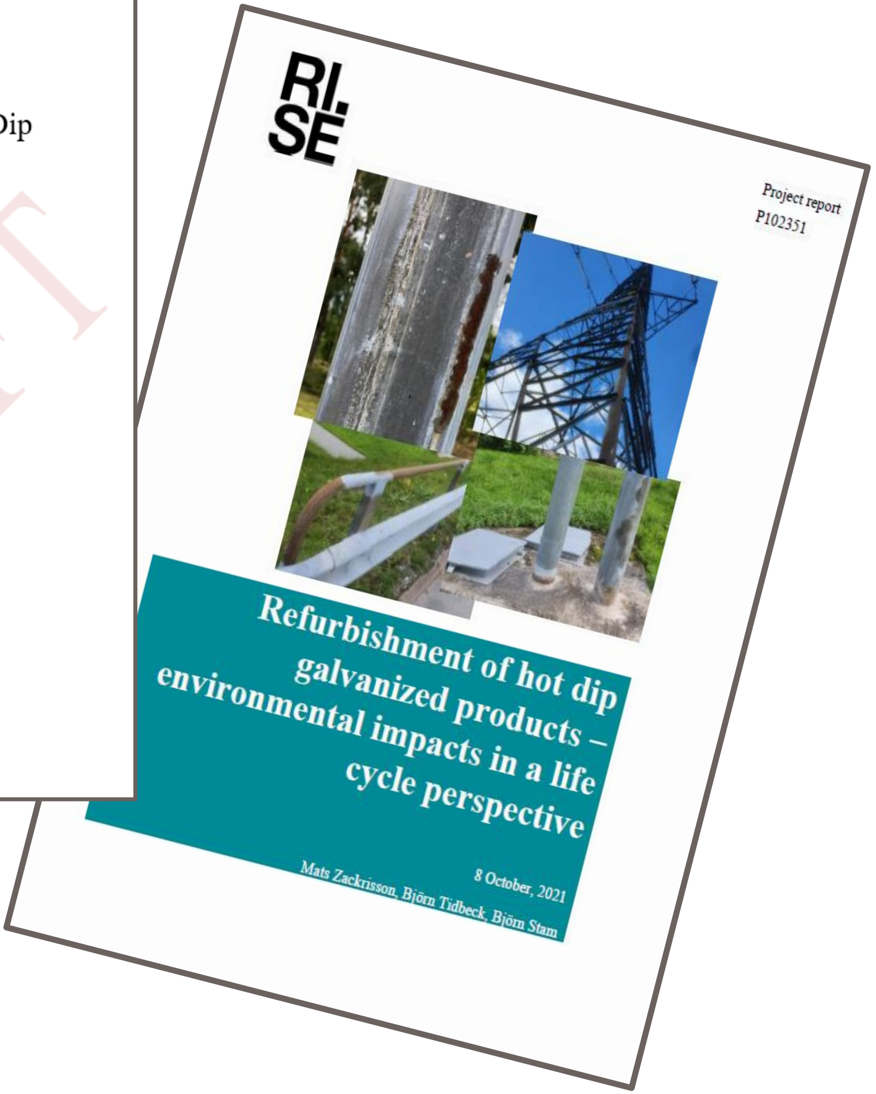
Project report
P102351
Refurbishment of hot dip galvanized products – environmental impacts in a life cycle perspective
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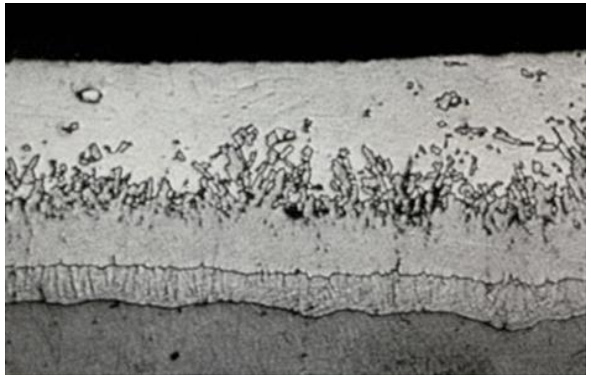
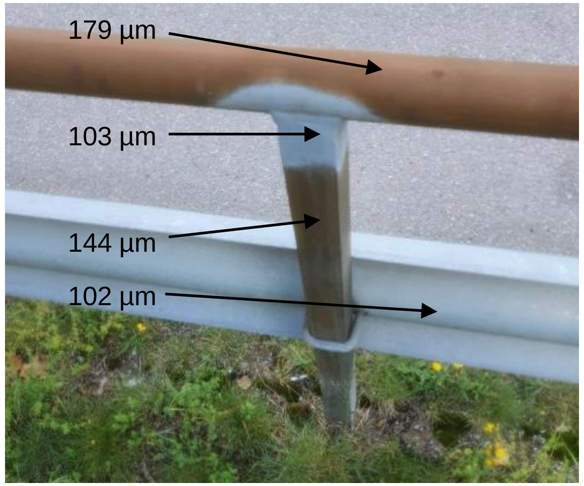
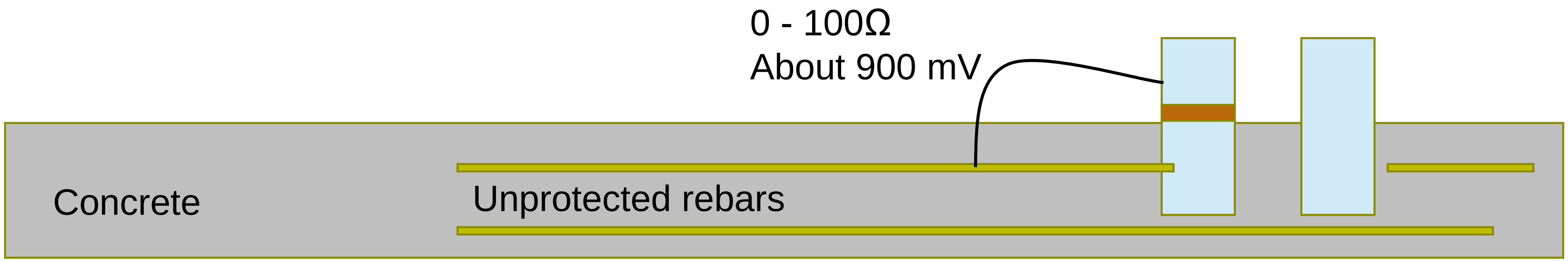
Inspecting hot dip galvanizing - DFT measurements



