

Comparative Life-Cycle Analysis of Building Materials for the Thermal Upgrade of an Existing Building

Chiara Piccardo¹, Ambrose Dodoo², Leif Gustavsson² and UnibenTettye²

¹ University of Genoa, Genoa, Italy

² Linnaeus University, Växjö, Sweden

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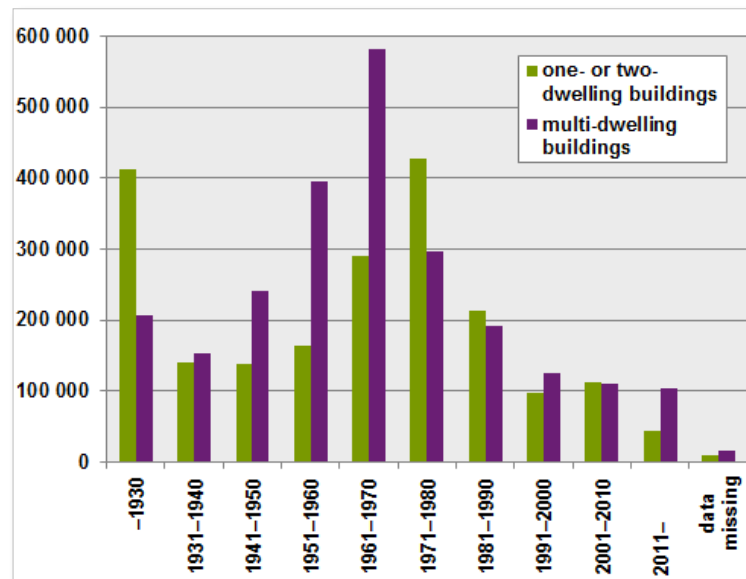
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

Background

- The 'Europe 2020 Strategy' sets a 20% energy saving target by 2020.
- The Directive 2018/844/EU requires minimum energy performance for both new and renovated buildings.
- The passive house concept is a model for high performance buildings.
- In Sweden, 30% of the building stock was built between 1961 and 1975.



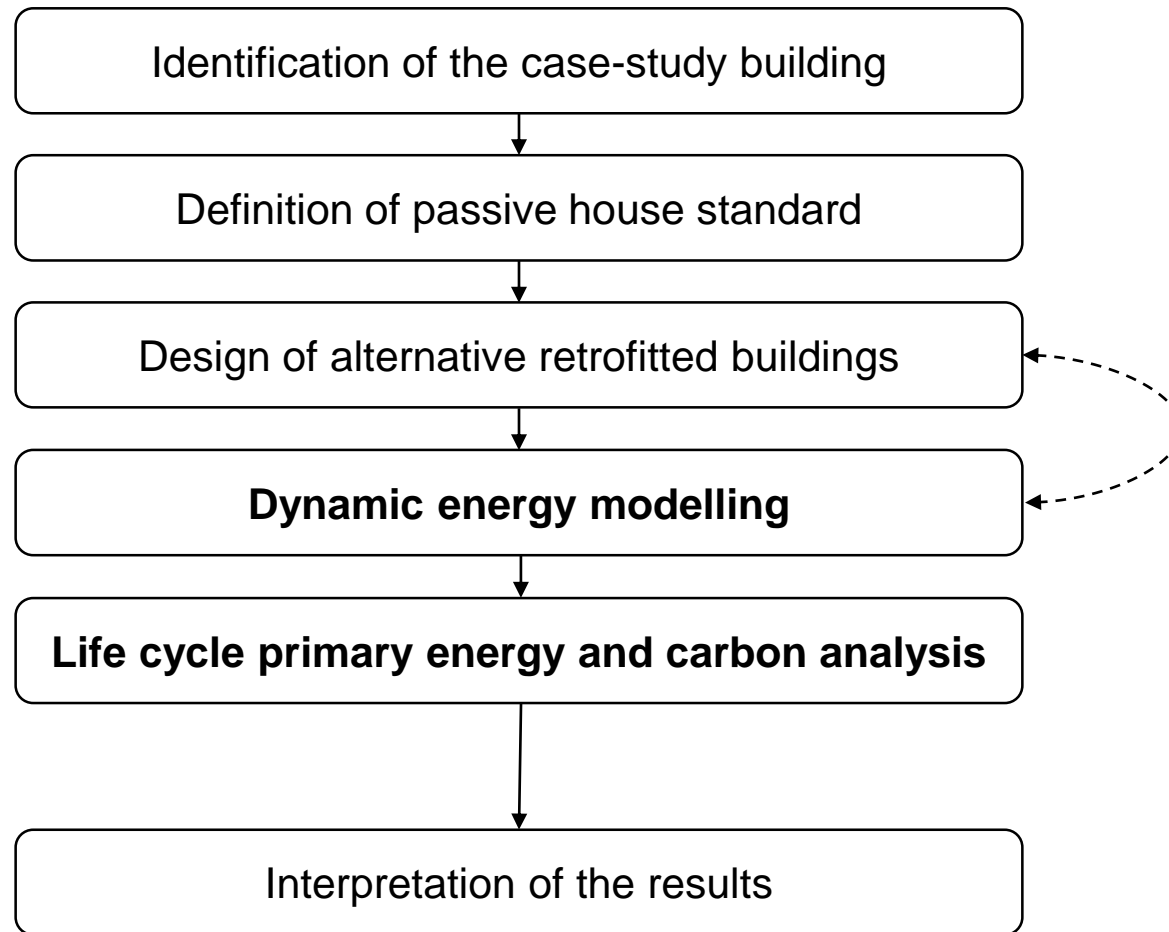
Number of dwellings by type of building and period of construction (source: Statistics Sweden).

