MOTT MACDONALD

Innovations in Transport Infrastructure

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Some new things

Asset Management

- BIM
- Photogrammetry
- Artificial Intelligence – machine learning of survey data to extrapolate information
- Iterative design processes

Training

Sustainability

- Reducing breakouts in concrete
- Use of alkali activated cementitious materials
- Net zero

Sustainability

Embodied Energy

When raw materials are processed, energy is used. This is captured in “Embodied Energy”

“*Embodied energy is the energy consumed by all of the processes associated with the production of a structure, from the acquisition of natural resources to product delivery. This includes the mining and manufacturing of materials and equipment, the transport of the materials and the administrative functions*

Buildings and Government Efficiency
Australian Greenhouse Office
Department of the Environment and Heritage “

“

Embodied Energy of Common Materials

Material	NZ figures	Circular Ecology Figures ($kgCO_2e/kg$)
Polymers	120 MJ/l (6$kgCO_2e/kg$)	3.76
Reinforcing Steel	10.1/8.9 MJ/kg (0.35$kgCO_2e/kg$)	1.09 avg, 0.28min, 3.2max
Virgin imported structural steel	35 MJ/kg (1.24$kgCO_2e/kg$)	2.10 avg, 0.98 min 3.6 max
Stainless steel	75 MJ/kg (5.46kg/CO_2e/kg)	4.41
Zinc	51 MJ/kg	3.09
Virgin Aluminium	201 MJ/kg extruded (8$kgCO_2e/kg$)	6.83
Recycled Aluminium	17.3 MJ/kg extruded (0.72$kgCO_2e/kg$)	

https://www.wgtn.ac.nz/architecture/centres/cbpr/resources/pdfs/ee-coefficients.pdf

http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html

Embodied Energy of Common Materials

To convert between the two it depends on the carbon footprint of the energy supply,

Both sources have figures for reinforcing steel, which is widely recycled.

Two figures are used for structural steel in the UK in the remainder of the paper. 35MJ/kg is based on the virgin structural steel in the New Zealand Work. 17MJ/kg is based on the ratio between structural steel and reinforcement in the circular ecology data, applied to the MJ/kg figure for structural steel in the New Zealand work.

Assessment Approach

ISO 9223 contains definitions and examples of different environments

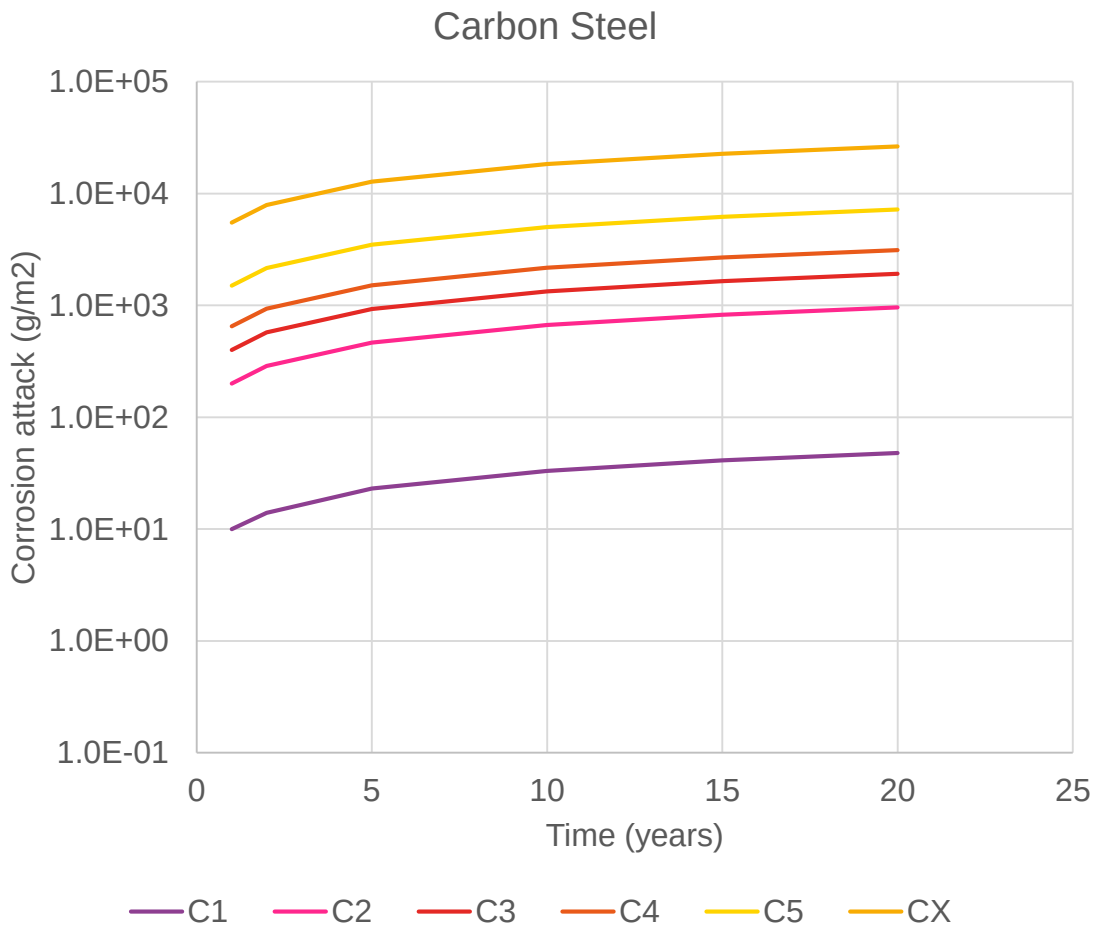
ISO 9224 provides information on how rates reduce with time.

