Energy and carbon balance of materials used in a building envelope renovation

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Background

- Construction and demolition (C&D) waste contributes to over 25% of all waste generated.
- The Directive 2008/98/EC on waste requires a minimum of 70% the C&D waste recovery by 2020, promoting high quality recycling.
- In Sweden, C&D waste accounts for the highest share of primary waste and has been increasing in the last few years.
- In Sweden, 30% of the current existing building stock is expected to require major renovations in the coming years.
- In future, retrofitting works could affect the C&D waste generation significantly.

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Research questions

What are the energy and carbon impacts of retrofitting a building…

1. …in the production phase?

2. …in the end-of-life phase?

3. Can the recovery of C&D waste reduce the production primary energy and carbon emission of buildings?

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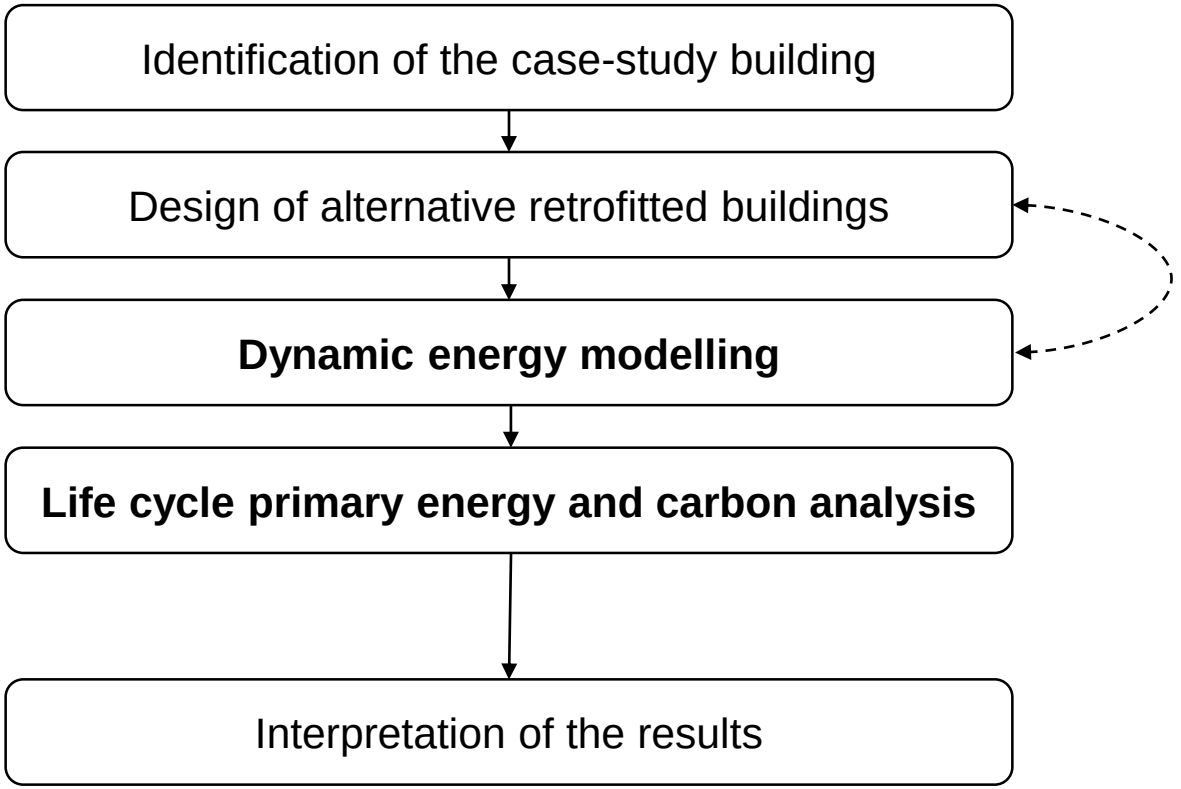
Research structure and methods



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Case study

- **Location:** Ronneby, Southern Sweden
- **Year of construction:** 1974
- **Building type:** concrete-framed building
- **Total heated floor area:** 2000 m^2
- **Ventilation system:** mechanical ventilation for exhaust air
- **Heat energy supply:** district heating system

Assumed to be retrofitted to **30 kWh/m²,year** (Passive House Institute standard)

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Design of the retrofitted building