Courtesy Nordic Galvanizers



Avoiding reoccuring maintenance need



Proposed repair method

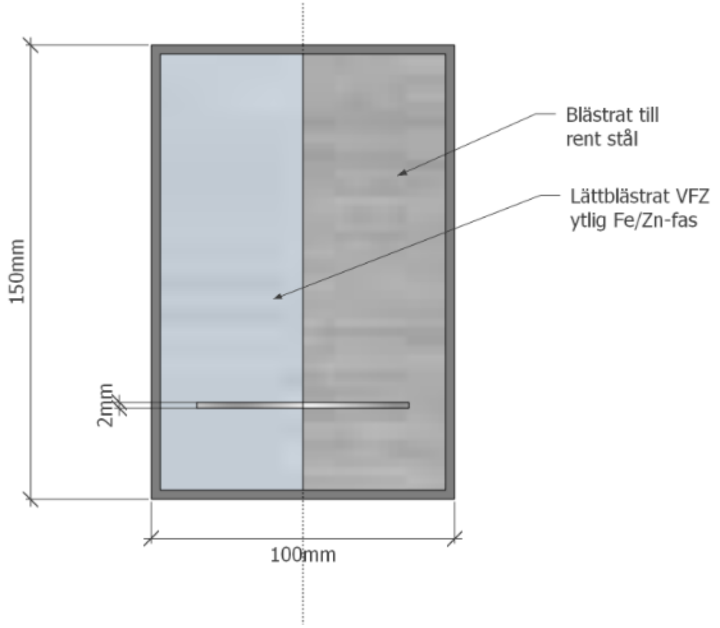
- **Spot repairs**
  - If the corrosivity is low, C3 (for zinc) or lower, small damages can be left unattended provided that they are not located in sensitive areas of the steel structure.
  - Washing, grinding with abrasive paper, brush painting with waterborne zinc silicate
  - Washing, blasting to Sa3, and coating with thermally sprayed zinc or Zn/Al
  - Washing, blasting to Sa2½, and painting with zinc rich coating product
- **Refurbishments of complete steel structures**
  - The Induron method
  - Wet abrasive blasting followed by painting with vinyl coating
  - Wet abrasive blasting followed by painting with zinc rich coating
  - Dry abrasive blasting to Sa3, followed by coating with thermally sprayed zinc or Zn/Al

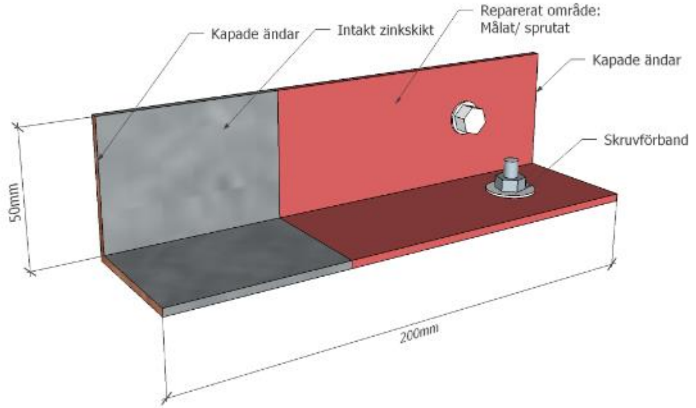
Sample matrix for outdoor testing

Sample abbreviation	product name	Description	Sample type	Pretreatment	tot DFT	DFT Zn	DFT Coating	Number of coats
A	Fontezinc HR	Waterborne zinc silicate	L-profile	Laser cleaning	178	124	54	1
B	Temazinc 99	solvent borne zinc rich epoxy	L-profile	Laser cleaning	146	124	22	1
C	Temasil 90	Solvent borne zinc ethyl silicate	L-profile	Laser cleaning	147	125	22	1
D	Bridge system	solvent borne	L-profile	Laser cleaning	294	123	171	3
E	Fontezinc HR	Waterborne zinc silicate	L-profile	Grinding	128	72	56	1
F	Temazinc 99	solvent borne zinc rich epoxy	L-profile	Grinding	125	99	26	1
G	Temasil 90	solventborne l zinc ethysilicate	L-profile	Grinding	116	96	20	1
H	Biltema spray	solvent borne 1-c	L-profile	Grinding	124	101	23	1
I	Bridge system	solvent borne 1-c	L-profile	Grinding	306	96	210	3
J	Zinga	solvent borne 1-c	L-profile	Laser cleaning	184	125	59	1
K	Zinga	solvent borne 1-c	L-profile	Grinding	211	125	86	1
L	Induron	Solvent borne High solid	L-profile	Untreated	285	120	165	1
M	Fontezinc HR	Waterborne zinc silicate	flat panels	blasting	161	61	100	1
N	Temazinc 99	solvent borne zinc rhich epoxy	flat panels	blasting	133	53	80	1
O	Temasil 90	solventborne ethyl zinc silicate	flat panels	blasting	134	49	85	1
P	Bridge system	solvent borne	flat panels	blasting	421	51	370	3
Q	Sprayed Zn	flame	flat panels	blasting			160	1
R	Sprayed Zn	light arc	flat panels	blasting			220	1
S	Zinga	solvent borne 1-c	flat panels	blasting	204	44	147	2
T	ZingAlu	solvent borne 1-c	flat panels	blasting	218	80	138	2
U	Aquazinga	Waterborne zinc silicate	flat panels	blasting	193	72	121	2