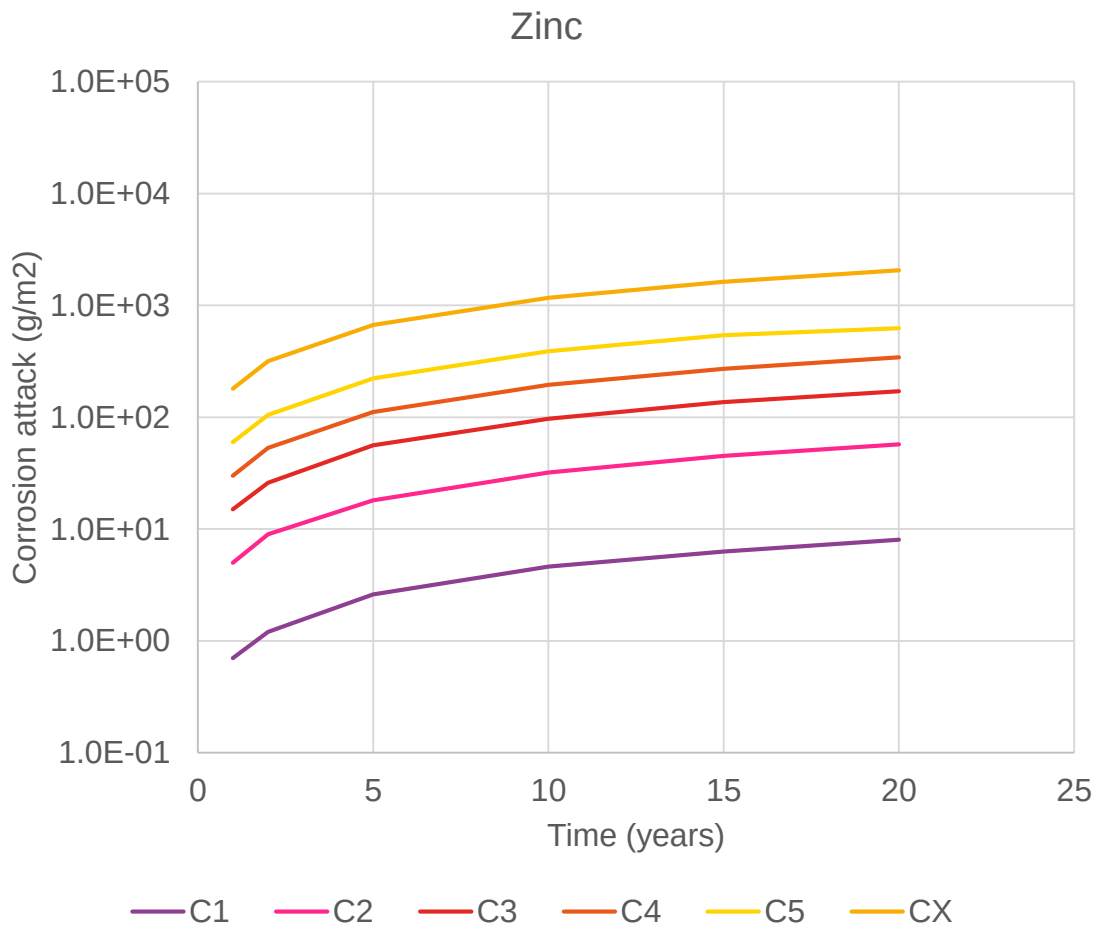
ISO 12944 provides example coating thicknesses for different environments and a range of durability options.