Research questions

1. What are the energy and carbon implications of retrofitting a building?
2. What if we assume different passive house standards?
3. What if we the primary energy use for retrofitting a building compared to the operational energy saving?
4. What if we assume alternative building materials?



Research structure and methods



Case study

- **Location:** Ronneby, Southern Sweden
- **Year of construction:** 1974
- **Building type:** concrete-framed building
- **Total heated floor area:** 2000 m²
- **Ventilation system:** mechanical ventilation for exhaust air
- **Heat energy supply:** district heating system



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Definition of passive house standard

We selected two different passive house standards applicable in Sweden:

- 50 kWh/m², year (50PH)
- 30 kWh/m², year (30PH)

to be achieved in the retrofitted buildings.

Passive house standard	Energy use* [kWh/m ² , year]
FEBY12	≤ 50
Passive House Institute (PHI)	≤ 30

* space and tap water heating

Design of the retrofitted buildings

The following retrofitting measures are adopted:

efficiency upgrade of technical devices

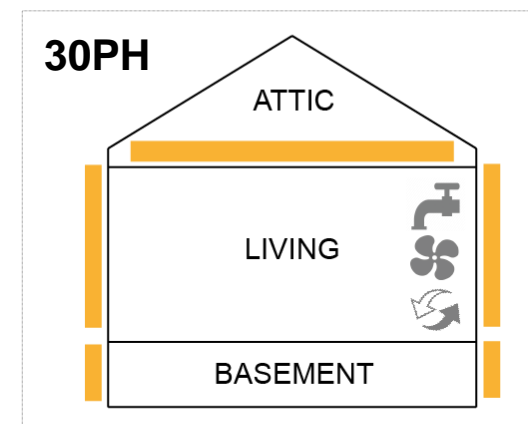
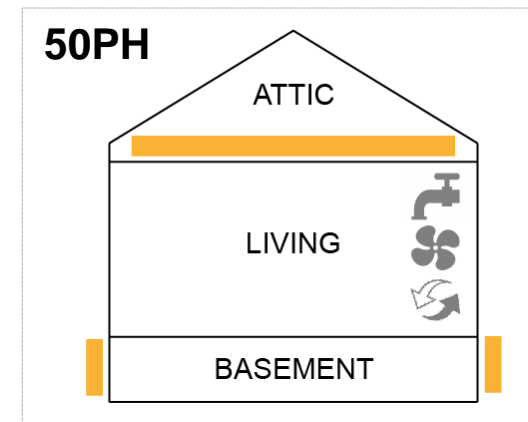
- energy-efficient ventilation fans
- energy-efficient ventilation heat recovery (VHR) unit
- efficient water taps

