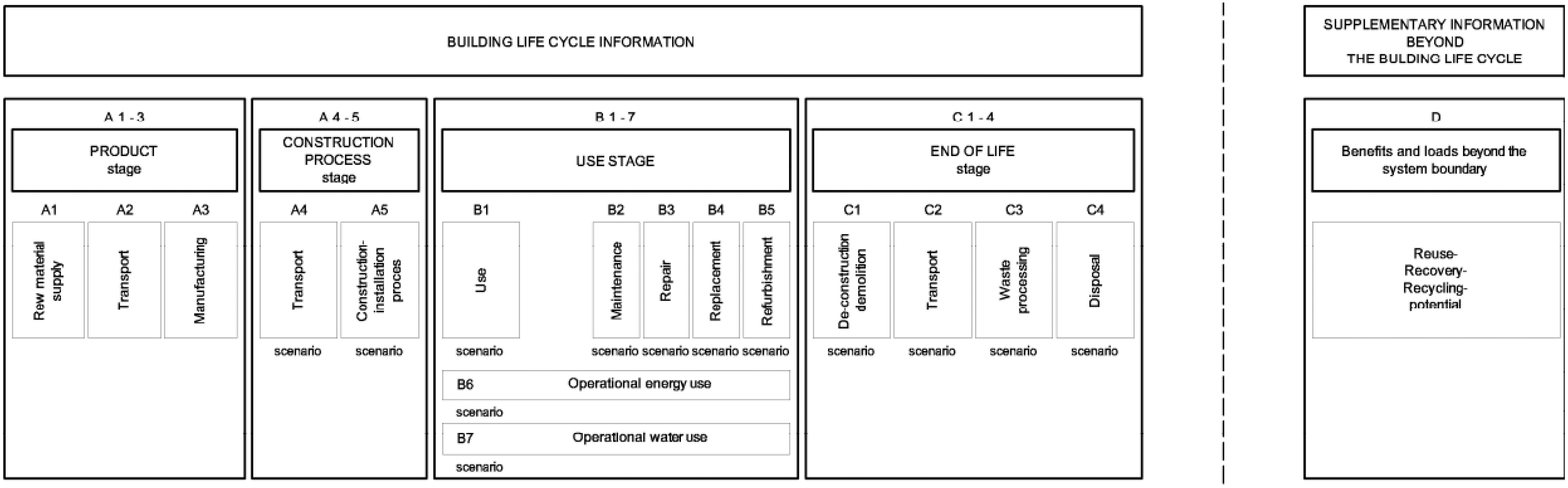
Woodn’t it be nice…

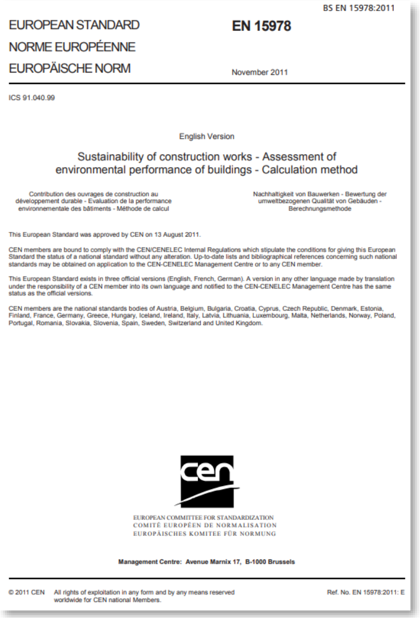
Exploring the embodied carbon of timber construction using dynamic life cycle assessment

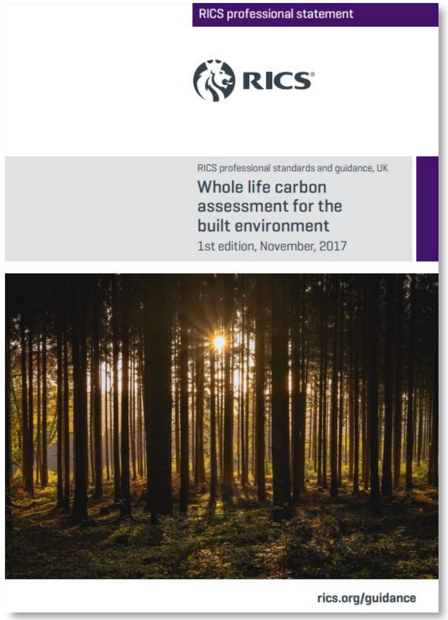
Dr. Will Hawkins

6th RECBE meeting

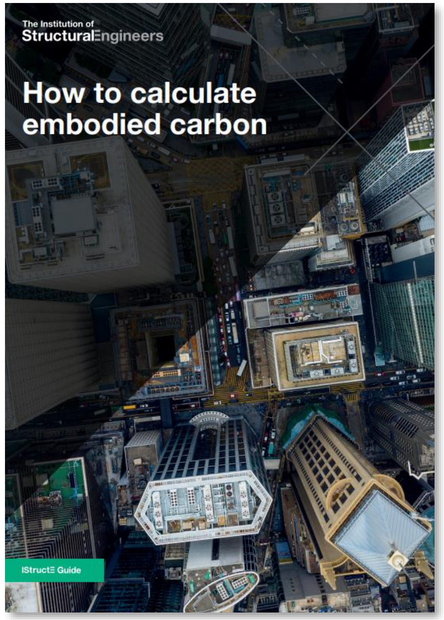
29th January 2021

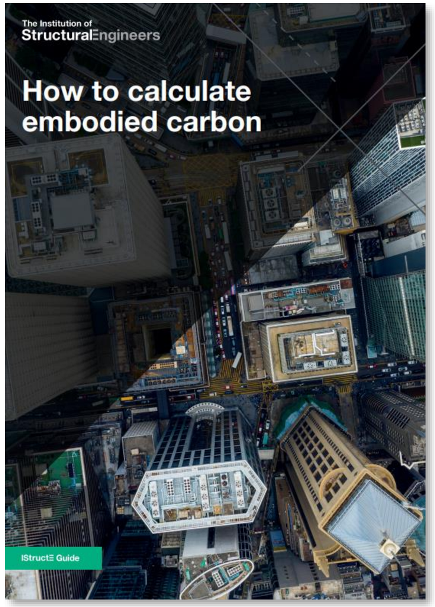

BUILDING LIFE CYCLE INFORMATION
SUPPLEMENTARY INFORMATION BEYOND THE BULDING LIFE CYCLE
A 1 - 3
PRODUCT stage
A1
A2
A3
Raw material supply
Transport
Manufacturing
A 4 - 5
CONSTRUCTION PROCESS stage
A4
A5
Transport
Construction-installation proces
scenario
scenario
B 1 - 7
USE STAGE
B1
B2
B3
B4
B5
Use
Maintenance
Repair
Replacement
Refurbishment
scenario
scenario scenario scenario scenario
B6
Operational energy use
scenario
B7
Operational water use
scenario
C 1 - 4
END OF LIFE stage
C1
C2
C3
C4
De-construction demolition
Transport
Waste processing
Disposal
scenario
scenario
scenario
scenario
D
Benefits and loads beyond the system boundary
Reuse-
Recovery-
Recycling-
potential

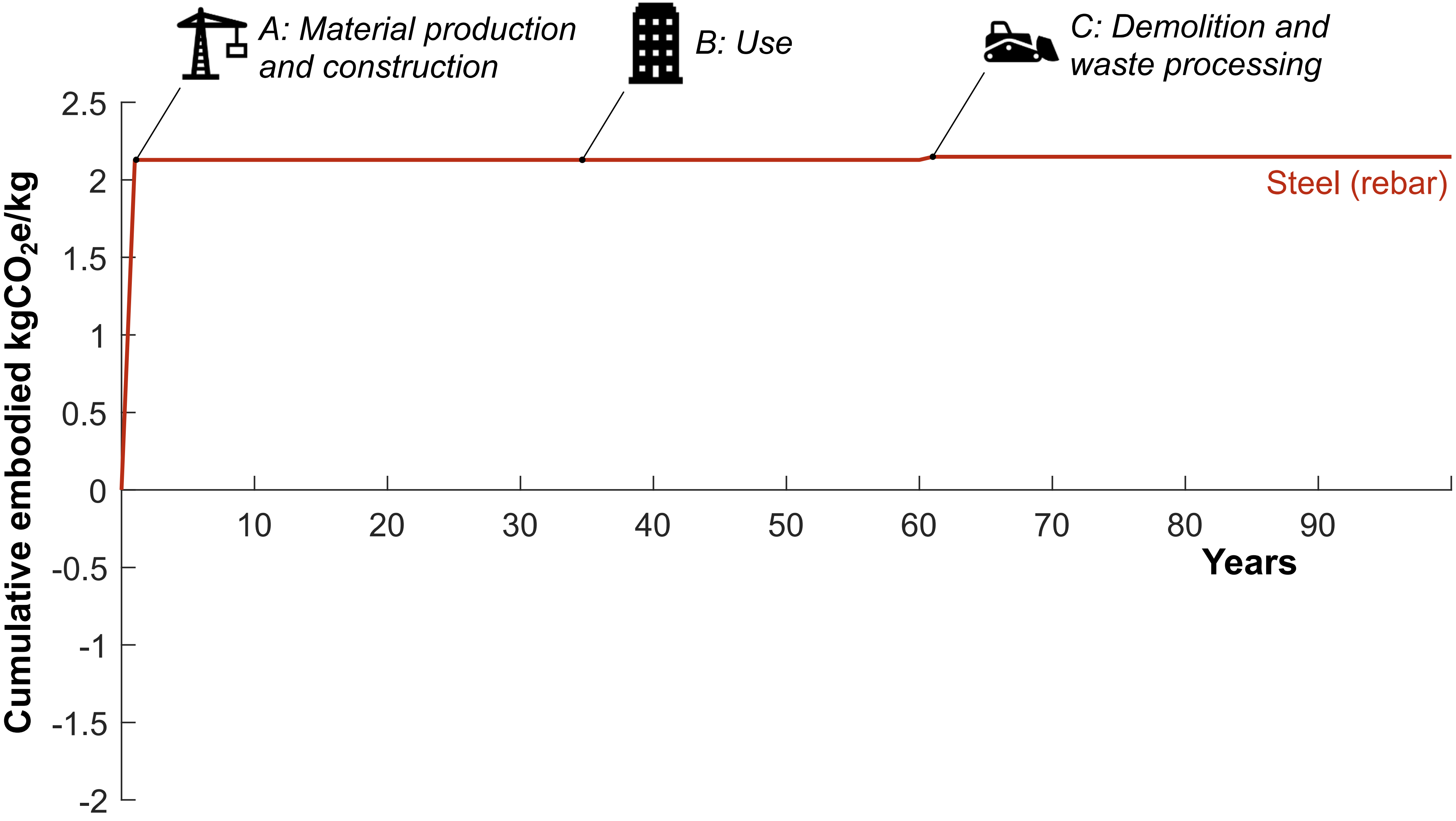

BS EN 15978:2011
EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM
EN 15978
November 2011
ICS 91.040.99
English Version
Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
cen
EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG
Management Centre: Avenue Marnix 17, B-1000 Brussels
© 2011 CEN
Ref. No. EN 15978:2011: E