The approach taken is to evaluate the energy lost in allowing corrosion to take place for steel or galvanised steel, with coatings reapplied every 15 years over the life of a structure.

Assessment Approach

ISO 9224 damage with time





Example 1, Steel not galvanised (17MJ/kg)

	Steel corrosion rate Microns per year	Kg / yr / m^2	Mass lost in 15 years kg / m^2	Energy lost MJ / m^2	Energy in coating MJ	Energy difference
C1	1.3	0.010	0.042	0.72		
C2	25	0.195	0.803	13.8	20.5	-6.7
C3	50	0.390	1.607	27.6	25.6	2.0
C4	80	0.624	2.571	44.2	33.3	10.9
C5	200	1.560	6.427	111	38.4	72.1

Example 1

Coating steel in C1/C2 environments uses more energy than is lost in 15 years of corrosion

Example 2

Coated, galvanised steel, 1m^2.

Coating lasts 15 years then corrosion starts,

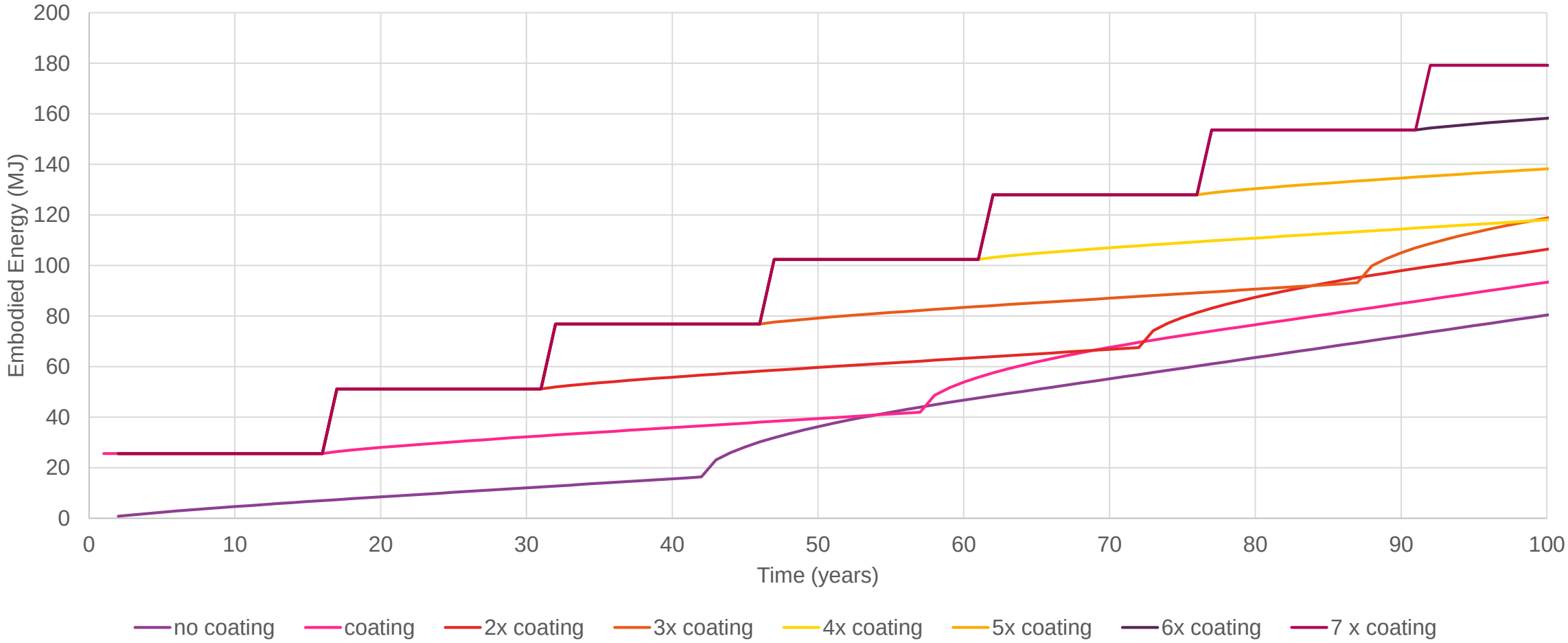
- this is not how coatings fail,
- they don’t all stay perfect then fall off at 15 years.