The following retrofitting measures are adopted:

efficiency upgrade of technical devices

Retrofitting measures	Unit	Initial building	Retrofitted building
Ventilation fans	%	33%	50%
ventilation heat recovery (VHR) unit	%	76%	85%
Efficient water taps	% (energy saving)	-	-40%

thermal improvement of the building envelope

Retrofitting measures	Unit	Initial building	Retrofitted building
Airtightness	l/sm^2 (at 50 Pa)	0,8	0,3
Extra insulation - attic	cm	0	+28/36
Extra insulation - walls	cm	0	+16/17
Extra insulation - basement	cm	0	+19/20
U-value windows	W/m^{2}K	2.,9	0.,6

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Comparing alternative building materials

We combine alternative building materials for:

thermal insulation

- glass wool (G)
- rock wool (R)
- wood fibre (W)

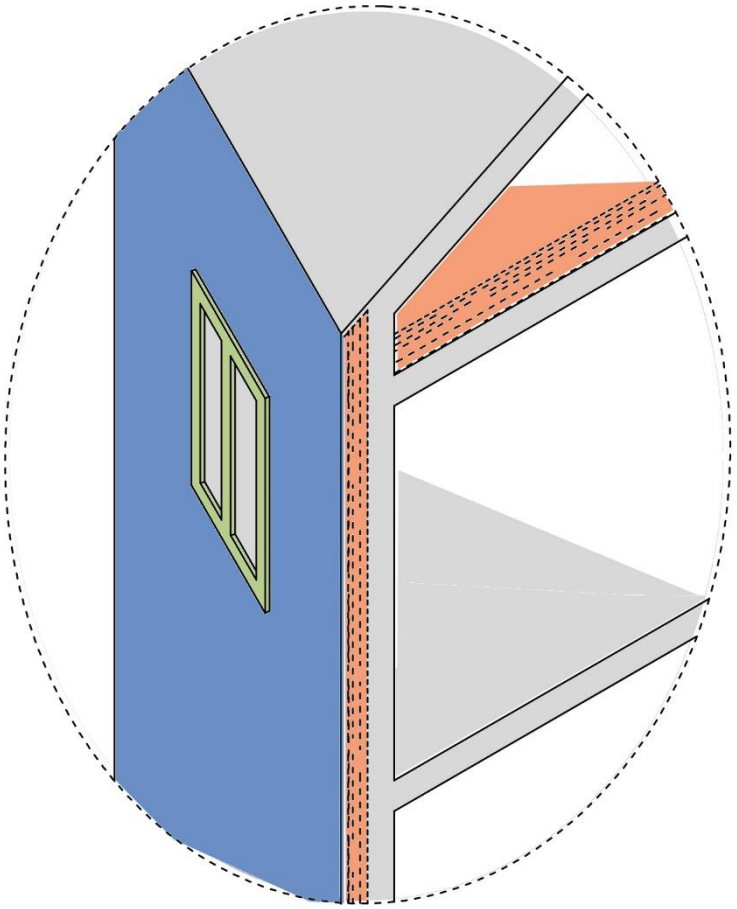
building cladding

- aluminium cladding (A)
- clay tiles cladding (B)
- wood cladding (W)

windows

- aluminium-framed windows (A)
- wood-framed windows (W)

Number of alternatives: 18.