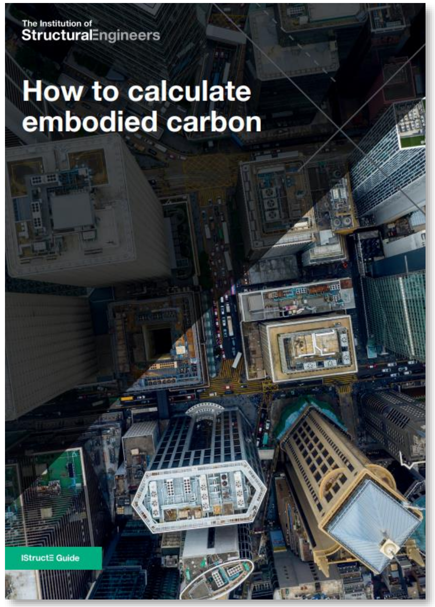

RICS professional statement
RICS
RICS professional standards and guidance, UK
Whole life carbon assessment for the built environment
1st edition, November, 2017
rics.org/guidance

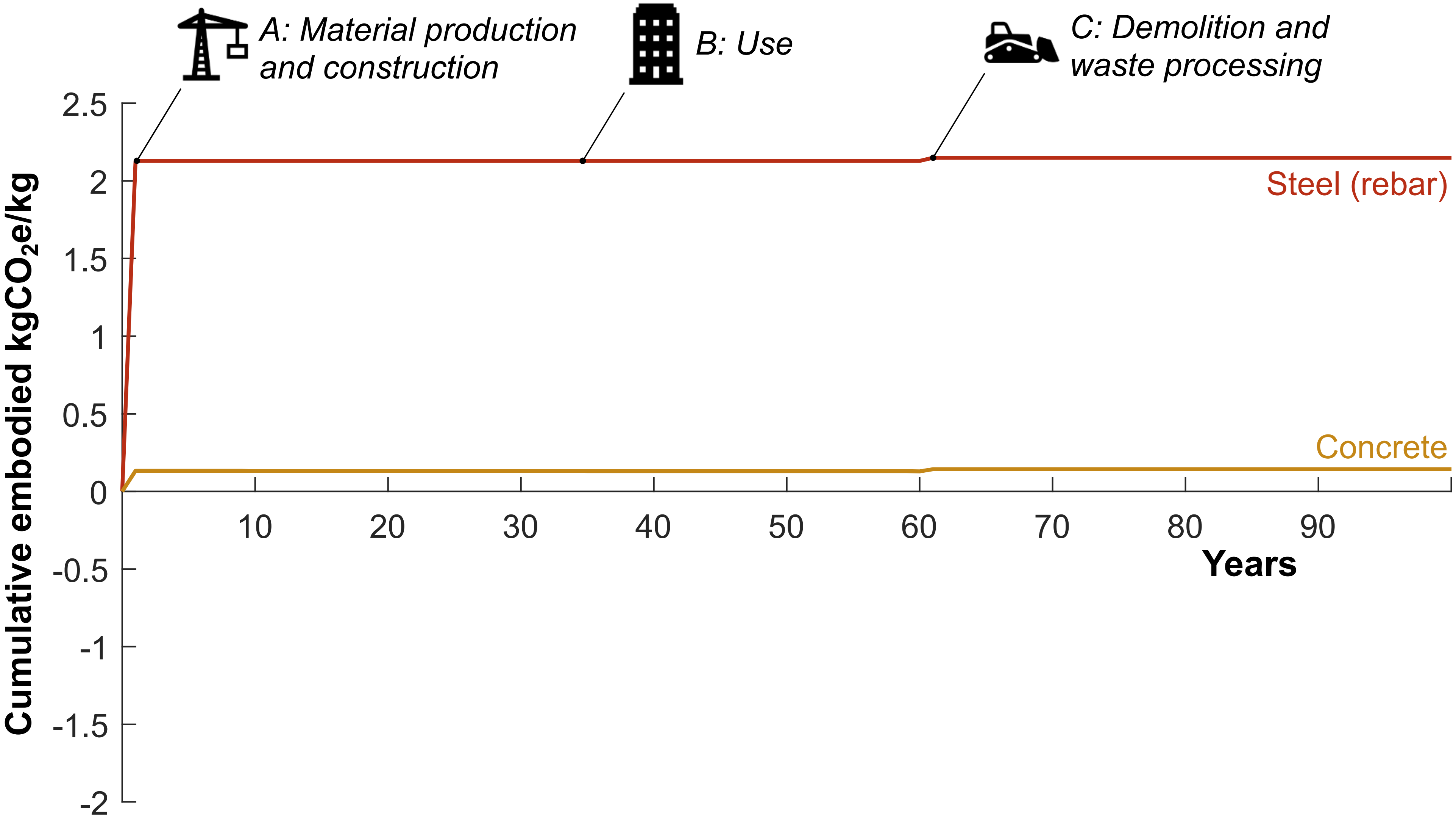

LETI Climate Emergency Design Guide
How new buildings can meet UK climate change targets
2020
2021
2022
2023
2024
2025
2030
Path to zero carbon
LONDON ENERGY TRANSFORMATION INITIATIVE

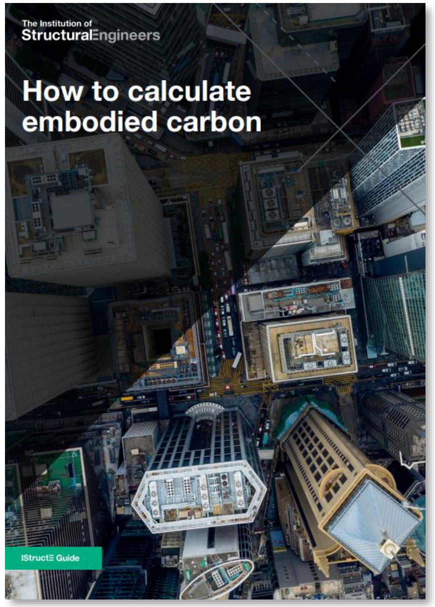

The Institution of StructuralEngineers
How to calculate embodied carbon
IStructE Guide


The Institution of StructuralEngineers
How to calculate embodied carbon
IStructE Guide

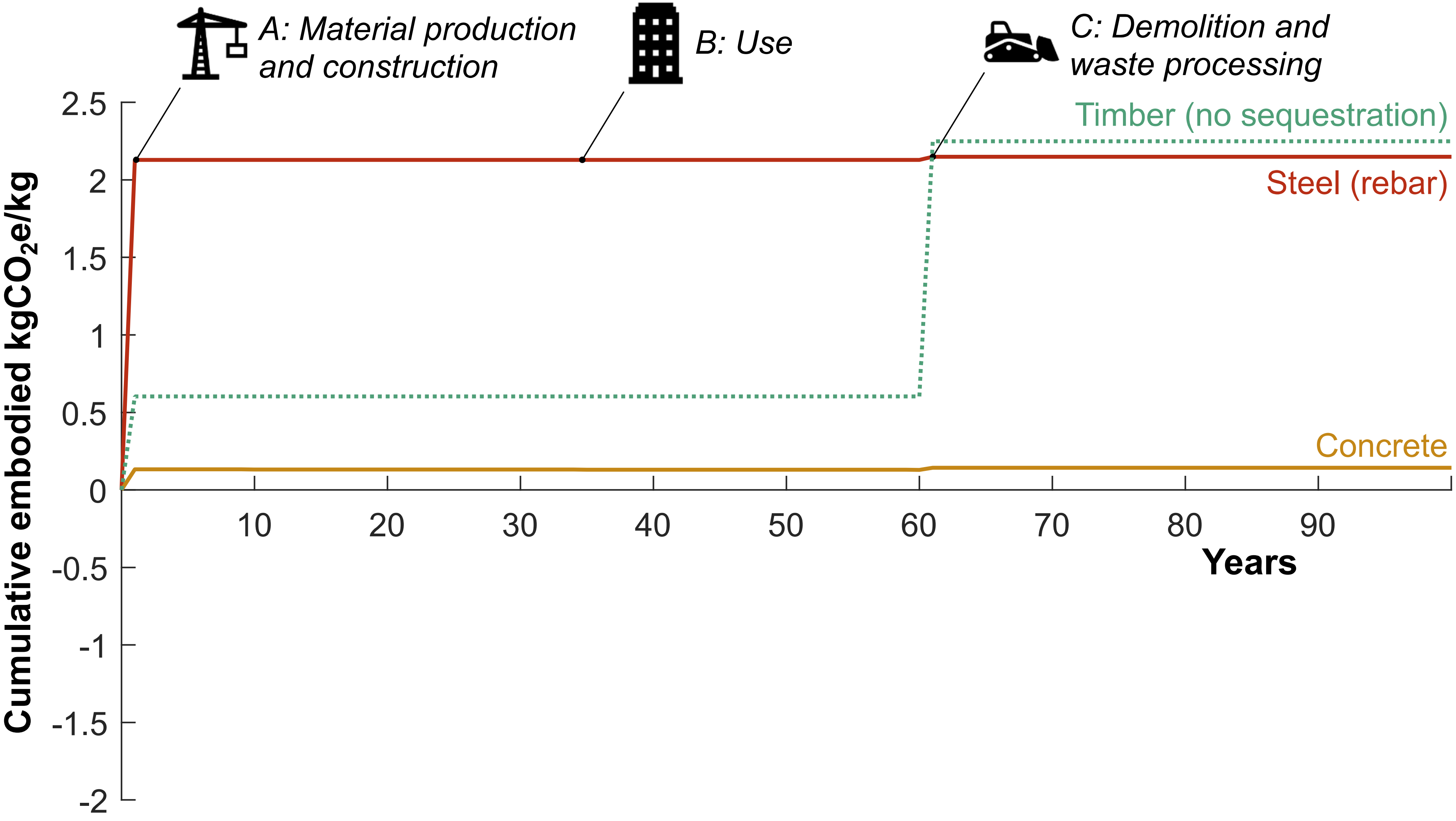

A: Material production and construction
B: Use
C: Demolition and waste processing
Cumulative embodied $kgCO_2e/kg$
Years
Steel (rebar)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
10
20
30
40
50
60
70
80
90