Galvanising corrodes, then steel corrodes

- Assumes galvanising is a simple barrier that is corroding uniformly

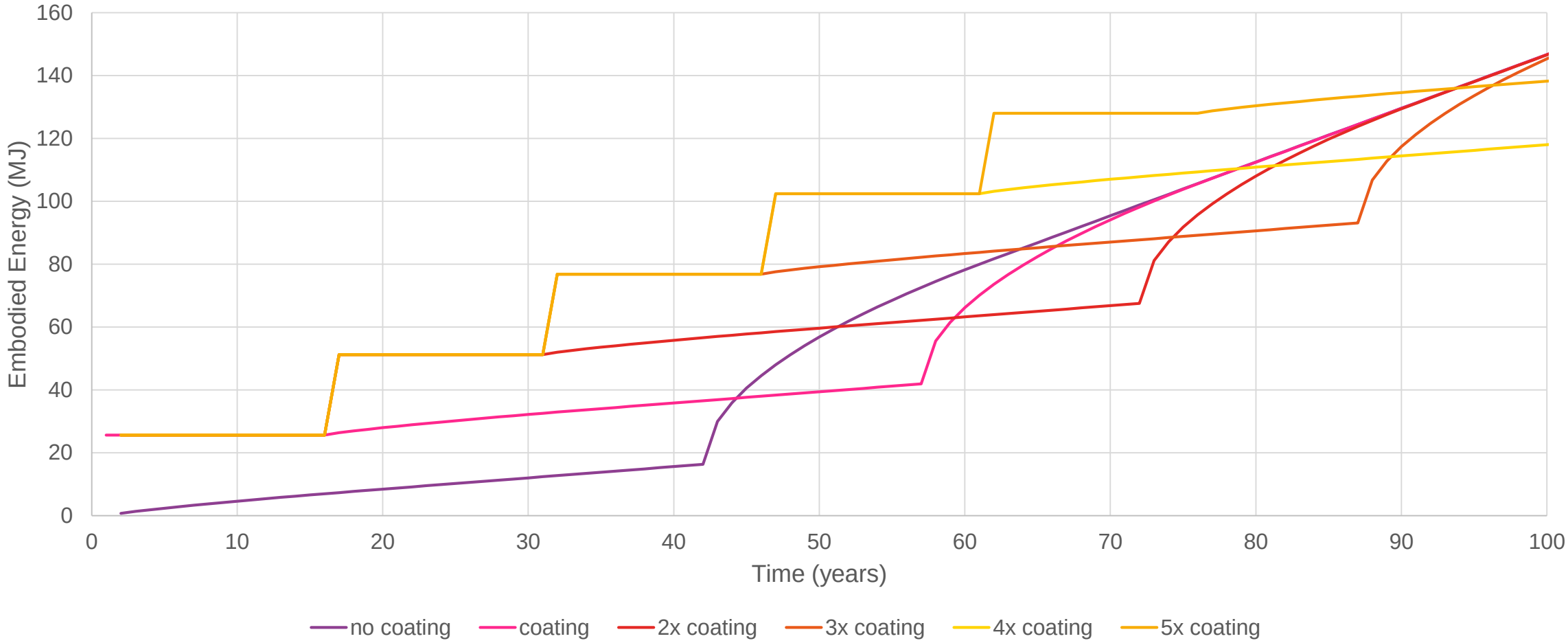
Example 2

C3, 45 micron galvanised steel, steel = 17MJ/kg



Example 2

C3, 45 micron galvanised steel, steel = 35 MJ/kg



Example 2

C3 environment with galvanising