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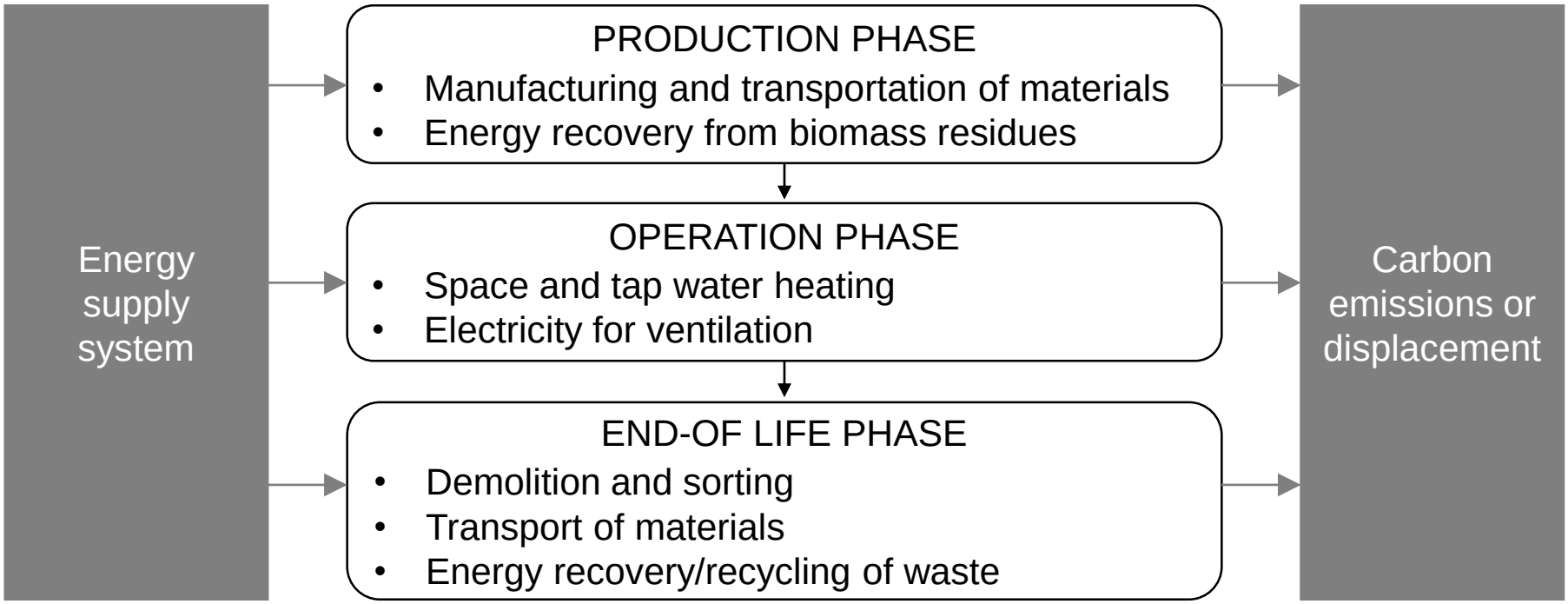
Life Cycle Analysis



Assumed building's service life: **50 years**

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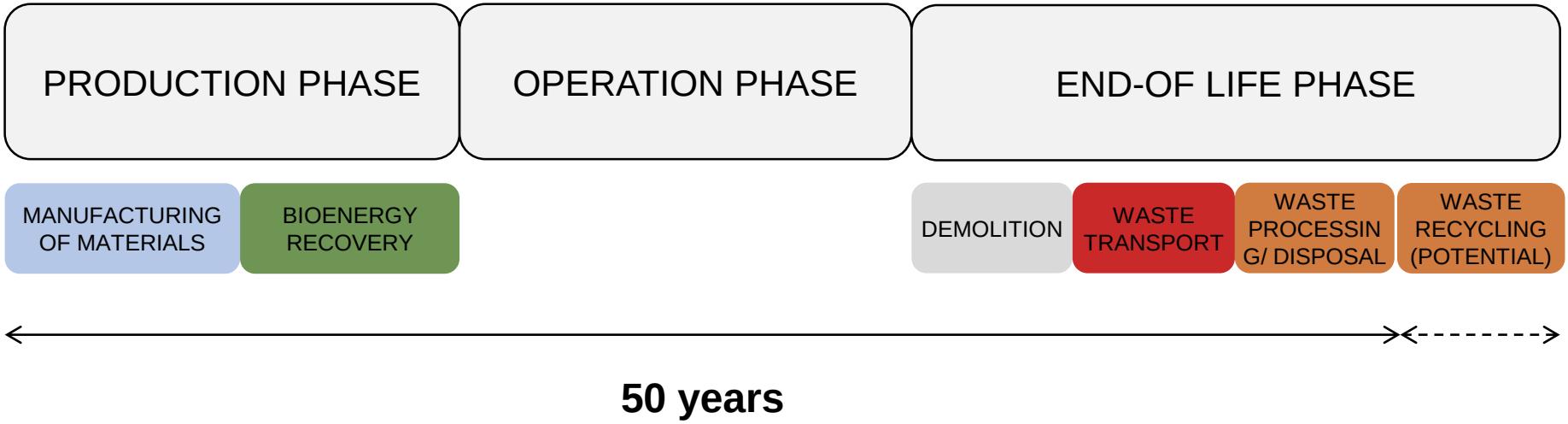
Life Cycle Phases Composition



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Assumed end-of-life options and recycling rates

Building material	Disposal		Recovery rate [%]		Recycling efficiency [% weight]
	Current scenario	Future scenario	Current scenario	Future scenario	
Aluminium	recycle		90	98	96
Brick	backfill		90	95	15
Glass*	landfill	recycle	0	50	120
Mineral wool*	landfill	recycle	0	90	9
Wood	energy recovery		90	90	100
XPS	energy recovery		90	90	100