The Institution of StructuralEngineers
How to calculate embodied carbon
IStructE Guide

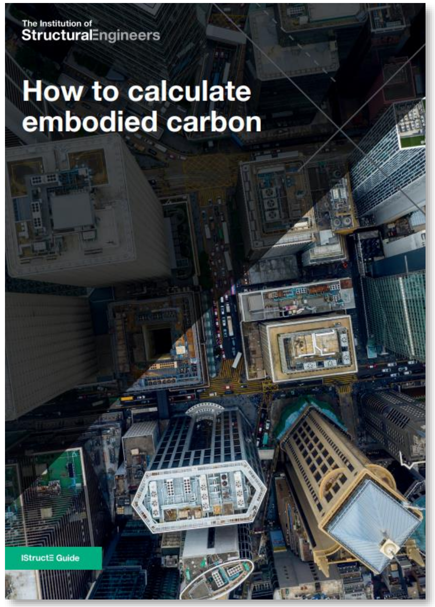

A: Material production and construction
B: Use
C: Demolition and waste processing
Cumulative embodied $kgCO_2e/kg$
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
10
20
30
40
50
60
70
80
90
Years
Steel (rebar)
Concrete

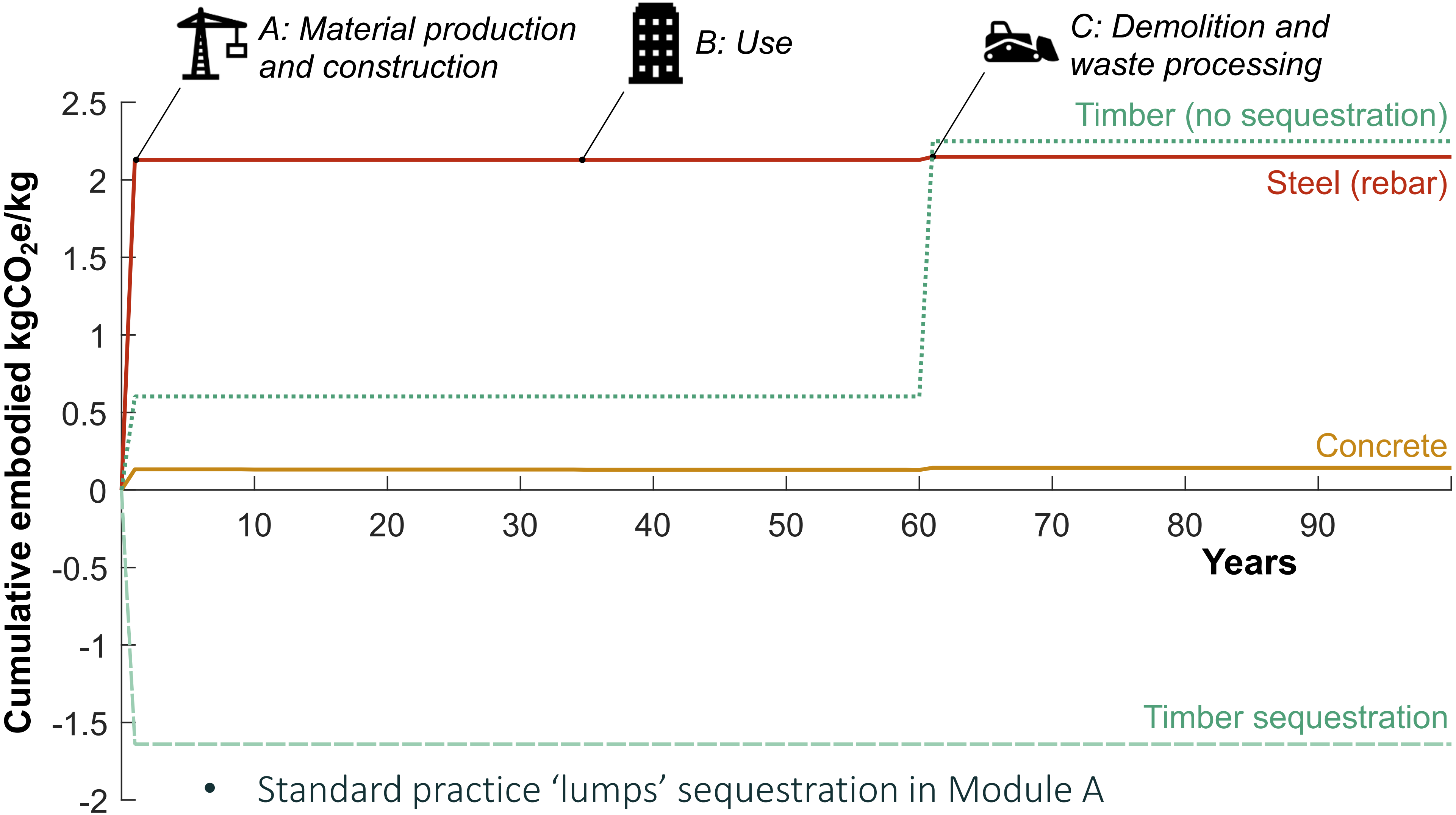


The Institution of
StructuralEngineers
How to calculate embodied carbon
IStructE Guide

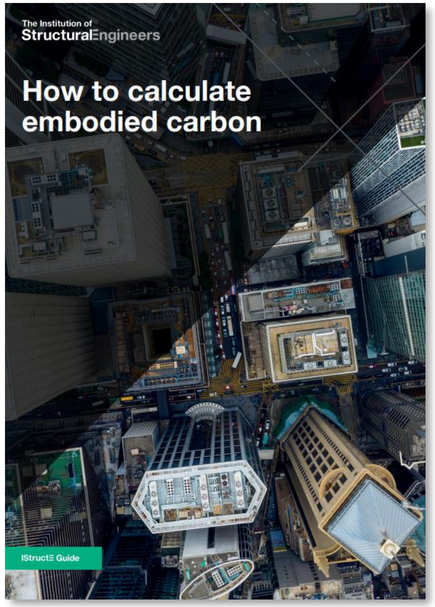


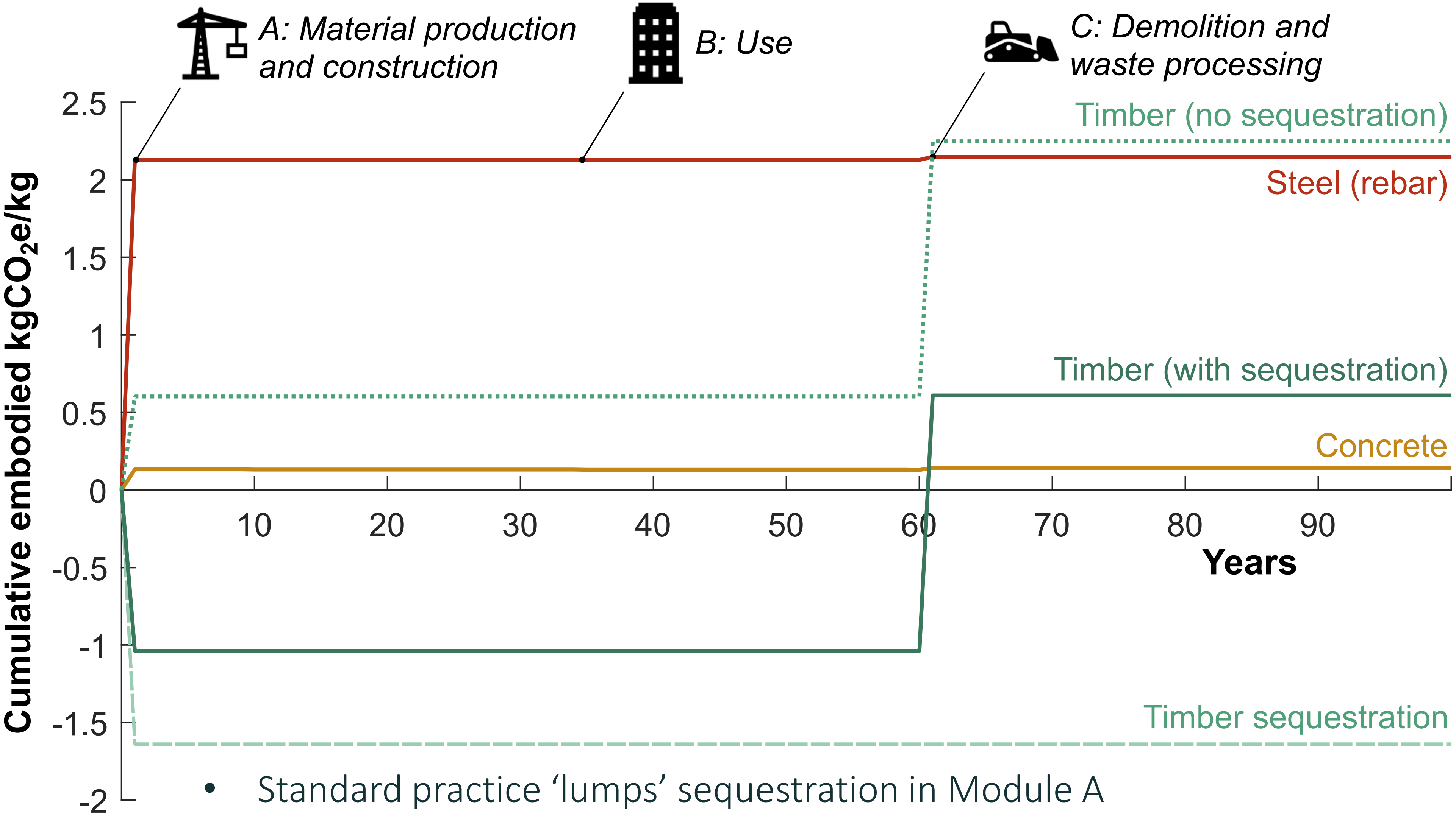
A: Material production and construction
B: Use
C: Demolition and waste processing
Timber (no sequestration)
Steel (rebar)
Concrete
Cumulative embodied $kgCO_2e/kg$
Years
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
10
20
30
40
50
60
70
80
90