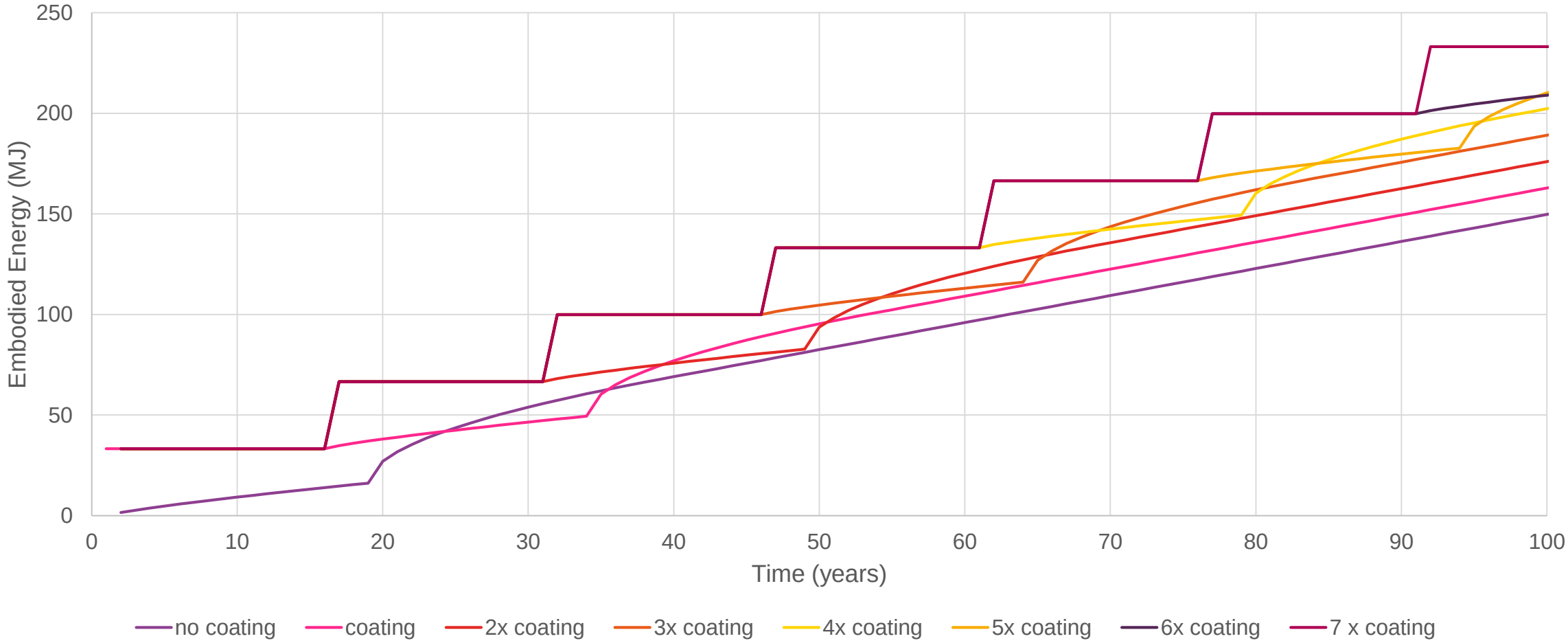
The most energy efficient approach for 100 years, is to apply as much galvanising as possible.

If steel is from reasonably recycled stock, don’t coat.

If steel is energy expensive, virgin stock with no recycling, coat often enough so that galvanising gets to end of life. (At 0 years, 15, 30 and 45 years then leave)