Optimal Maintenance of HDG structures

- Study will include exposure of:
    - HDG
    - Zinc-rich coatings
    - Thermally sprayed zinc
- Pretreatment will be performed with:
    - Blasting
    - Mechanical pretreatment
    - Laser cleaning
- Substrates of old/ new HDG steel





Field exposure of samples

- Flat panels with scribe exposed:

    1 set at Ryda,

    1 set at Riksväg 40,

    2 sets at Bohus-Malmön

- L-profiles with scribe exposed:

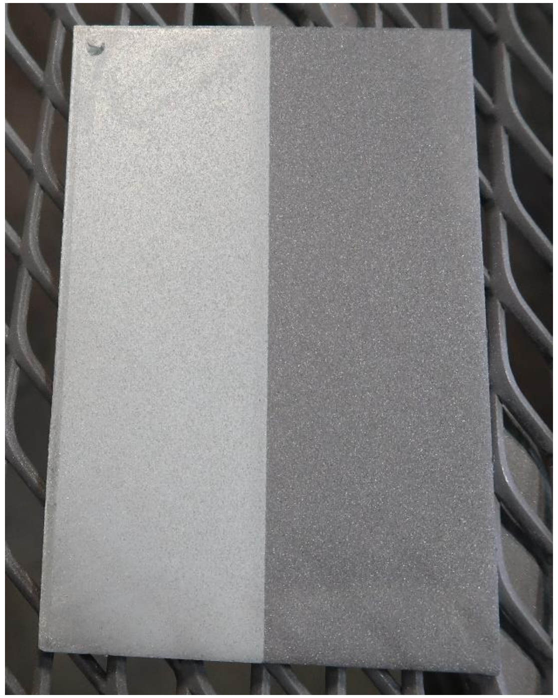
    1 set at Riksväg 40

    1 set at Bohus-Malmön

- L-profiles without scribe exposed:

    1 set at Ryda

    1 set at Bohus-Malmön



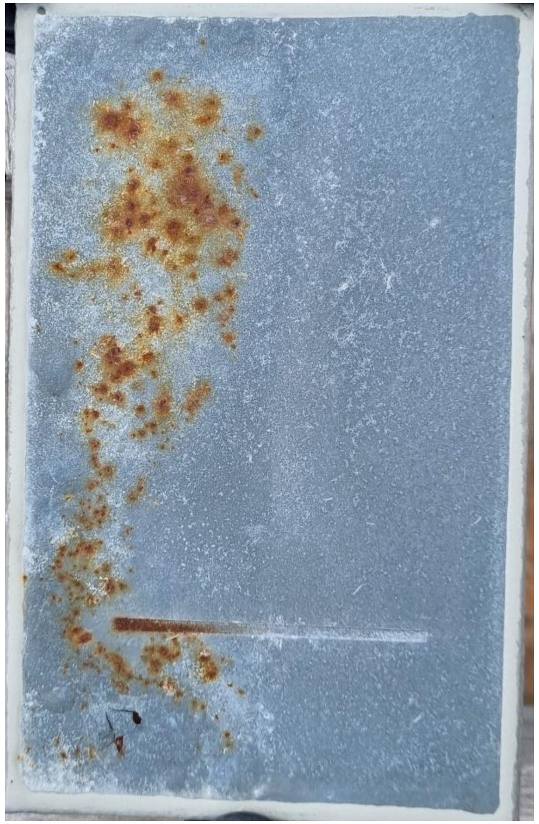
Field exposure of coated samples

Bohus-Malmön, Kvarnvik

Riksväg 40, Borås

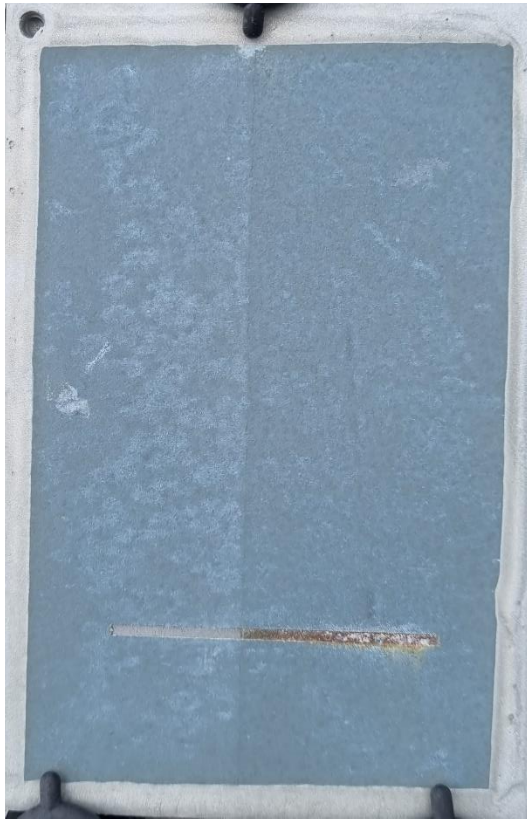