- Standard practice ‘lumps’ sequestration in Module A
  - E.g. RICS guide, ICE database





- Standard practice ‘lumps’ sequestration in Module A
    - E.g. RICS guide, ICE database
- What is the climate impact of delaying emissions?
- How can we compare biogenic and non-biogenic materials?

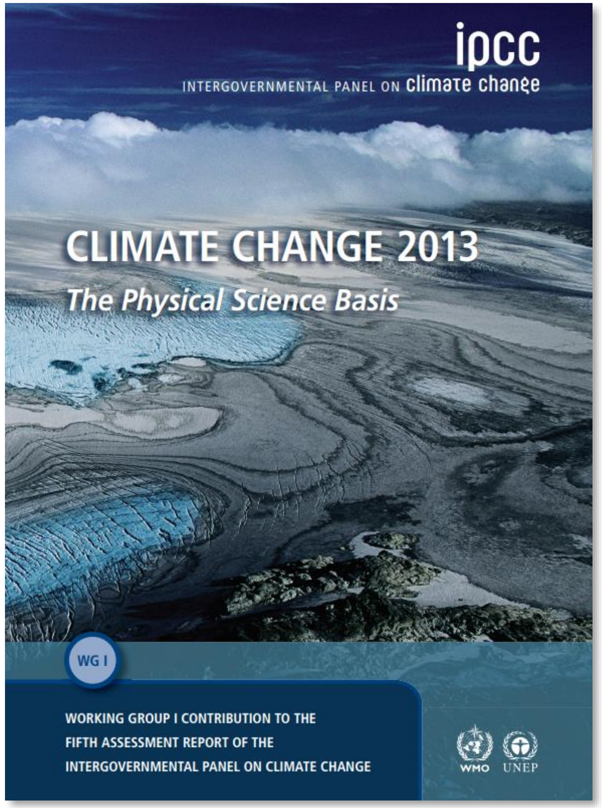
Dynamic life cycle assessment

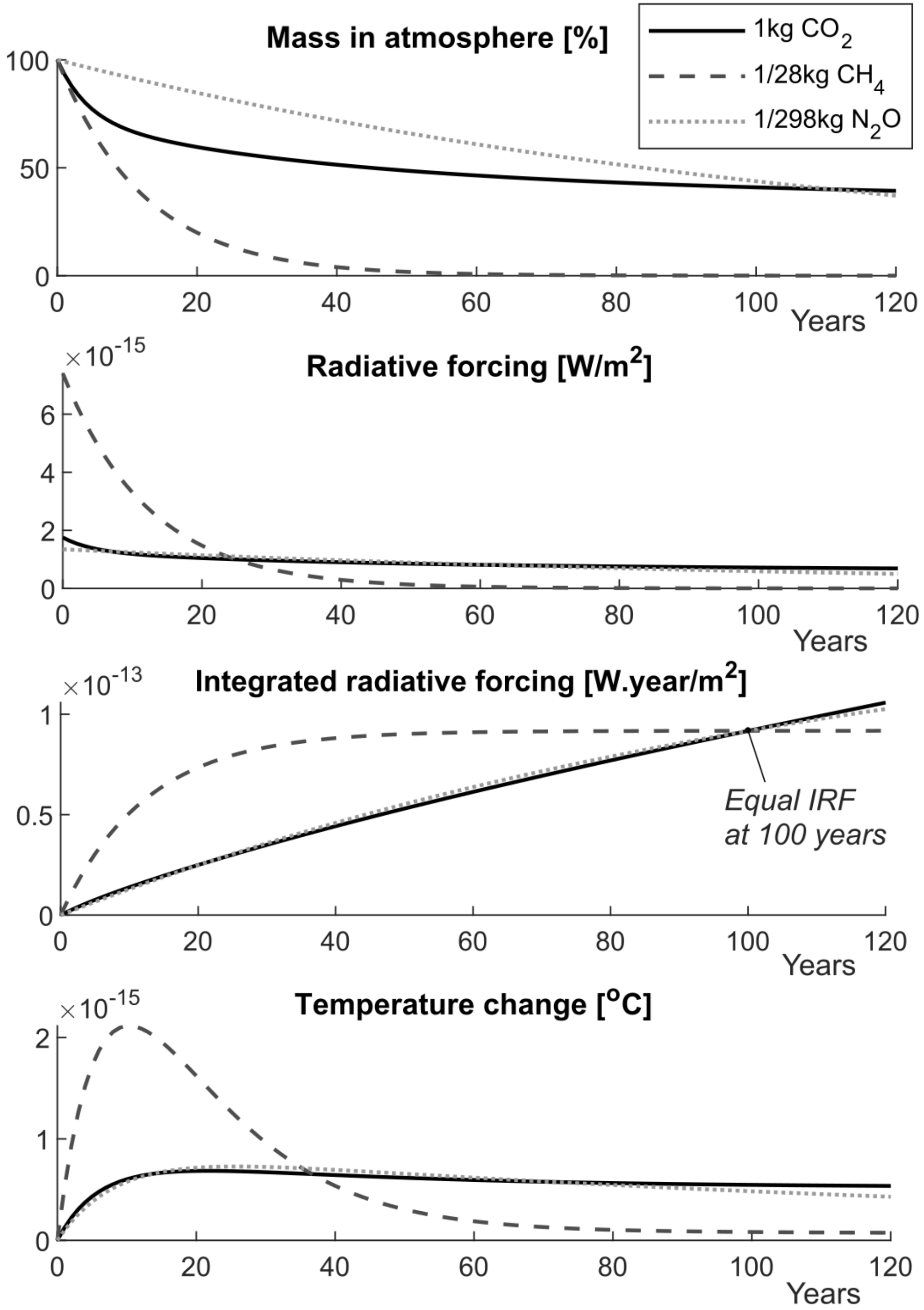
- Dynamic climate model using impulse functions:

  IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp

- Easily implemented using an open-source excel tool:

  Cooper, S., 2020. Temporal Climate Impacts. Bath: University of Bath Research Data Archive. Available from: https://doi.org/10.15125/BATH-00923.