thermal improvement of the building envelope

- extra insulation
- improved airtightness

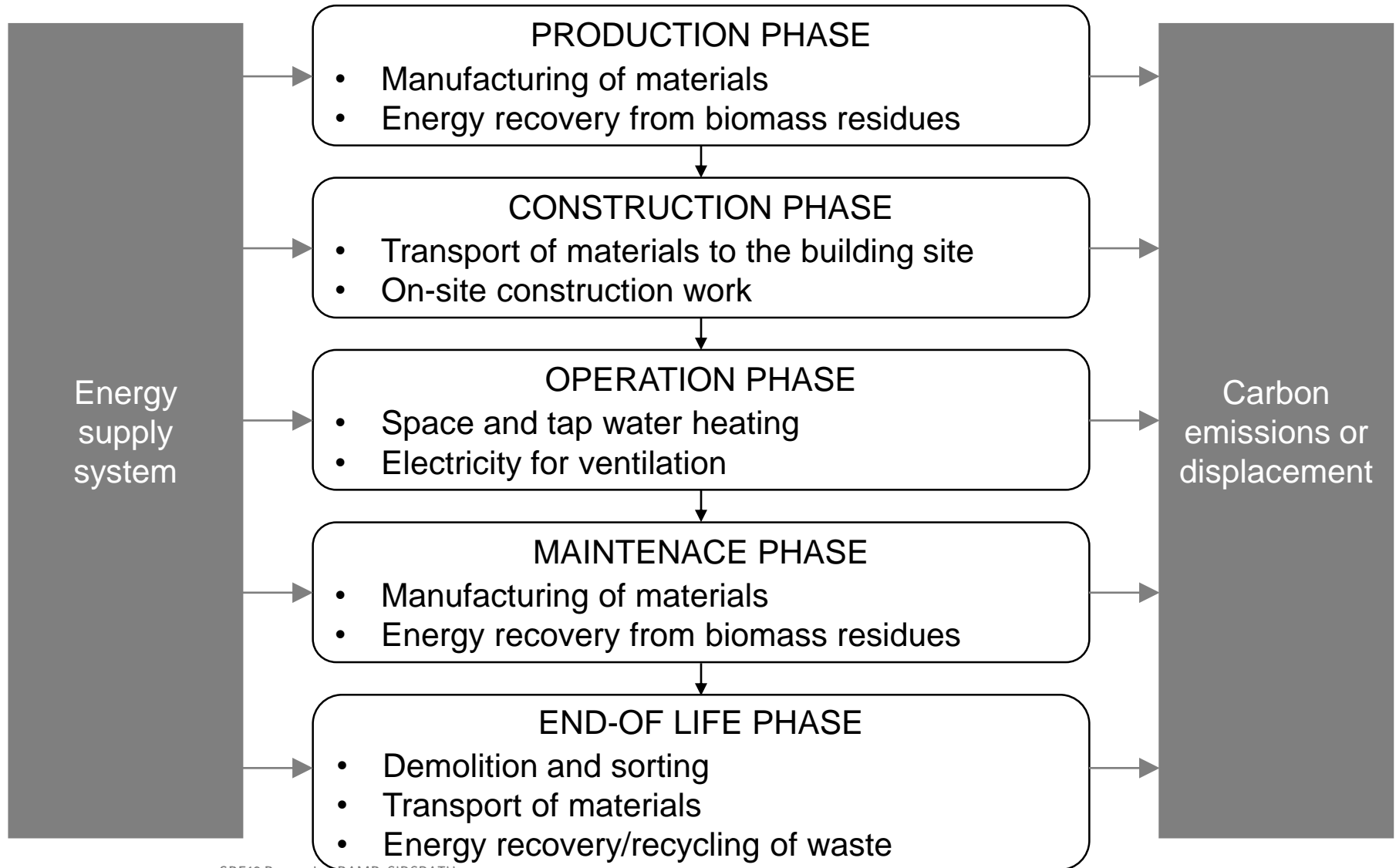
in the following building parts:

- basement
- attic
- windows and, if needed, external walls



- THERMAL IMPROVEMENT
- ⚡ EFFICIENT TAP WATER
- ⚙️ ENERGY-EFFICIENT FANS
- ↻ ENERGY-EFFICIENT VHR

Life Cycle Analysis



Comparing alternative building materials

We combine alternative building materials for:

thermal insulation

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

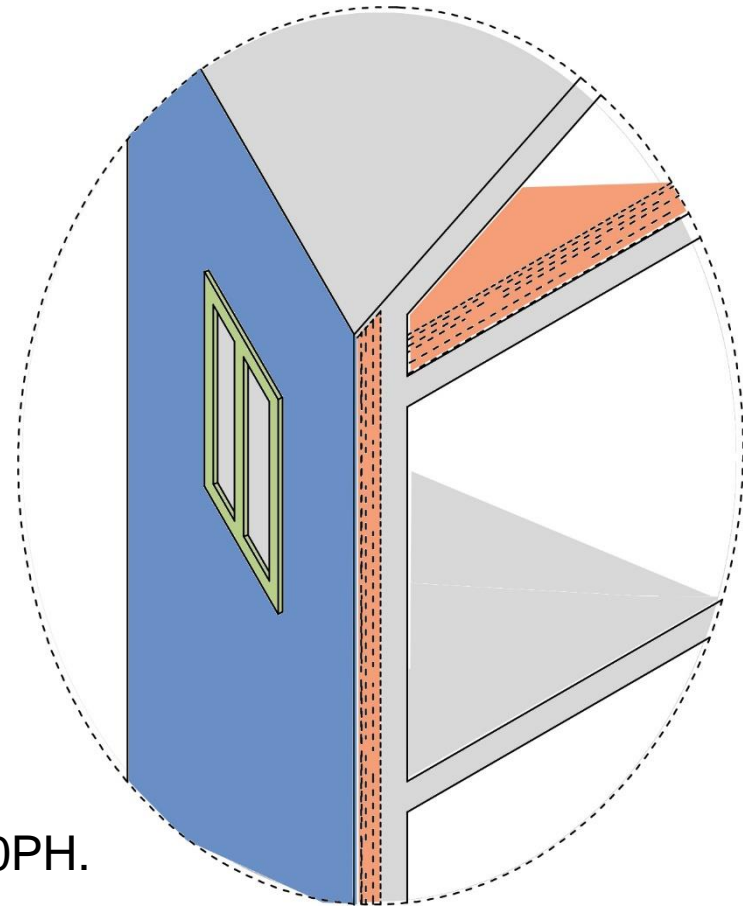
building cladding

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