Ryda, Enköping

Flat panels after 33 months at Bohus-Malmön



Zingalu

Zinga



TemaZinc 99

EP(Zn)/ EP/ PUR

Flat panels after 33 months at Bohus-Malmön

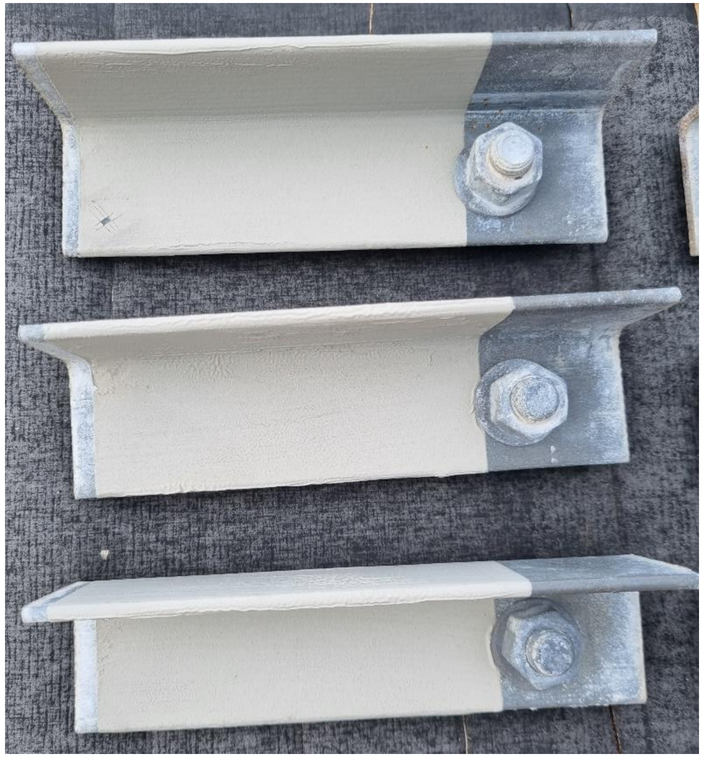