*** Materials expected to be recycled in the future scenario.**

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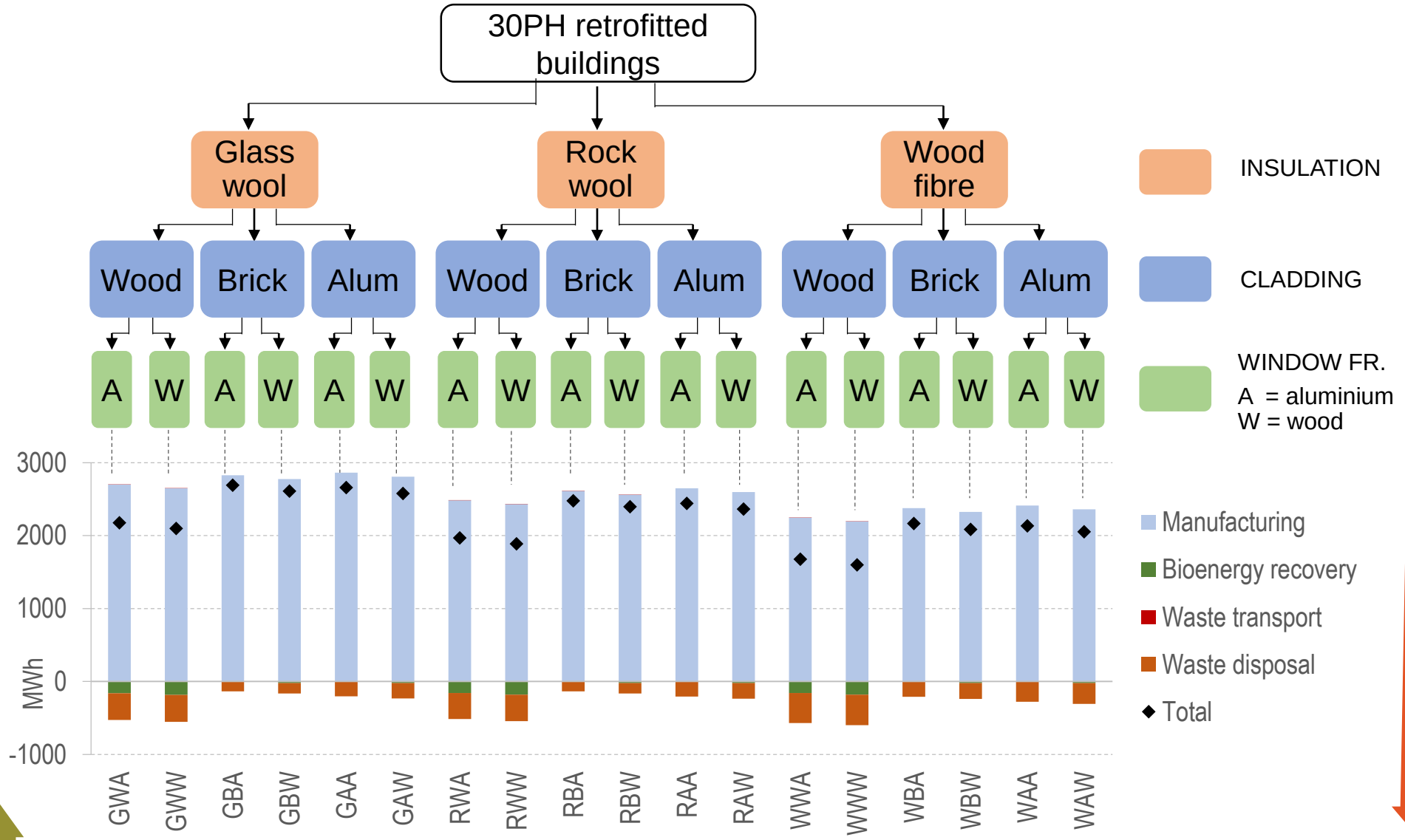
Results: Primary Energy (MWh)