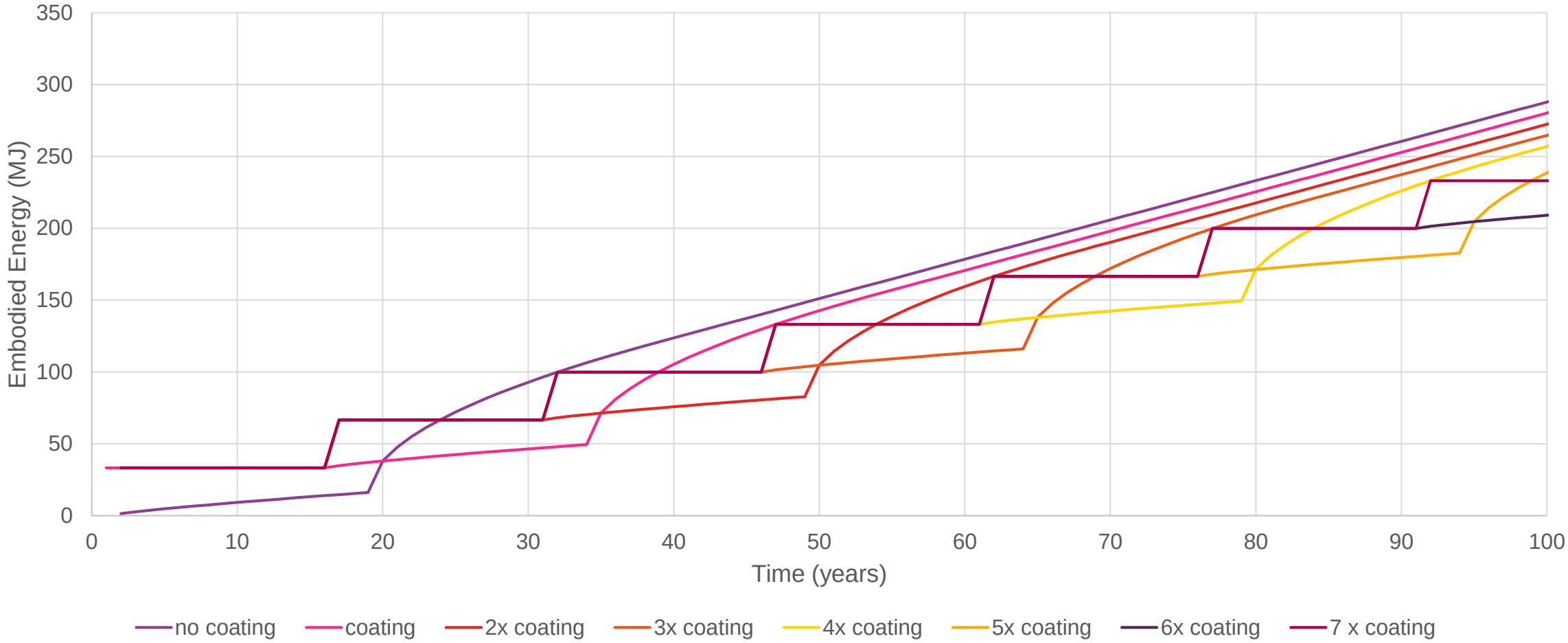
Example 3

C4, 45 micron galvanised steel, steel = 17 MJ/kg



Example 3

C4, 45 micron galvanised steel, steel = 35 MJ/kg



Example 3

C4 environment

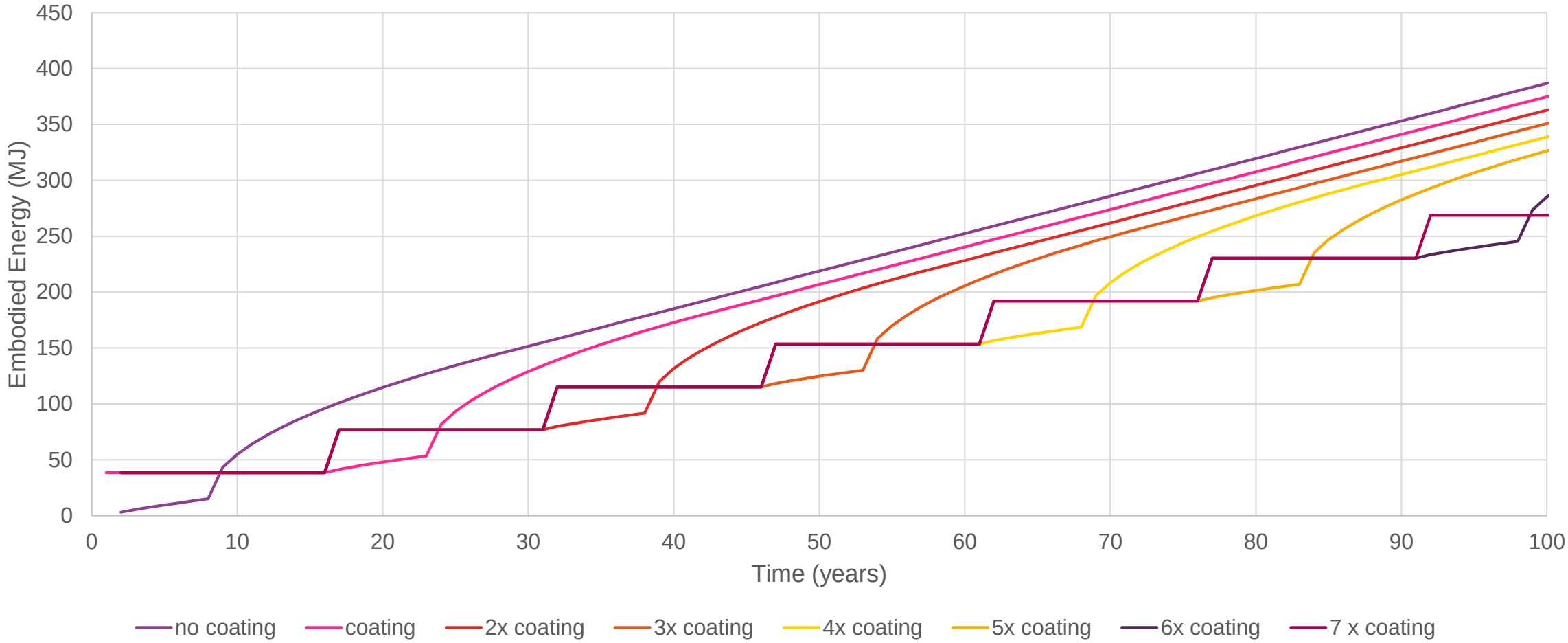
As with C3, the most energy efficient approach for 100 years, is to apply as much galvanising as possible.