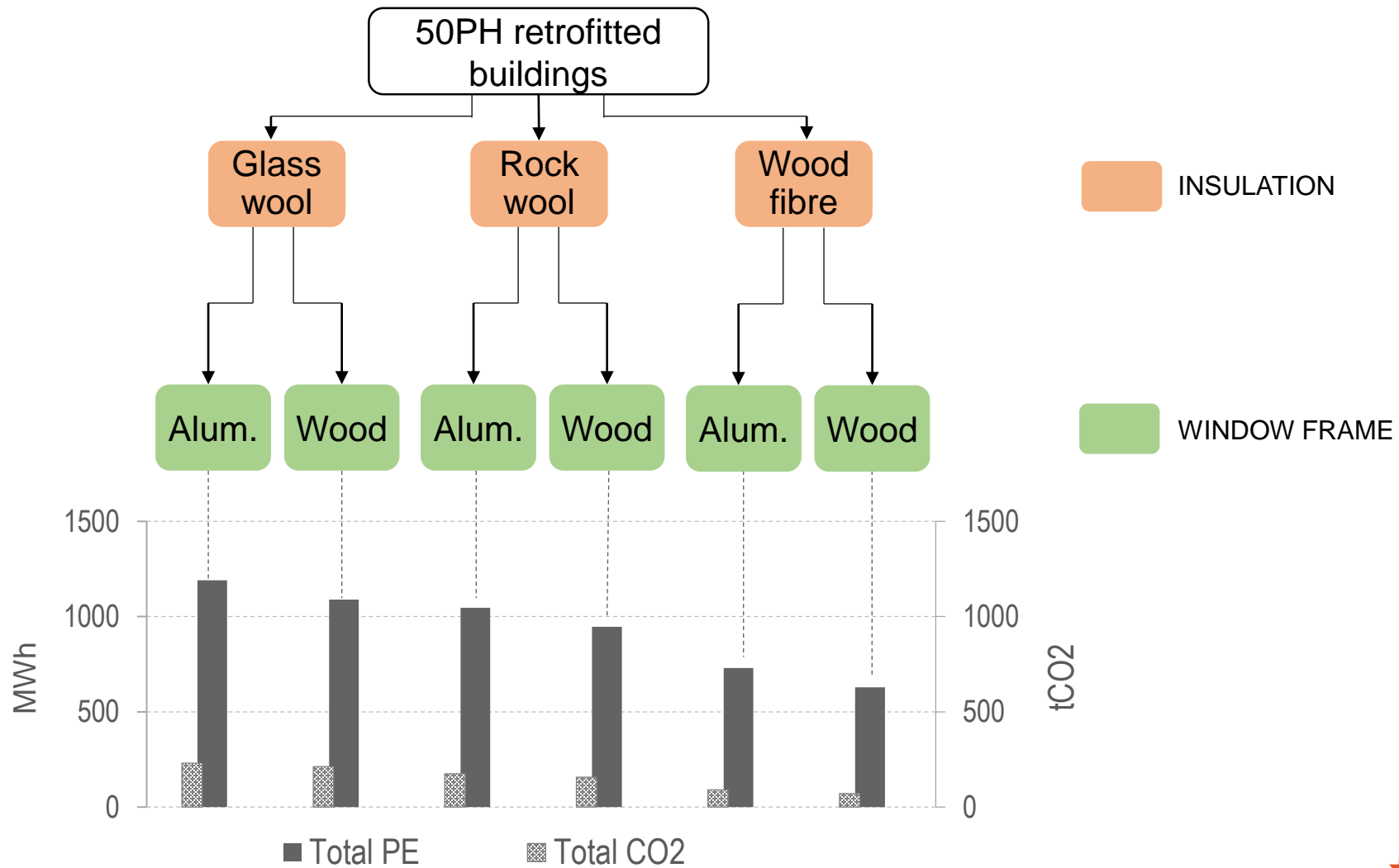
windows

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

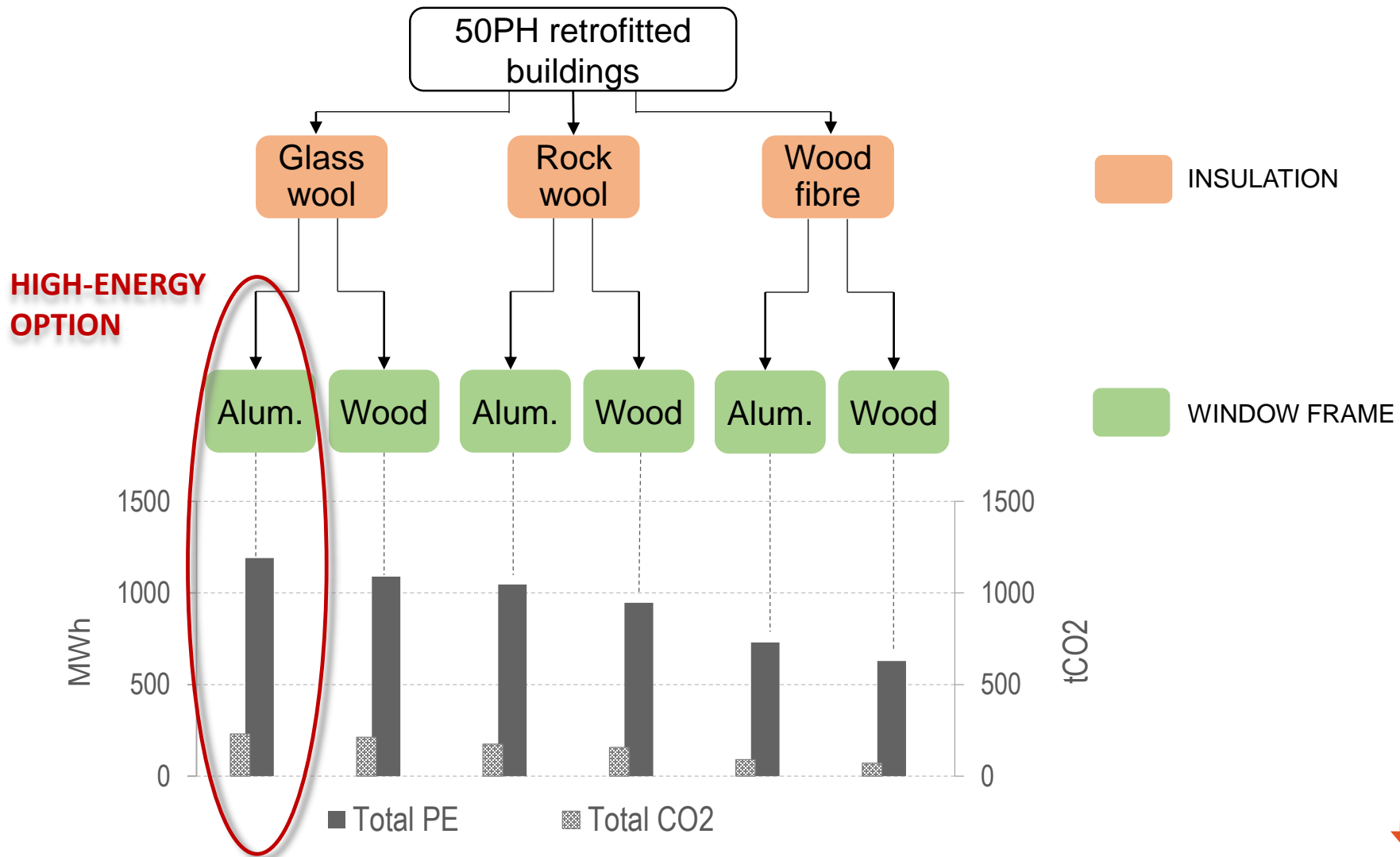
Number of alternatives: 6 for 50PH and 18 for 30PH.