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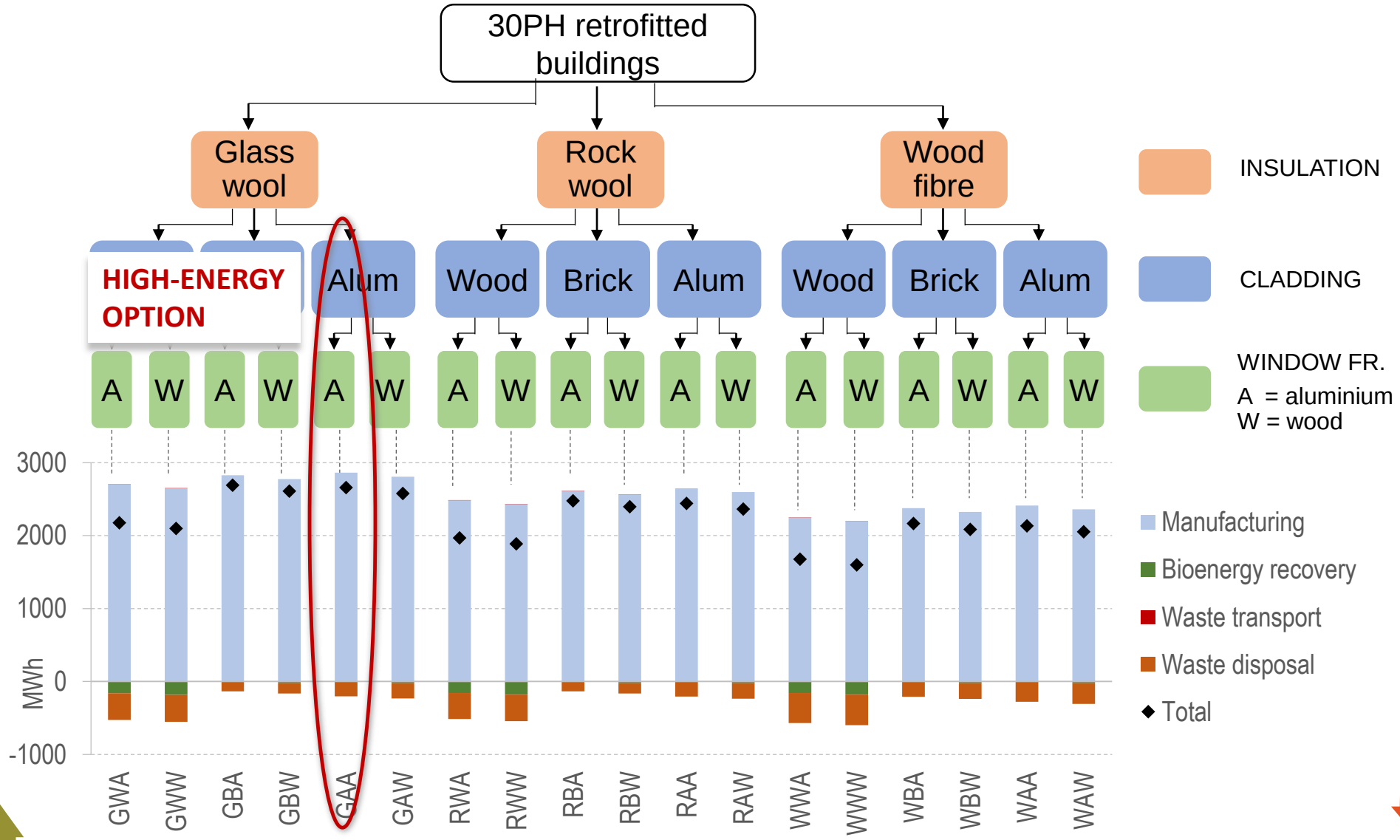