TemaSil 90

AquaZinga

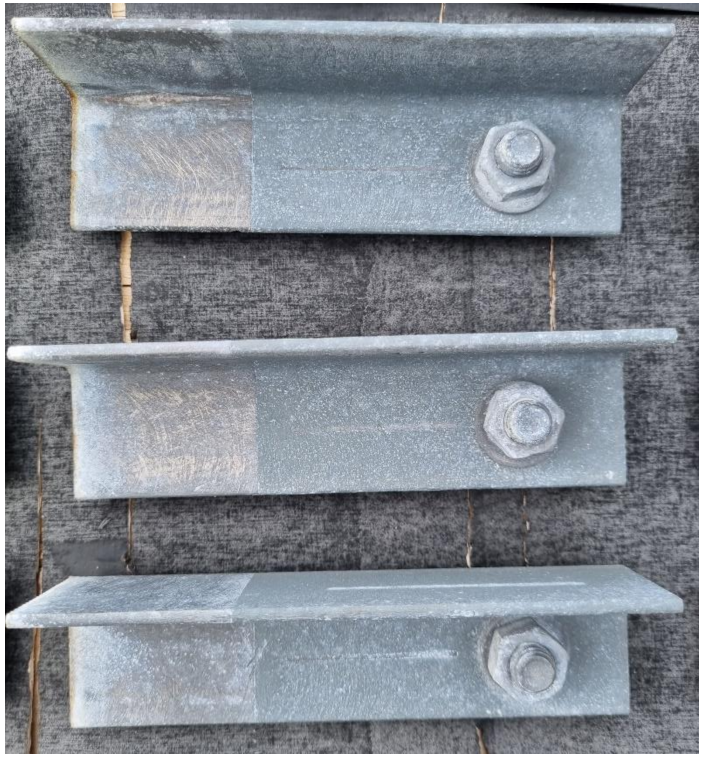
Fontezinc HR

TSZn

L-panels with differing pretreatment



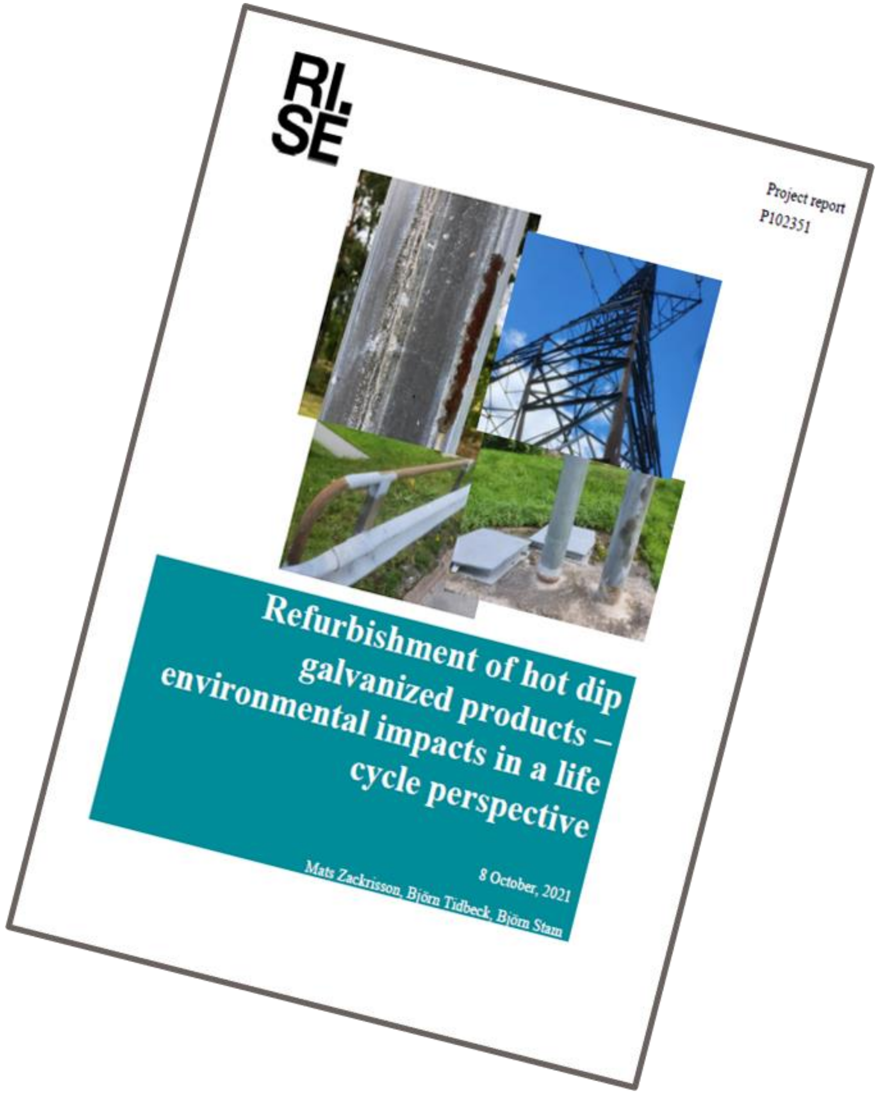
Washing



Disc grinder