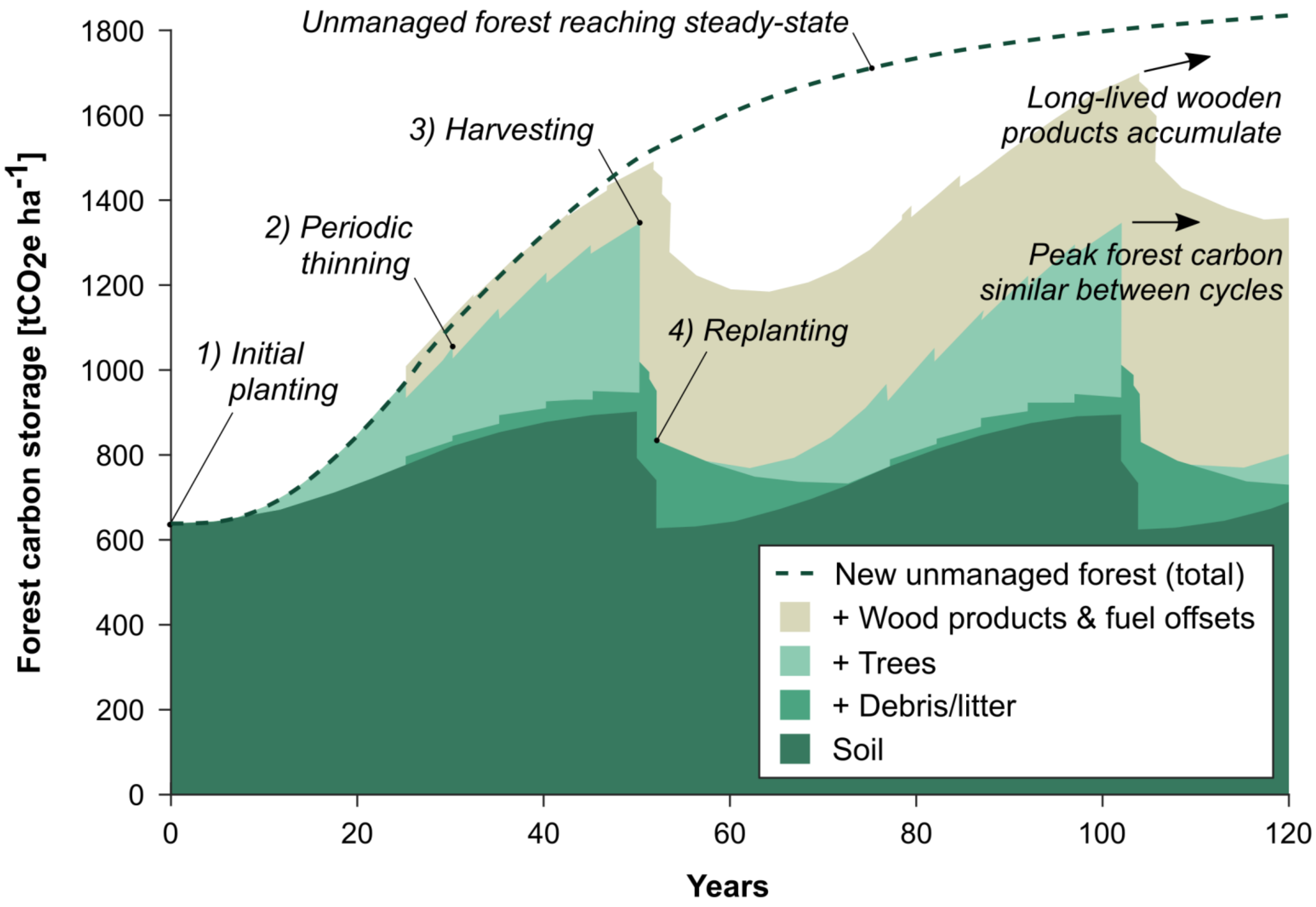


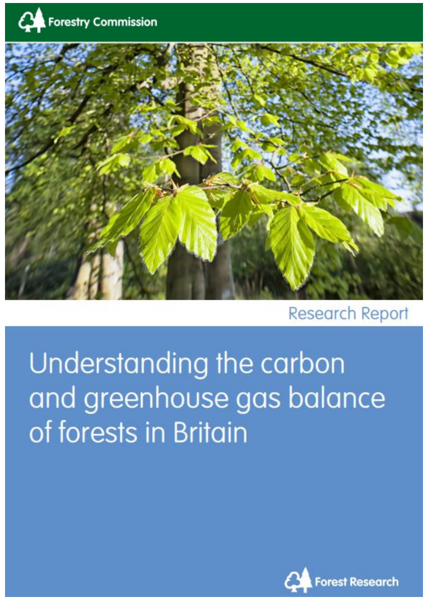


Approaches to sequestration

- The ‘lumped’ approach models an instantaneous removal of carbon from the atmosphere

  …but forests absorb carbon gradually:

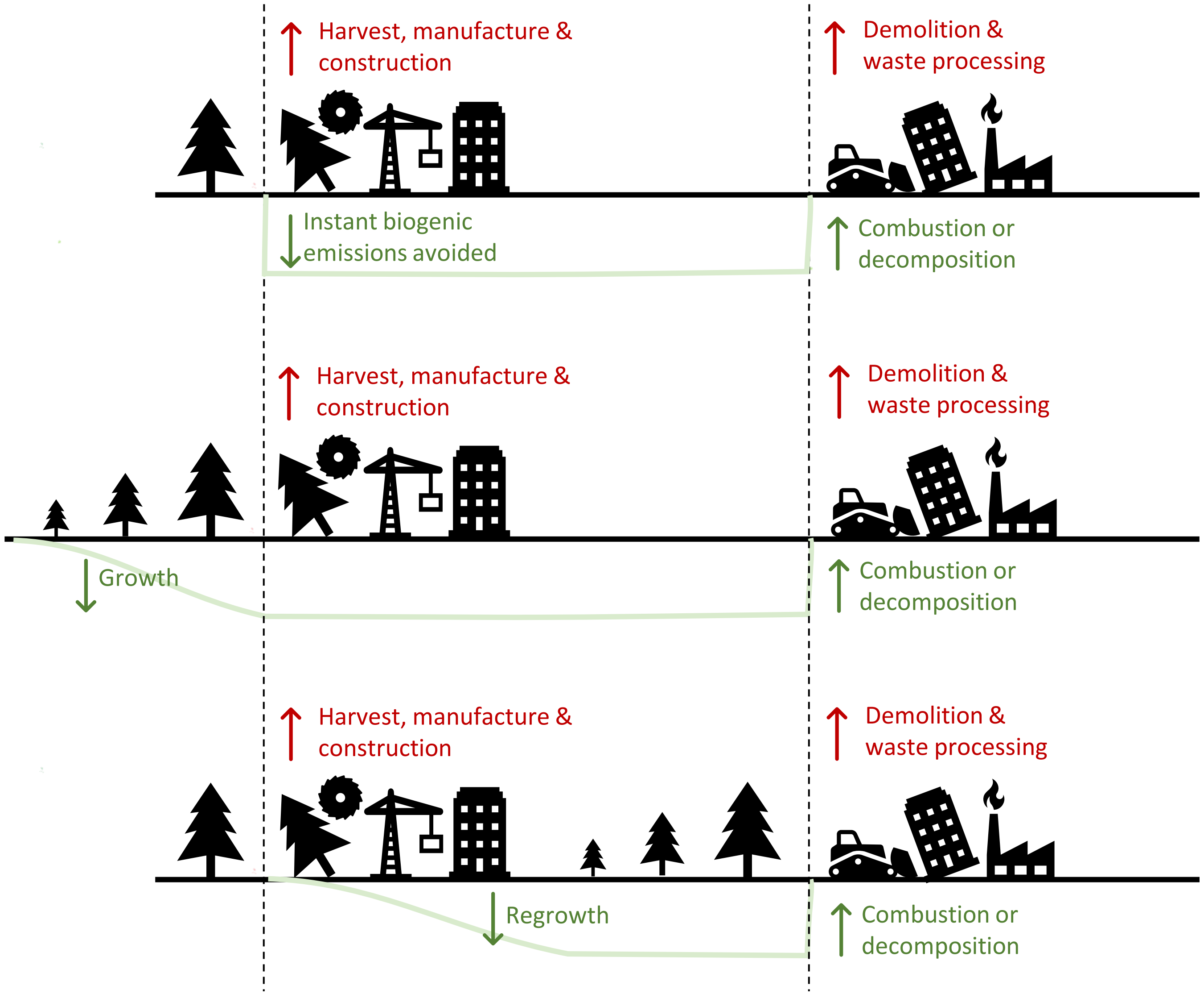




Adapted from:

J. Morison, R. Matthews, G. Miller, M. Perks, T. Randle, E. Vanguelova, M. White, and S. Yamulki. Understanding the carbon and greenhouse gas balance of forests in Britain. Research Report - Forestry Commission, UK, (No.018), 2012.

Approaches to sequestration



Lumped

- Assumes instant emission of harvested wood avoided
- Negative carbon for:

  building lifespan

Backward looking

- Starts and finishes with no forest
- Tracks the carbon in the timber structure
- Negative carbon for:

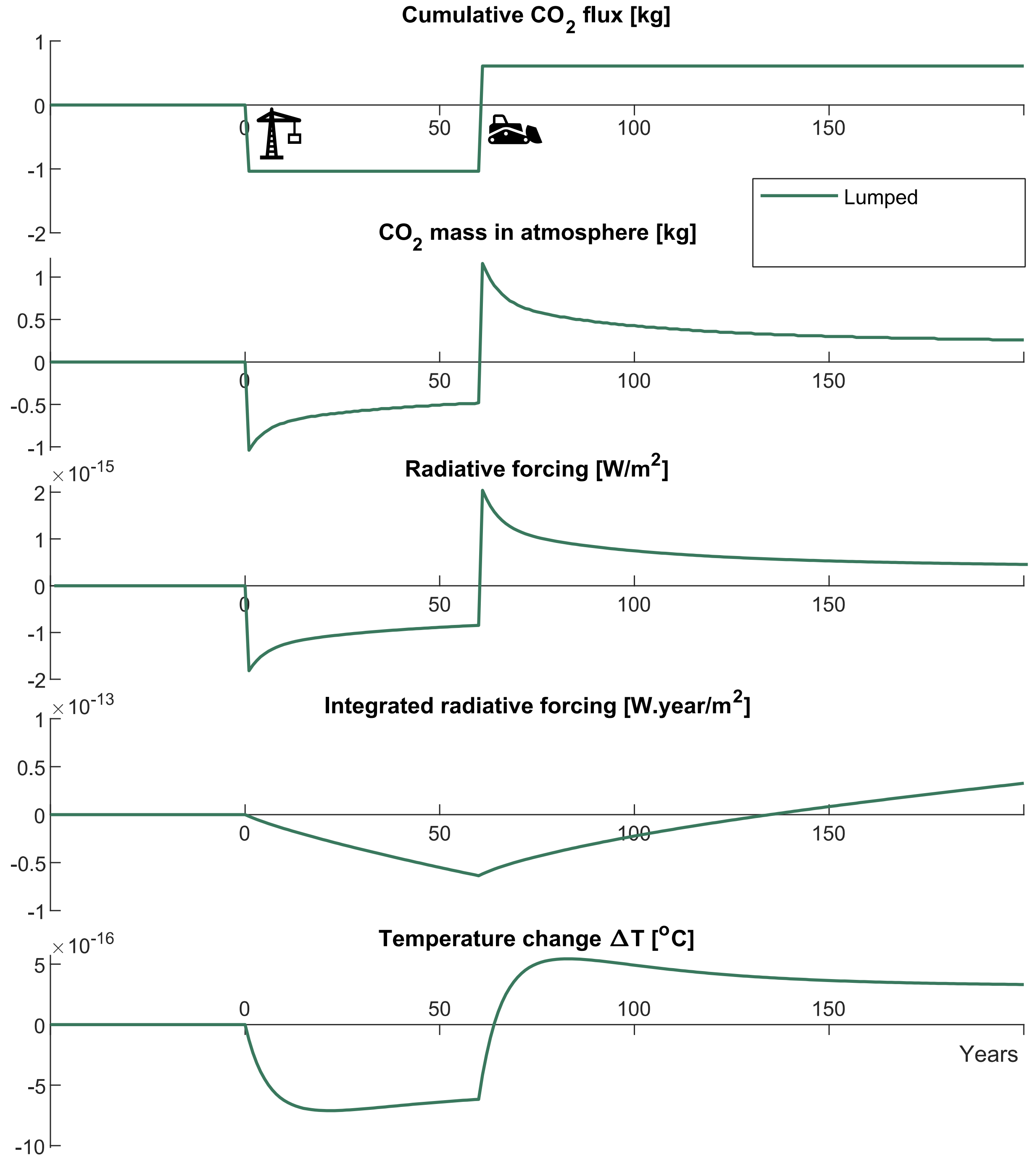
  building lifespan + growth period

Forward looking

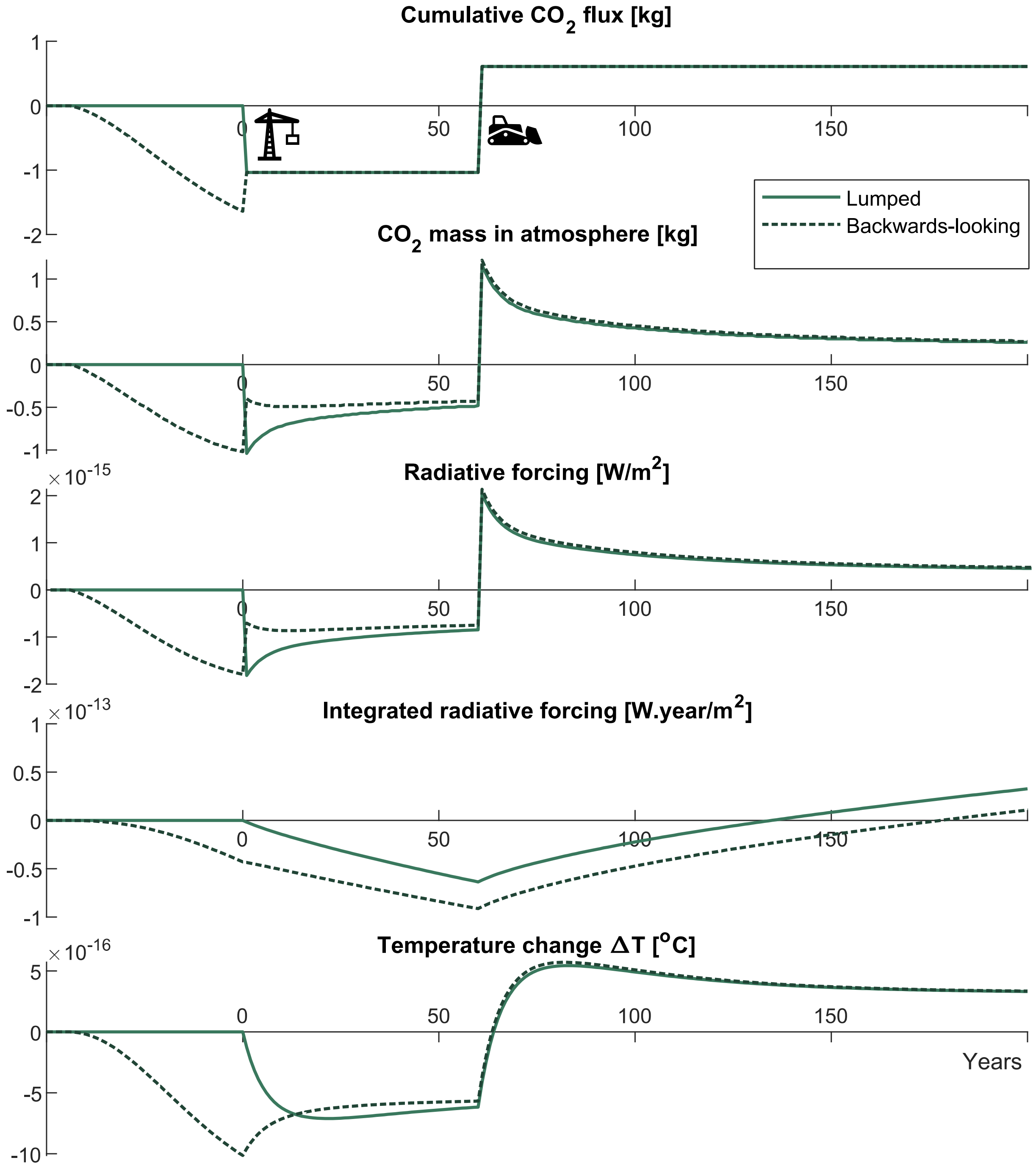
- Starts and finishes with forest
- Tracks the carbon fluxes into the atmosphere
- Negative carbon for:

  building lifespan – growth period

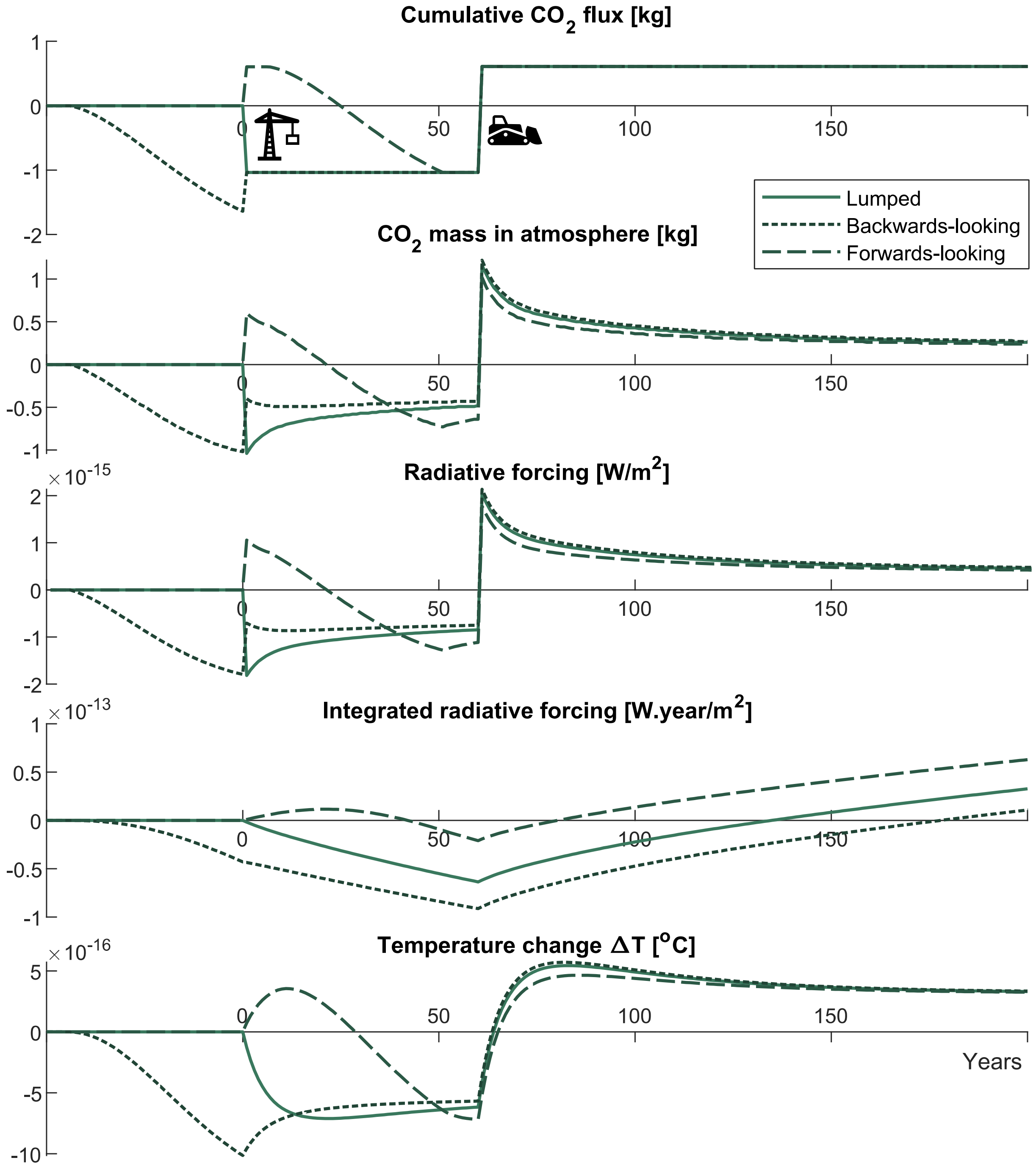
Comparison of sequestration approaches



Comparison of sequestration approaches



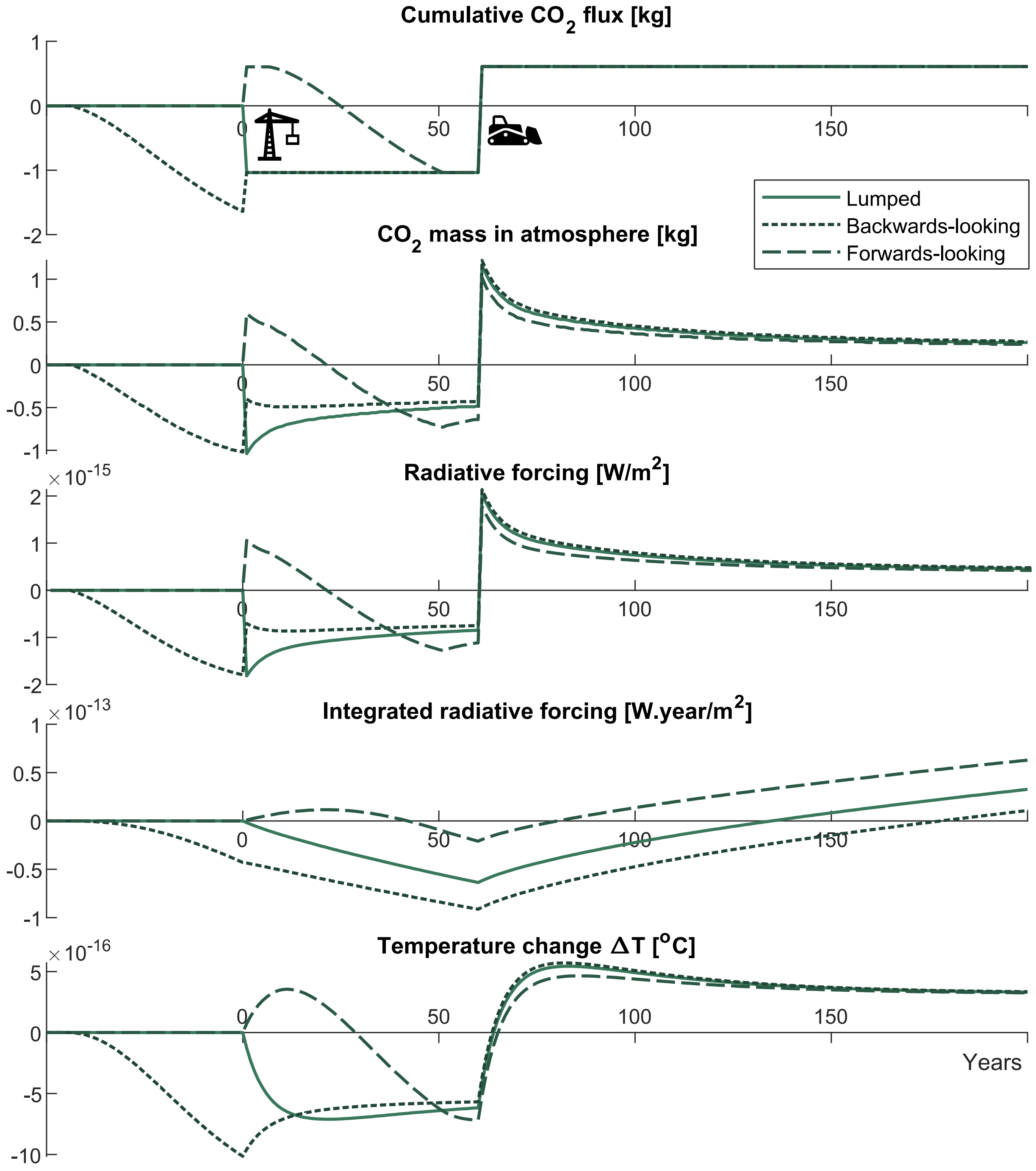
Comparison of sequestration approaches



Comparison of sequestration approaches

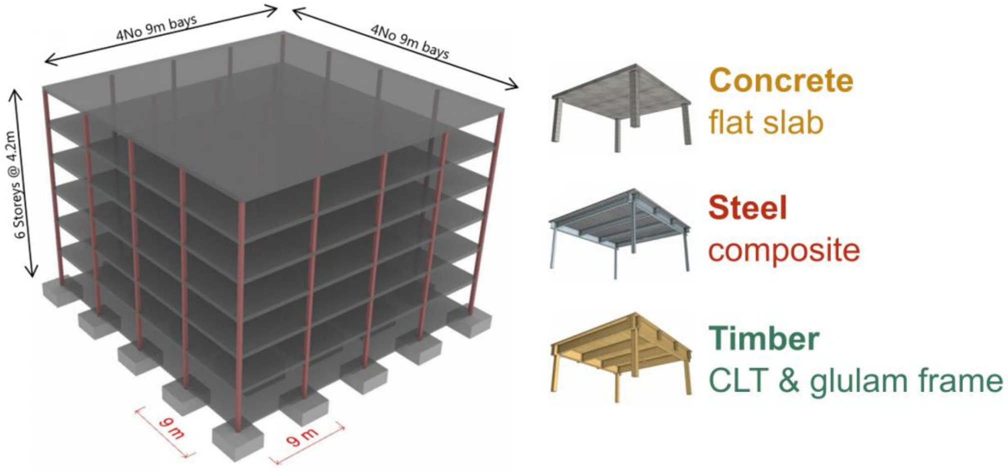
- The treatment of sequestration has a significant impact on climate response
- **Forward-looking approach** recommended:
  - Starts at zero, and models carbon fluxes from a climate perspective thereafter
  - Exposes production (A1-3) emissions
  - Encourages re-planting – consistent with sustainable certification (e.g. FSC)
  - Encourages longer building life AND faster regrowth
  - Evidence shows a delay between increased timber demand and forest storage:

    Abt, Karen L., et al. "Effect of policies on pellet production and forests in the US South: a technical document supporting the Forest Service update of the 2010 RPA Assessment." Gen. Tech. Rep. SRS-202, Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station. 33 p. 202 (2014).

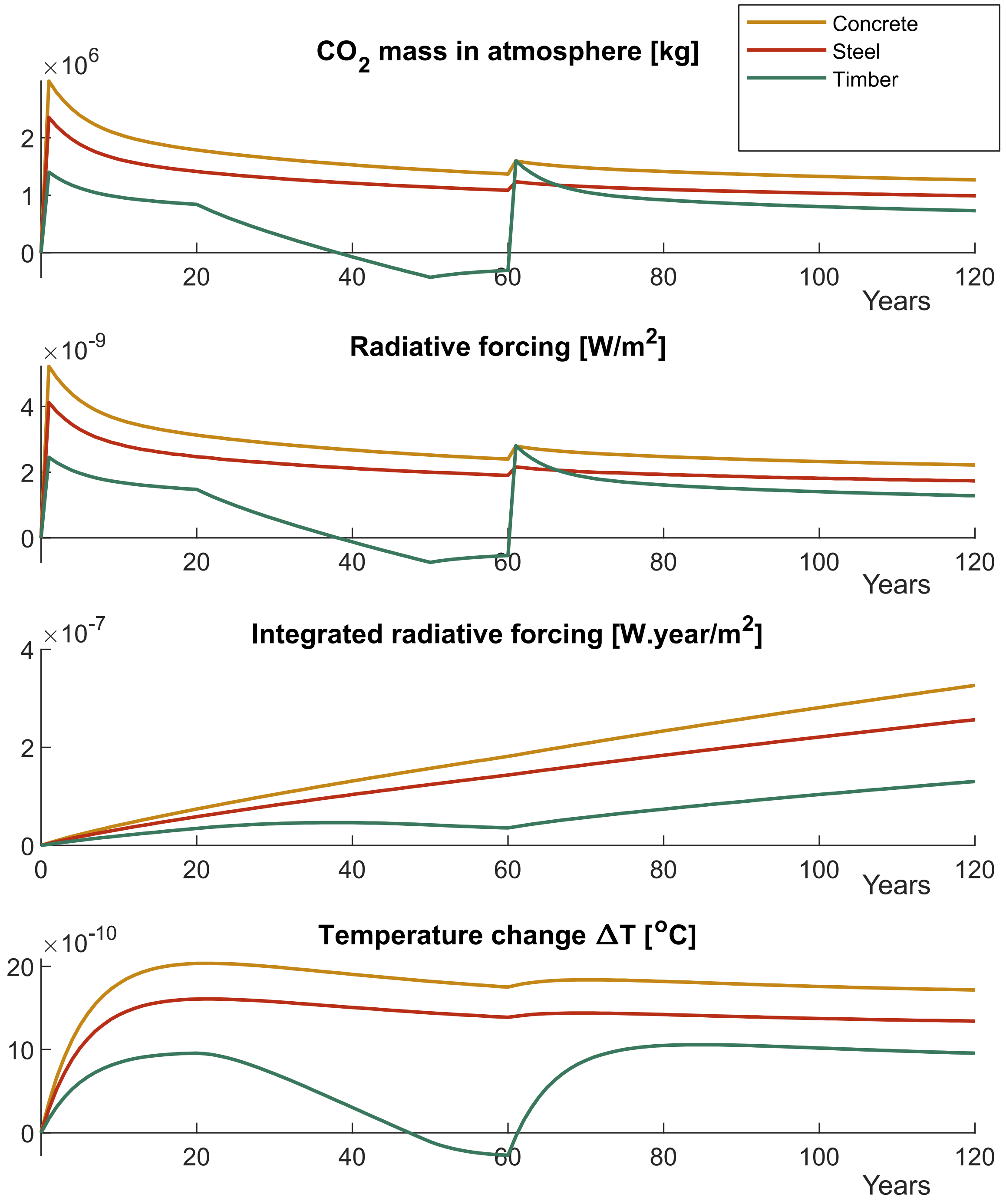


Comparison of a concrete, steel and timber building

- Comparative study published by BuroHappold and IStructE.

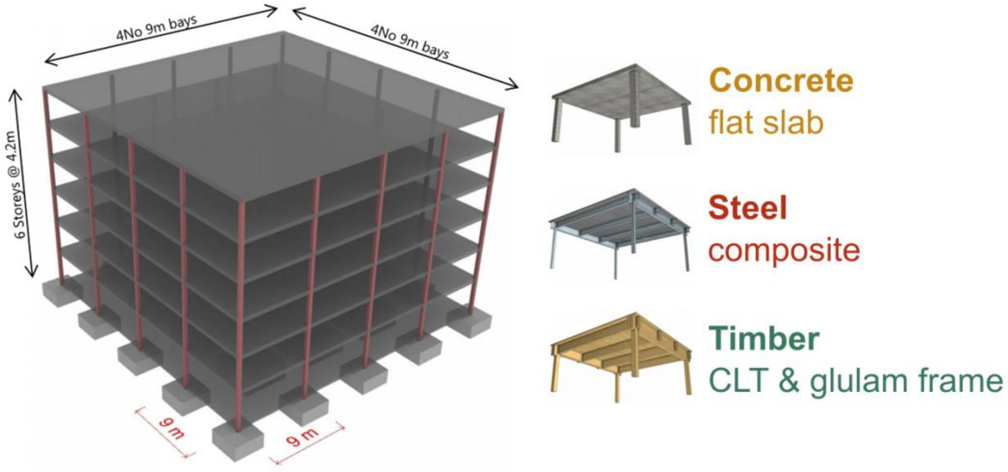


- Initial (A1-5) emissions create large temperature changes and dominate IRF
- Long-term temperature change is similar to Module A
- Climate-positive period of timber is prolonged by increased life and/or quicker re-growth