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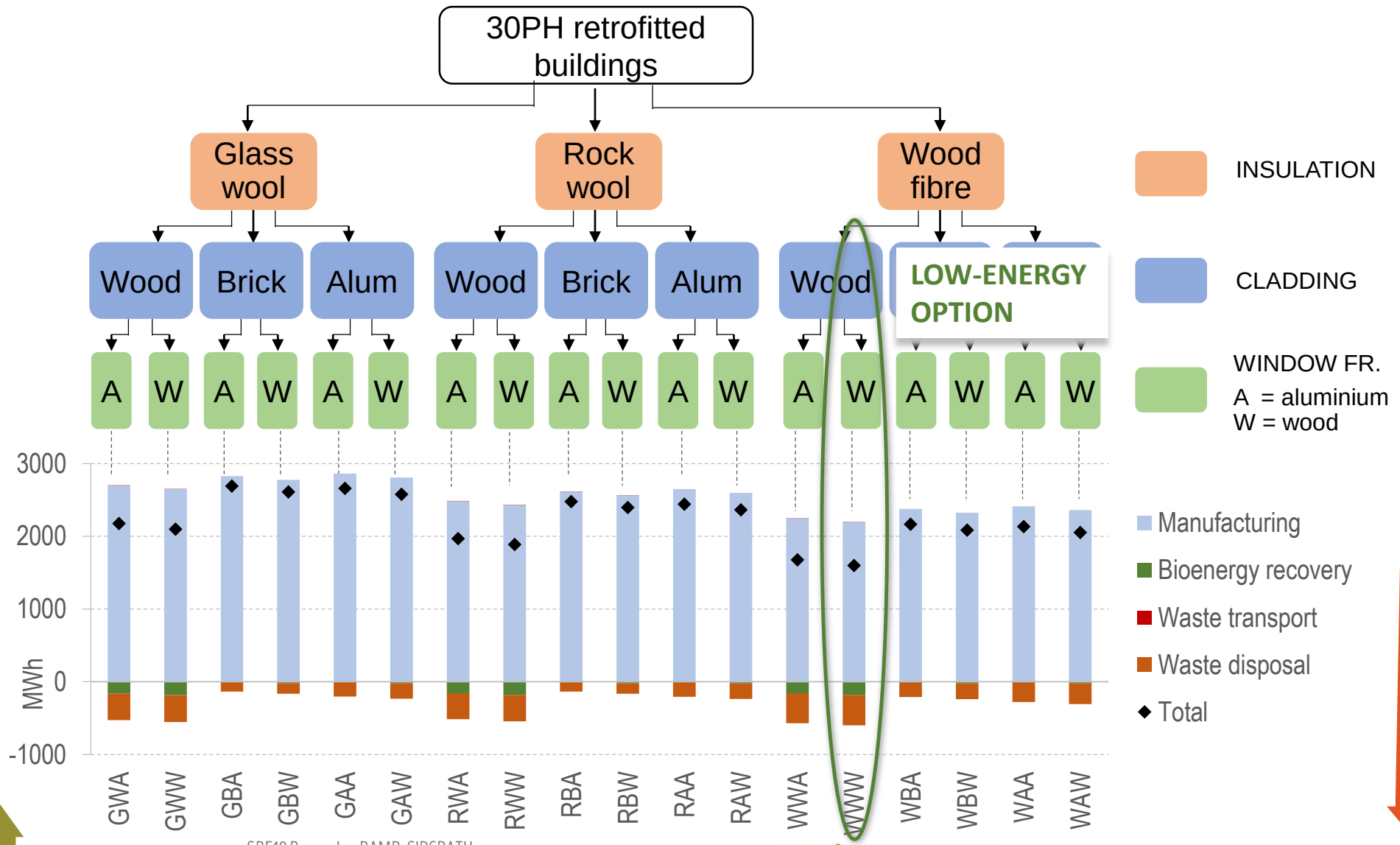

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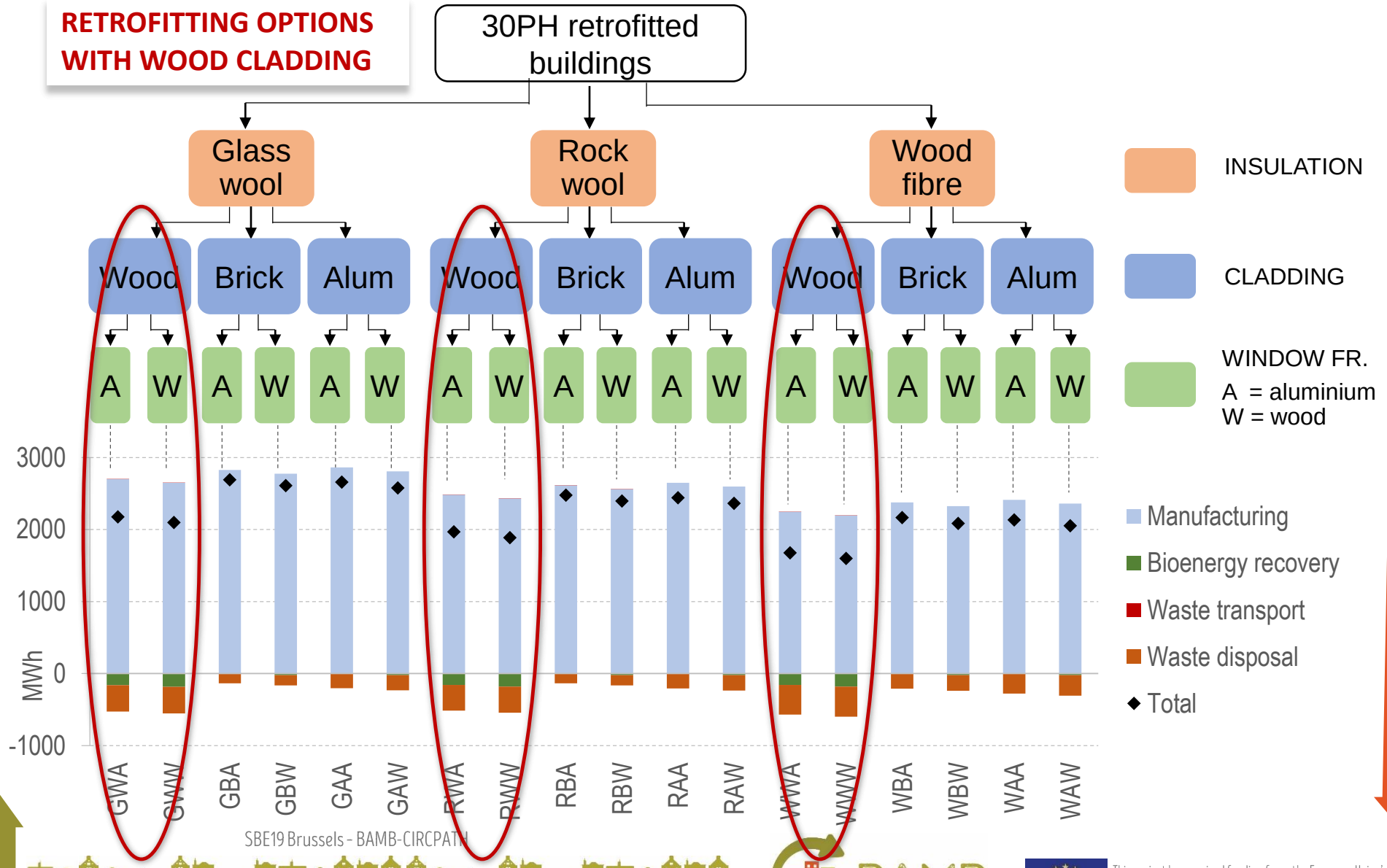
Results: Primary Energy (MWh)