laser cleaning

LCA and LCC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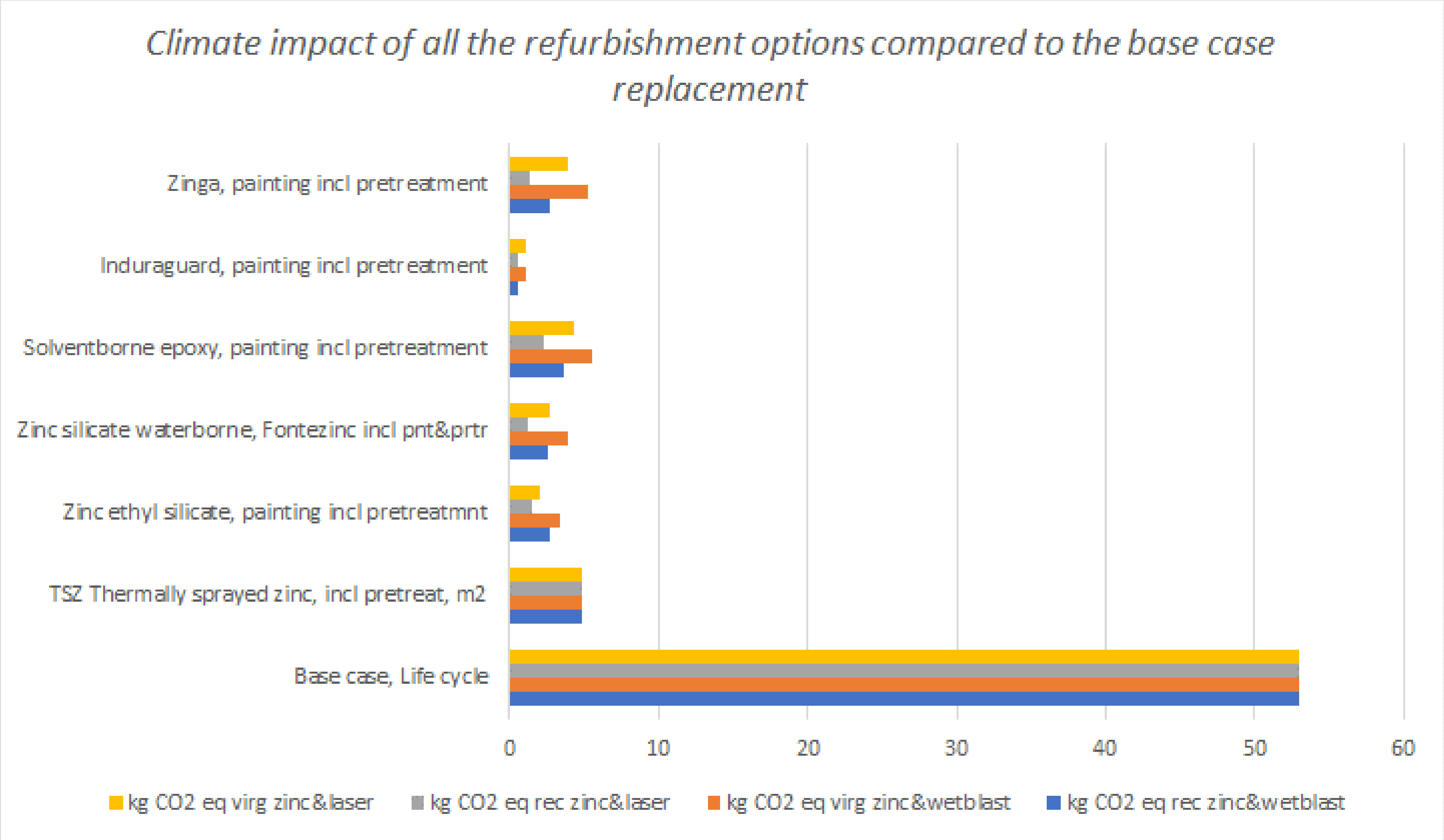
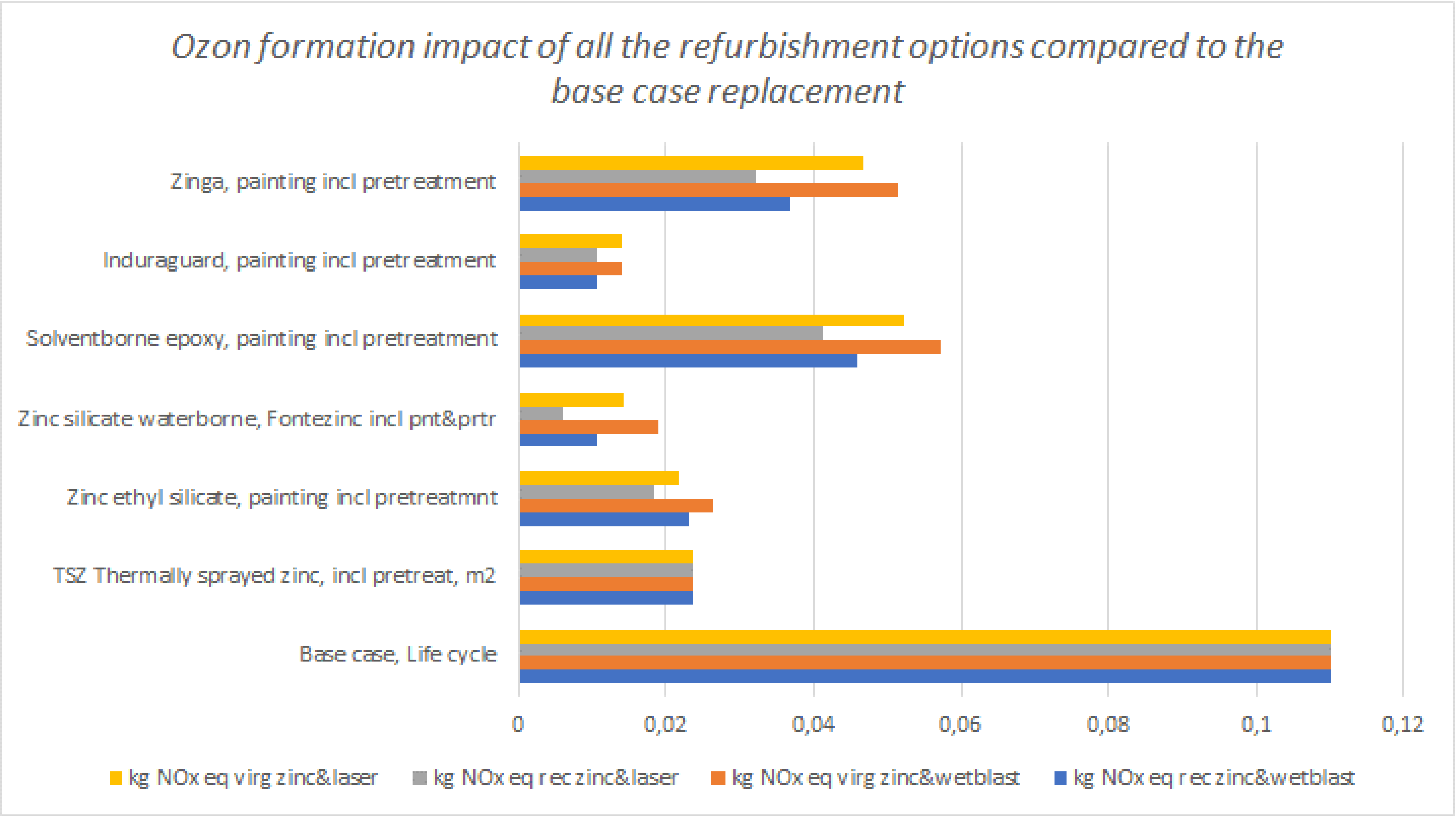
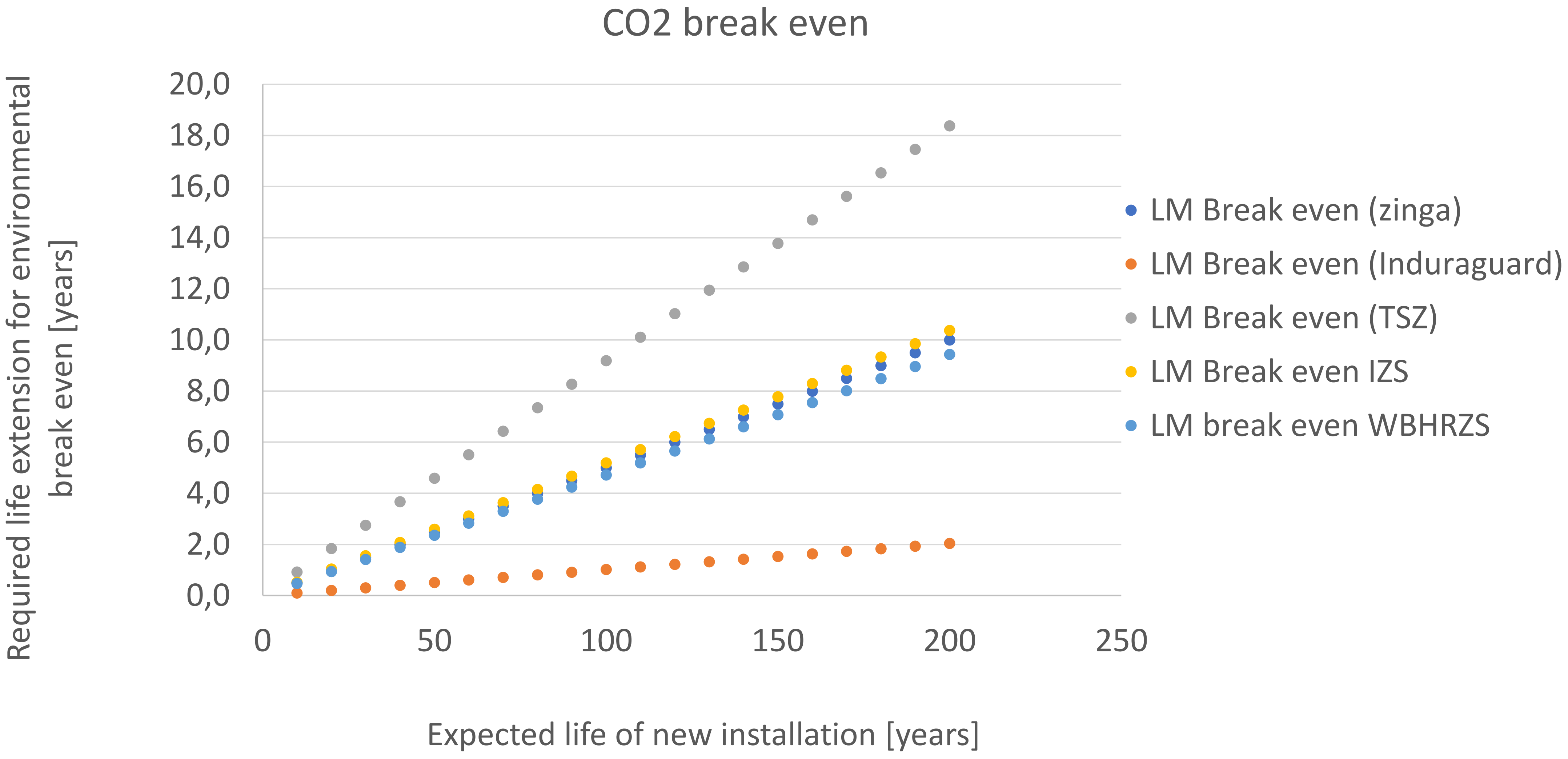