If steel is from reasonably recycled stock, don’t coat.

If steel is energy expensive, virgin stock with no recycling, coat often enough so that galvanising gets to end of life, but more coating required, every 15 years up to 75 years.

Example 4

C5, 45 micron galvanised steel, steel = 17 MJ/kg



Example 4

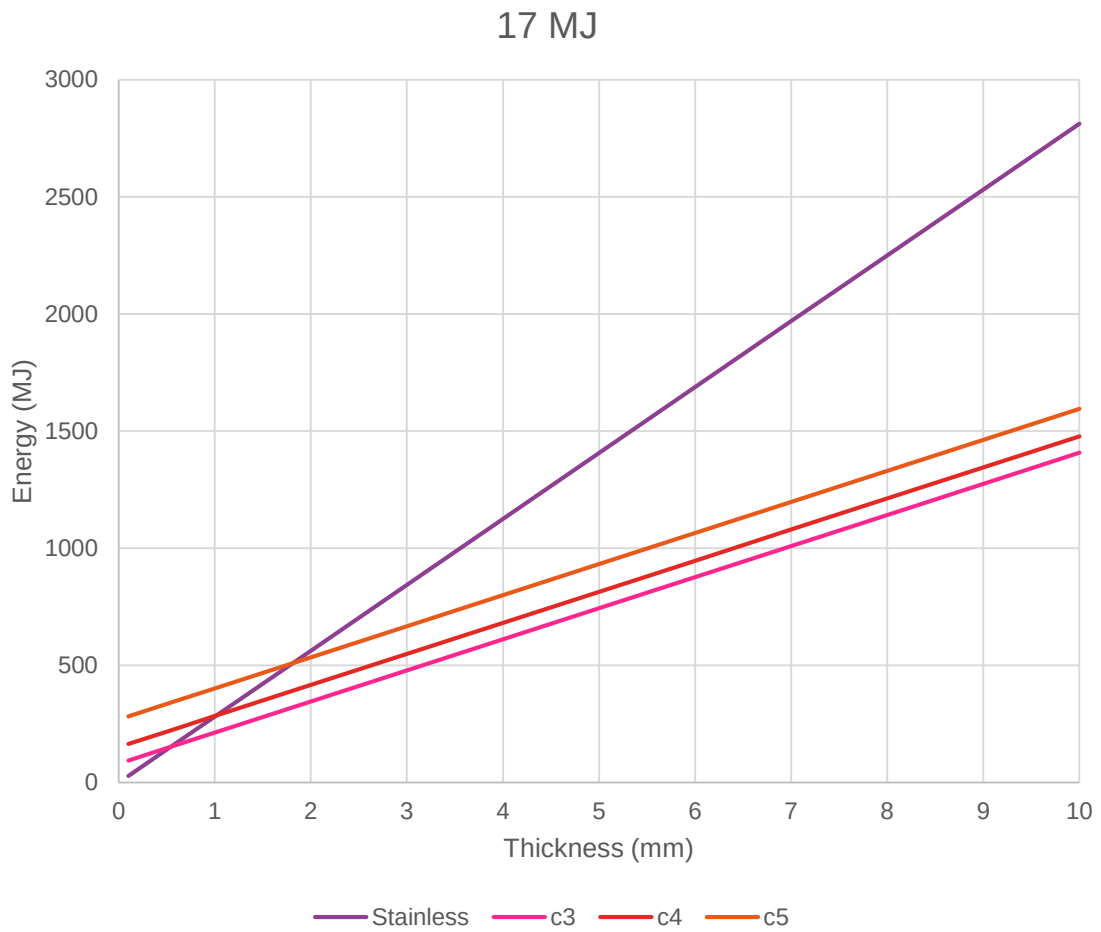
C5, 45 micron galvanised steel, steel = 17 MJ/kg