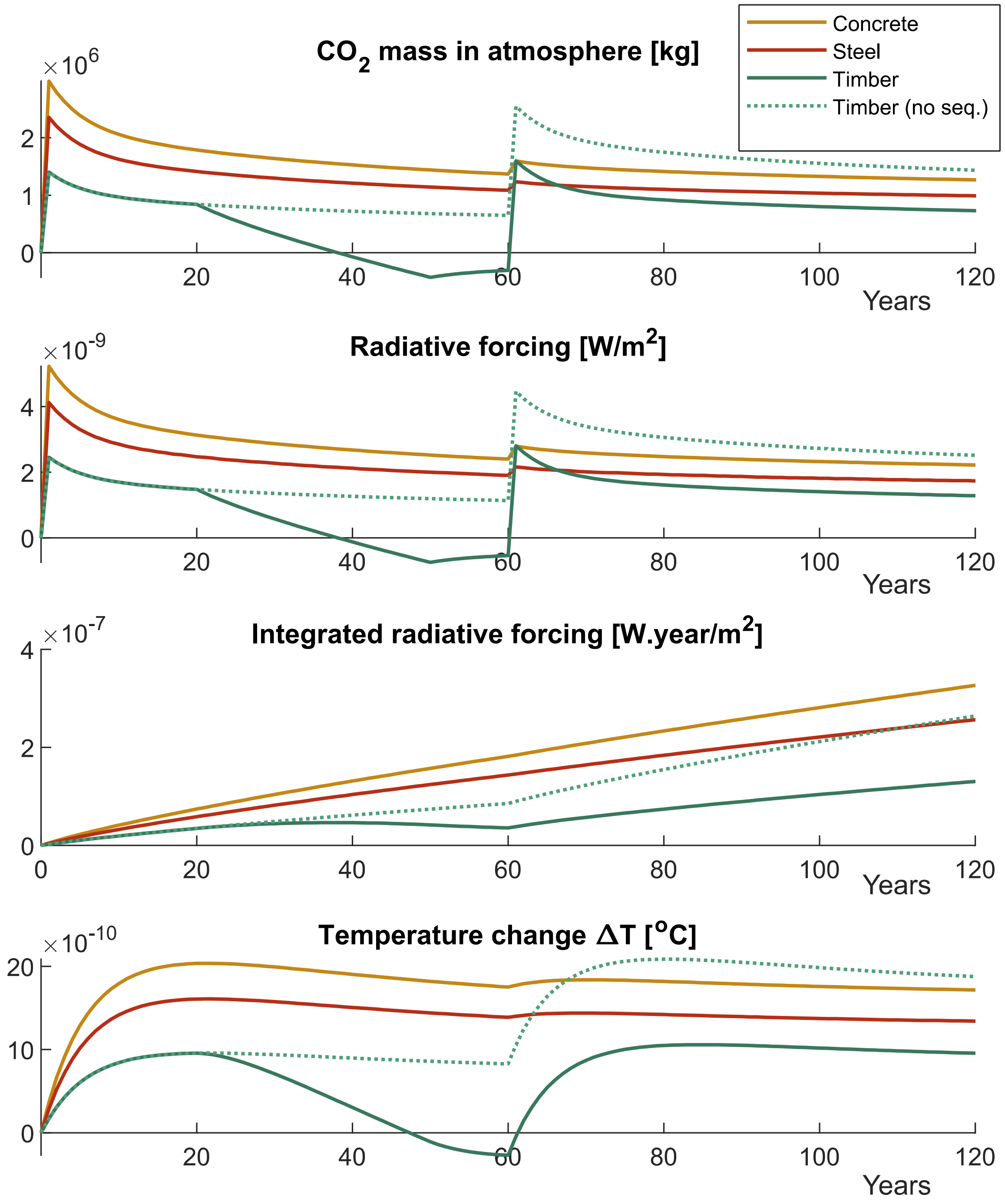


Comparison of a concrete, steel and timber building

- Comparative study published by BuroHappold and IStructE.

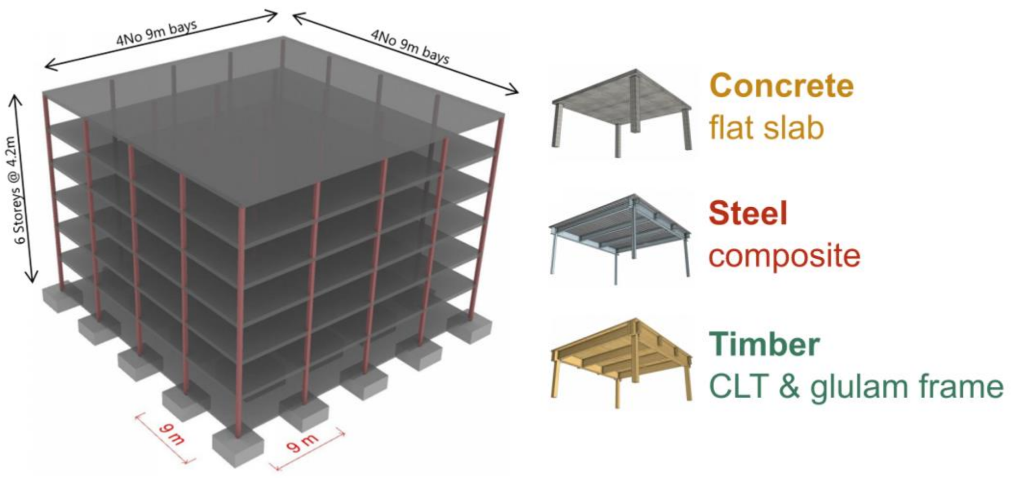


- Initial (A1-5) emissions create large temperature changes and dominate IRF
- Long-term temperature change is similar to Module A
- Climate-positive period of timber is prolonged by increased life and/or quicker re-growth
- If no re-planting occurs, timber can have the largest long-term impact

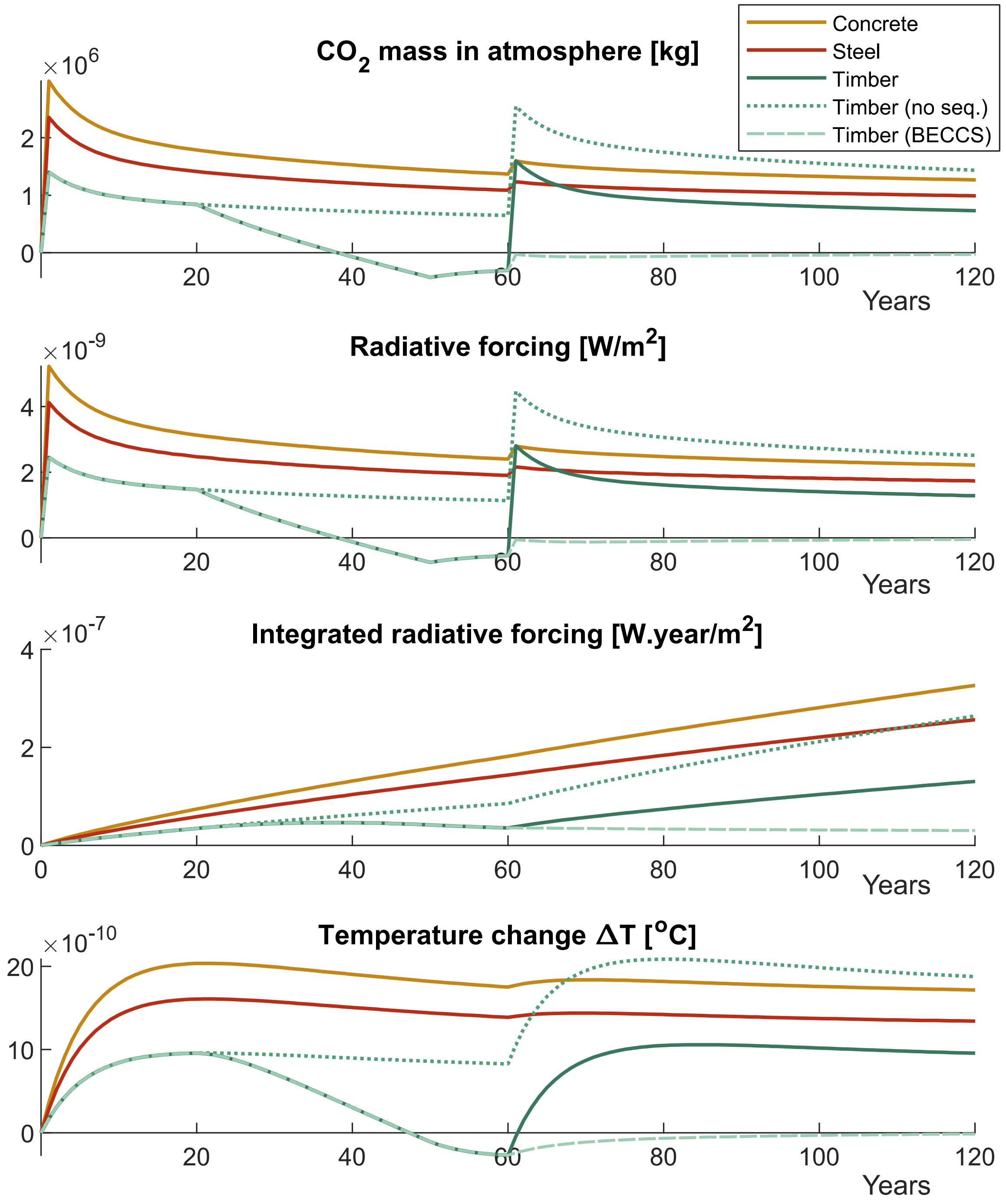


Comparison of a concrete, steel and timber building

- Comparative study published by BuroHappold and IStructE.



- Initial (A1-5) emissions create large temperature changes and dominate IRF
- Long-term temperature change is similar to Module A
- Climate-positive period of timber is prolonged by increased life and/or quicker re-growth
- If no re-planting occurs, timber can have the largest long-term impact
- If timber end-of-life emissions are avoided, we could have a climate-positive building in the long-term



Thank you

Associated publications

Hawkins, W. (2021). Timber and carbon sequestration. The Structural Engineer, 99(1), 18-20.

Hawkins W., Cooper S., Bukauskas A., Allen S., Roynon J., Ibell T. (2021) 'Rational whole-life carbon assessment using a dynamic climate model: Comparison of a concrete, steel and timber building structure', Structures (in press)

Thanks to

Sam Cooper, Aurimas Bukauskas, Steve Allen, Will Arnold, Jonathan Roynon