Results of the 50PH retrofitted buildings



Results of the 50PH retrofitted buildings



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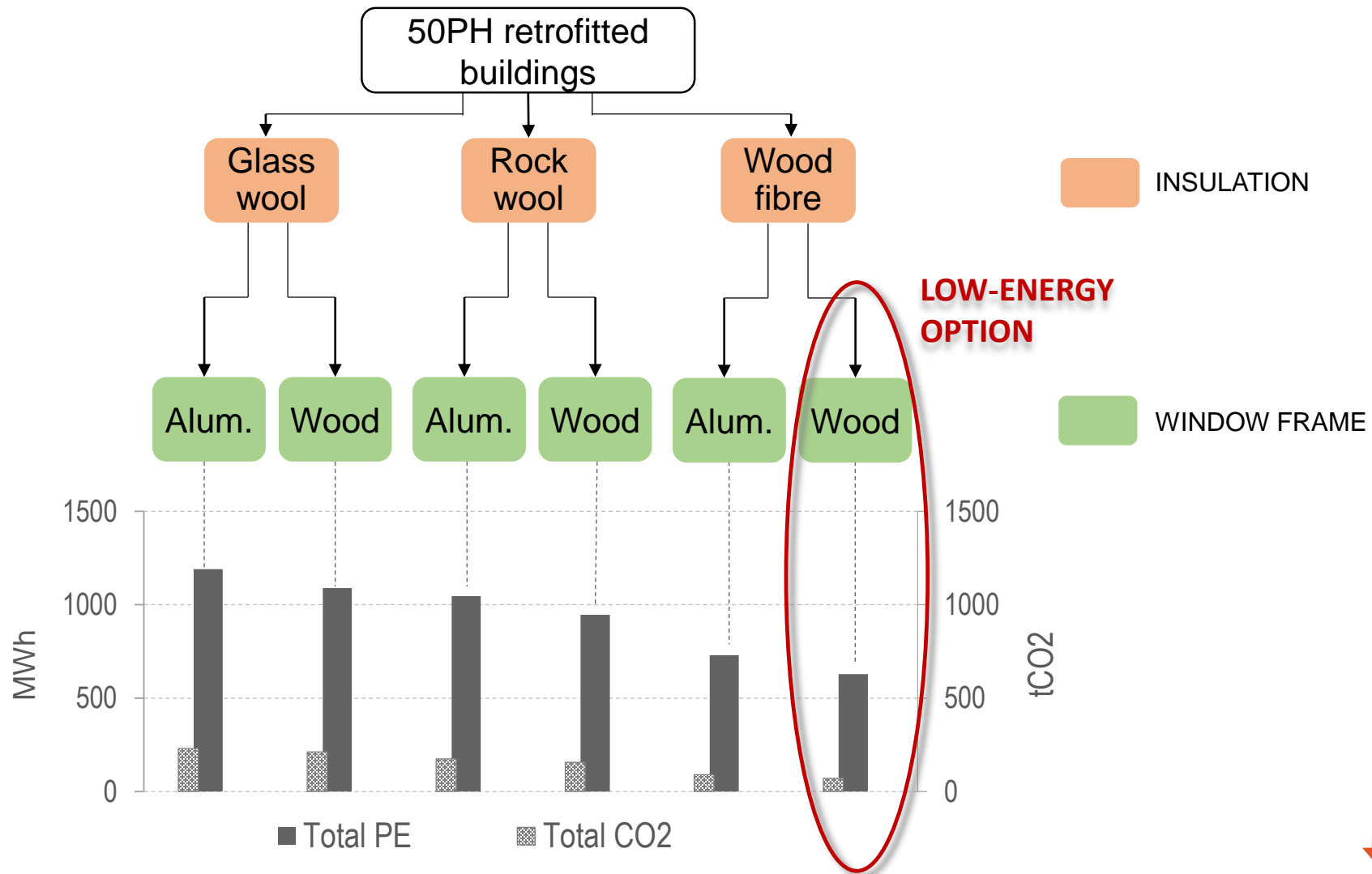


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Results of the 50PH retrofitted buildings



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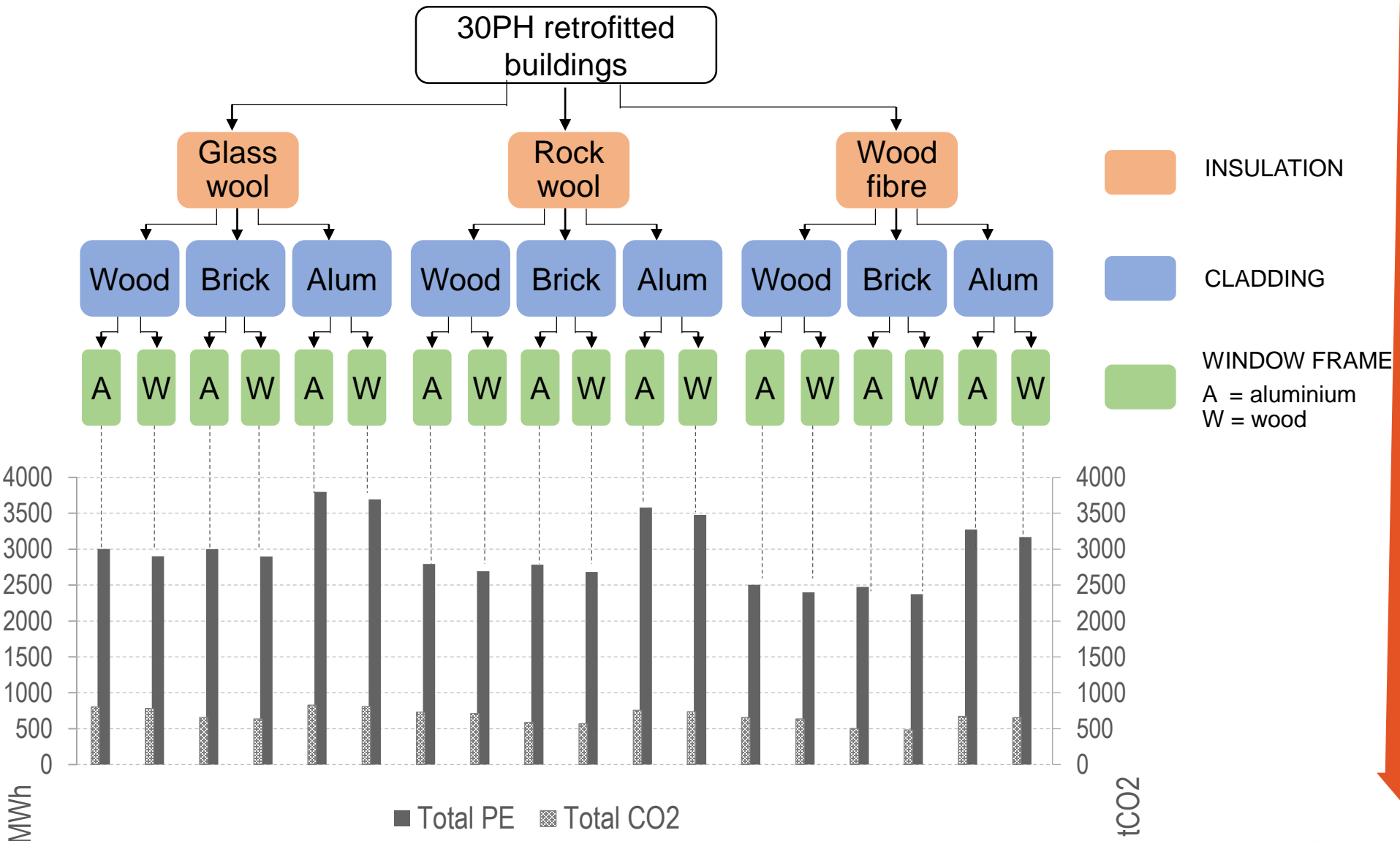