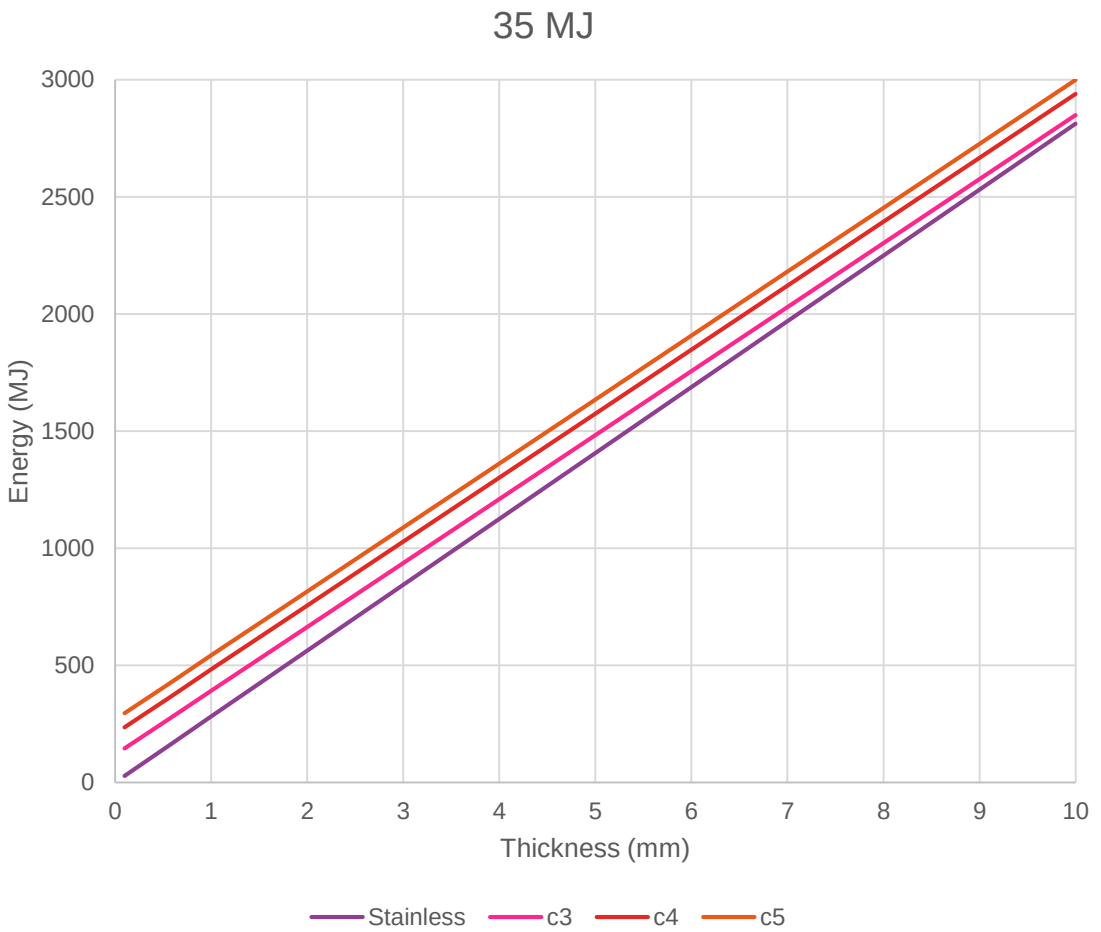
Due to high corrosion rates, regularly recoat to provide minimum embodied energy.

Galvanising did not provide significant benefit.

Stainless Steel

(No grade specific data, assuming no corrosion)





Summary

Embodied Energy reflects the deficit to the planet of construction

It can used to make engineering decisions about corrosion protection

In the examples in this study, based on the assumptions used:

C1 / C2 – don't coat

C3 / C4 – Steel with significant recycling - Galvanise, don't coat

C3 / C4 – Steel from Virgin Stock, imported - Galvanise, coat often enough to make the galvanising last the design life

C5 – Coat, don't galvanise.

If recylcing is not widespread, stainless is the least energy intensive option.

Care needs to be taken regarding the sources of the figures used

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Thank you