RETROFITTING OPTIONS WITH WOOD CLADDING



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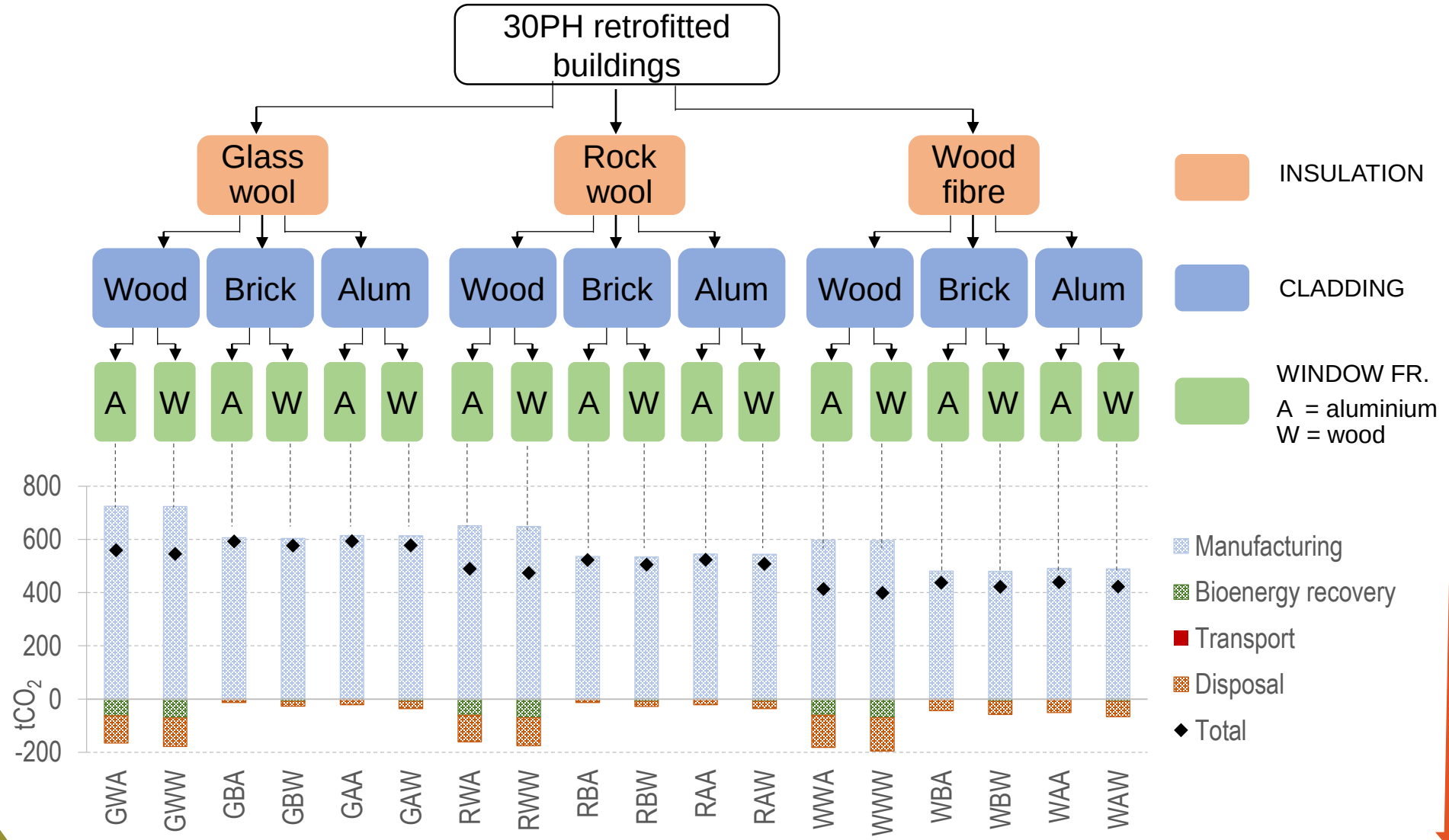
Results: Carbon Emission (tCO_2)