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Results of the 30PH retrofitted buildings



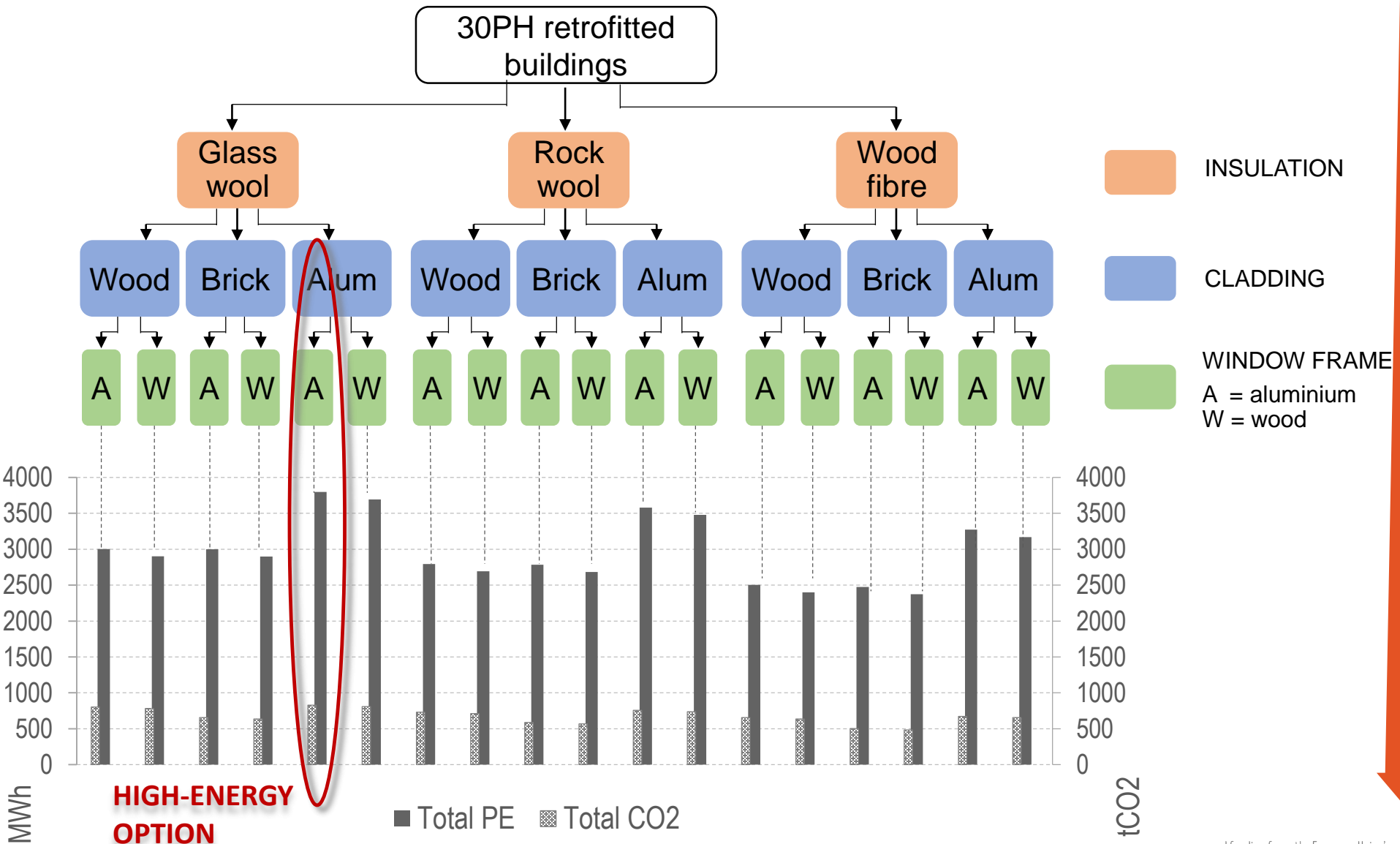
MWh

■ Total PE ▨ Total CO2

tCO2