Climate impact of all the refurbishment options compared to the base case replacement
Zinga, painting incl pretreatment
Induraguard, painting incl pretreatment
Solventborne epoxy, painting incl pretreatment
Zinc silicate waterborne, Fontezinc incl pnt&prtr
Zinc ethyl silicate, painting incl pretreatmnt
TSZ Thermally sprayed zinc, incl pretreat, m2
Base case, Life cycle
0
10
20
30
40
50
60
kg CO2 eq virg zinc&laser
kg CO2 eq rec zinc&laser
kg CO2 eq virg zinc&wetblast
kg CO2 eq rec zinc&wetblast

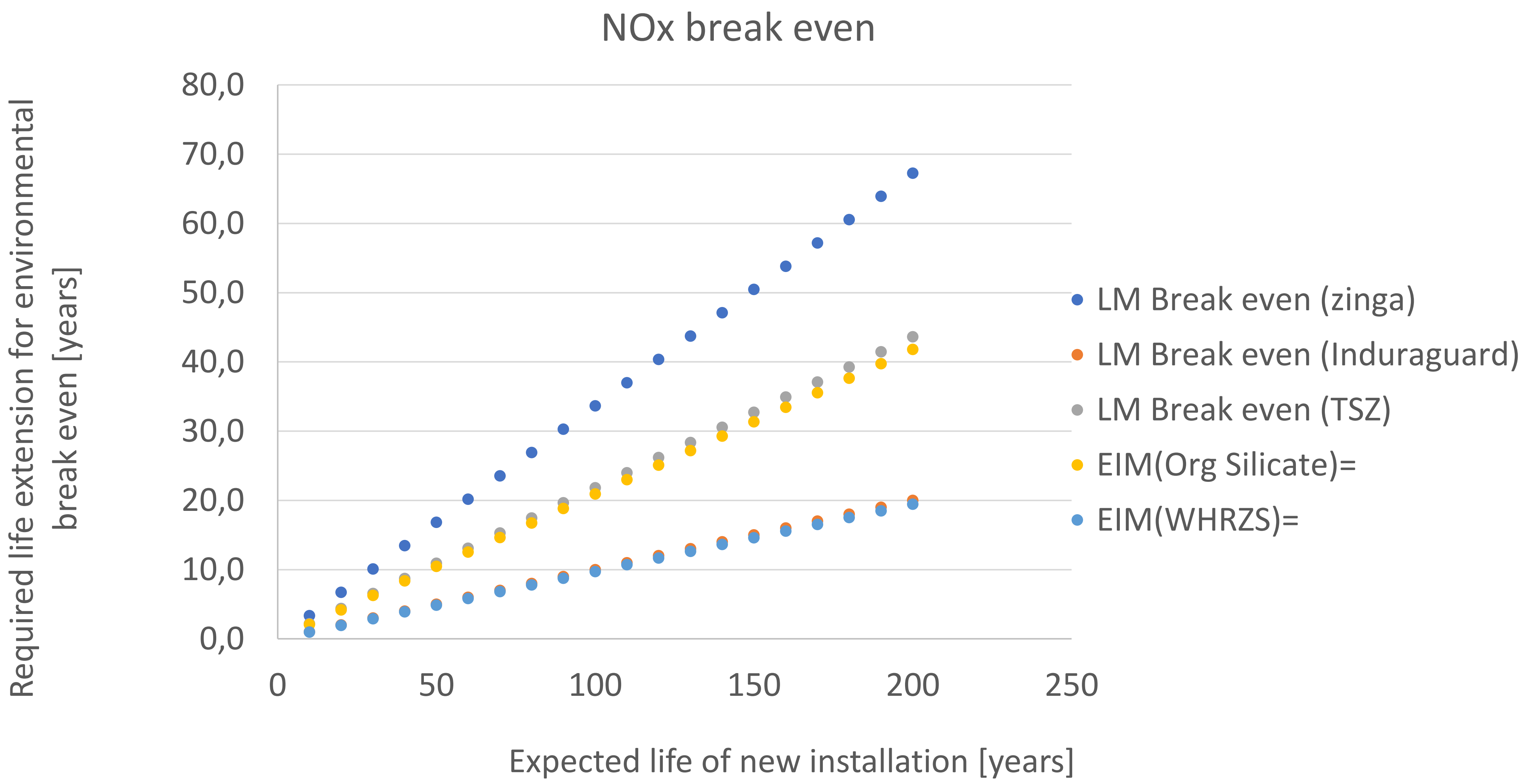

Ozon formation impact of all the refurbishment options compared to the base case replacement
Zinga, painting incl pretreatment
Induraguard, painting incl pretreatment
Solventborne epoxy, painting incl pretreatment
Zinc silicate waterborne, Fontezinc incl pnt&prtr
Zinc ethyl silicate, painting incl pretreatmnt
TSZ Thermally sprayed zinc, incl pretreat, m2
Base case, Life cycle
0
0,02
0,04
0,06
0,08
0,1
0,12
kg NOx eq virg zinc&laser
kg NOx eq rec zinc&laser
kg NOx eq virg zinc&wetblast
kg NOx eq rec zinc&wetblast

RI.
SE

Environmental break even



Environmental break even



Summary of LCA findings

- Pretreatment using blasting is a large contributor to the overall environmental footprint
- Pretreatment using laser reduce hazardous waste and gives lower environmental footprint
- The model includes virgin zinc for TSZn and HDG
- Zinc in coating may come from zinc dross, recycled from galvanizing plants
- Zinc origin recycled / virgin is significant factor for environmental footprint
- Thermally sprayed Zn and zinc silicates are good options where blasting is possible
- Without blasting posibilities, Induraguard 9200 appears to be an interesting alternative

Cost efficiency of refurbishing a 3 mSEK tower

- Norway (two towers) — Similar as new construction
  - Slurry blasting
  - Full scaffolding and containment
  - Painting with 2x Zinc rich paint

- New Zealand (400 towers / year) — About 1 mSEK
  - Wet blasting
  - Ground cover, no scaffolding no containment
  - Painting with vinylic coatings

- USA (up to 5000 towers / year) — About 100 kSEK
  - Minimal pretreatment using wire brush
  - No scaffolding no containment
  - Painting with 1x 250 µm Induraguard 9200

Rough estimations of cost and expected life extension of refurbishment for a power transmission tower in C2 (Steel) C3 (zinc)

Maintenance method	HDG 80µm	Zinga 120µm	IZS 90µm	WBHRZS 90µm	TSZ 100µm	Vinylic	Induragard 200µm
RebuildBase case Cost [% of base case]	100%						
Full containment, blasting Cost [% of base case]	n/a	100%	100%	100%	100%	100%	n/a
Partial containment, wet blasting Cost [% of base case]	n/a	35%	50%	50%	n/a	35%	n/a
No containment no blasting Cost [% of base case]	n/a	n/a	n/a	n/a	n/a	n/a	5%
expected life [years]	100	30	50	100	100	25	25

Note 1 *Green cost assumptions are based on cost from real refurbishment projects, orange costs are estimates based on similar refurbishment methods and the assumption that pretreatment is the main cost driver for refurbishments, it is estimated that zinc silicates require more thorough blasting compared to Zinga anv vinylic coatings, hence the slightly higher cost . Yellow cost assumptions is 100% for the base case by definition.*

Note 2 *Green life expectancies are based on experience from real refurbishment projects. Orange estimates are rough estimates based on reference object inspections and corrosion testing. Estimation in red is based on the AUS/NZ standard. Yellow life expectancies are based on zinc corrosion rates corresponding to C3 for zinc.*

Summary of expected logistics, cost and environment