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Answering to research questions

What are the energy and carbon impacts of retrofitting a building…

1. **…in the production phase?**

   The production primary energy use and carbon emission depend on the building materials. Wood options have the lowest energy and carbon impacts.

2. **…in the end-of-life phase?**

   The disposal primary energy and carbon emissions are negative due to the dominant recycling of recovered materials.

3. **Can the recovery of C&D waste reduce the production primary energy and carbon emission?**

   Based on the assumed C&D waste recovery and the studied building and solutions, the primary energy use and CO_2 emission can be reduced by 5%-21% and 2%-24%, respectively, depending on the material alternative.

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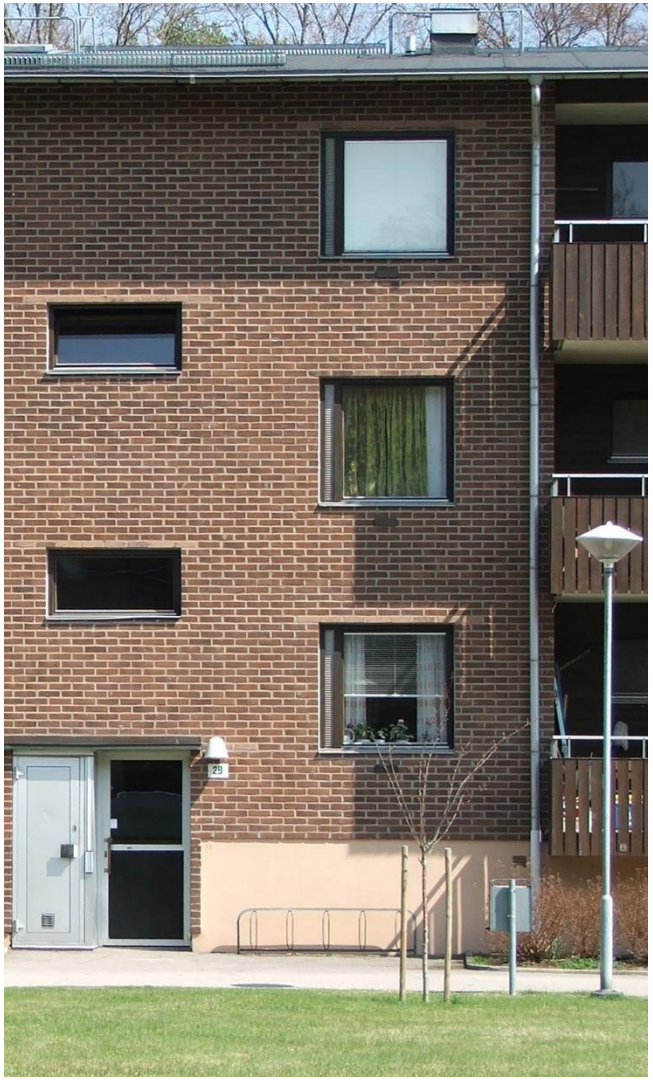
Conclusions

- C&D waste recovery for recycling or energy purposes is advantageous in a life cycle perspective.
- Recycling is usually convenient in terms of primary energy and carbon benefits.
- Bioenergy recovery in the production phase significantly contributes to the primary energy and carbon in the life cycle of the retrofitted buildings.
- Design for disassembly could facilitate the disassembly of building parts in future, optimizing the efficiency of CDW recovery.



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Thank you for your attention

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