Results of the 30PH retrofitted buildings



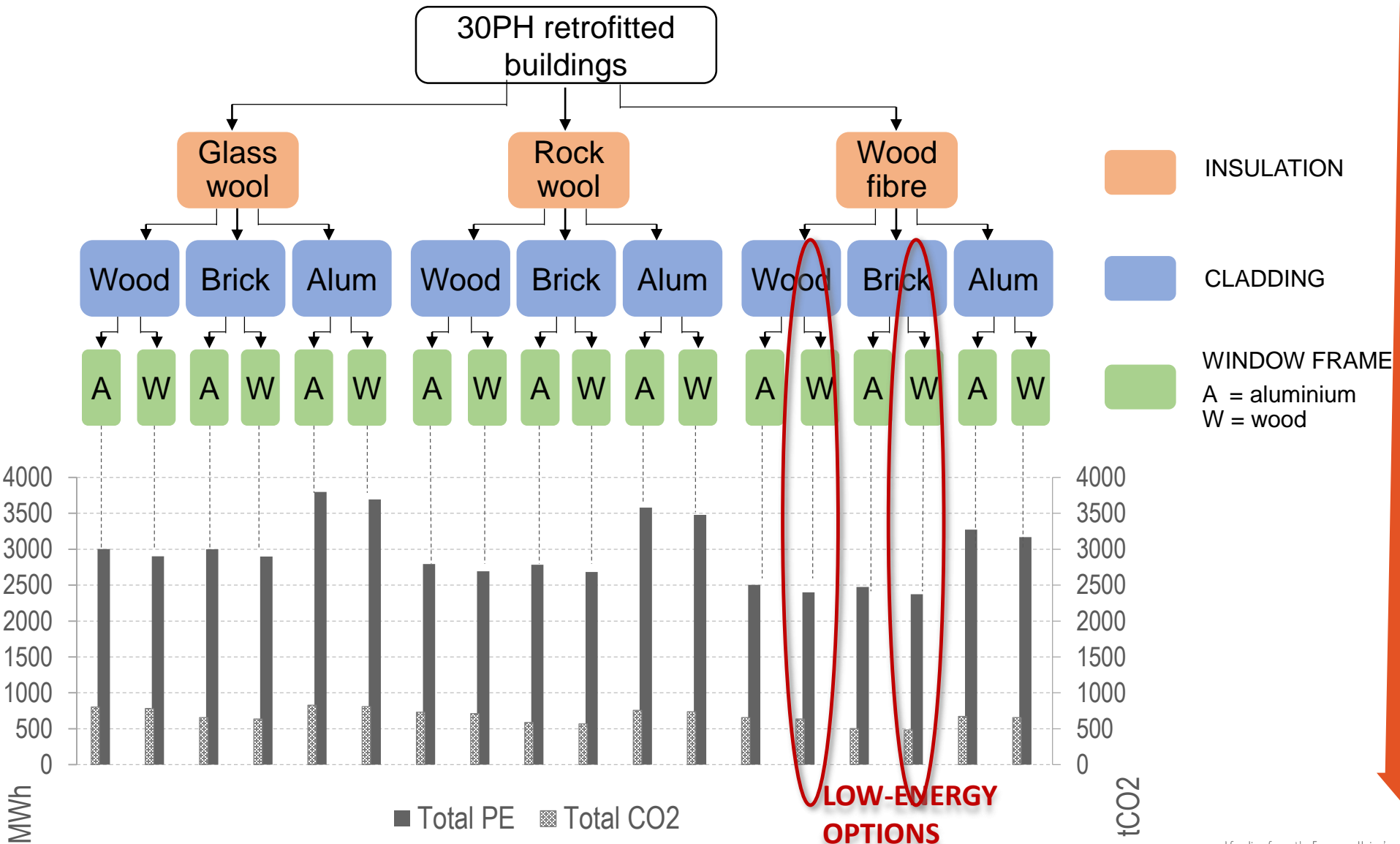
MWh

tCO2



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Results of the 30PH retrofitted buildings



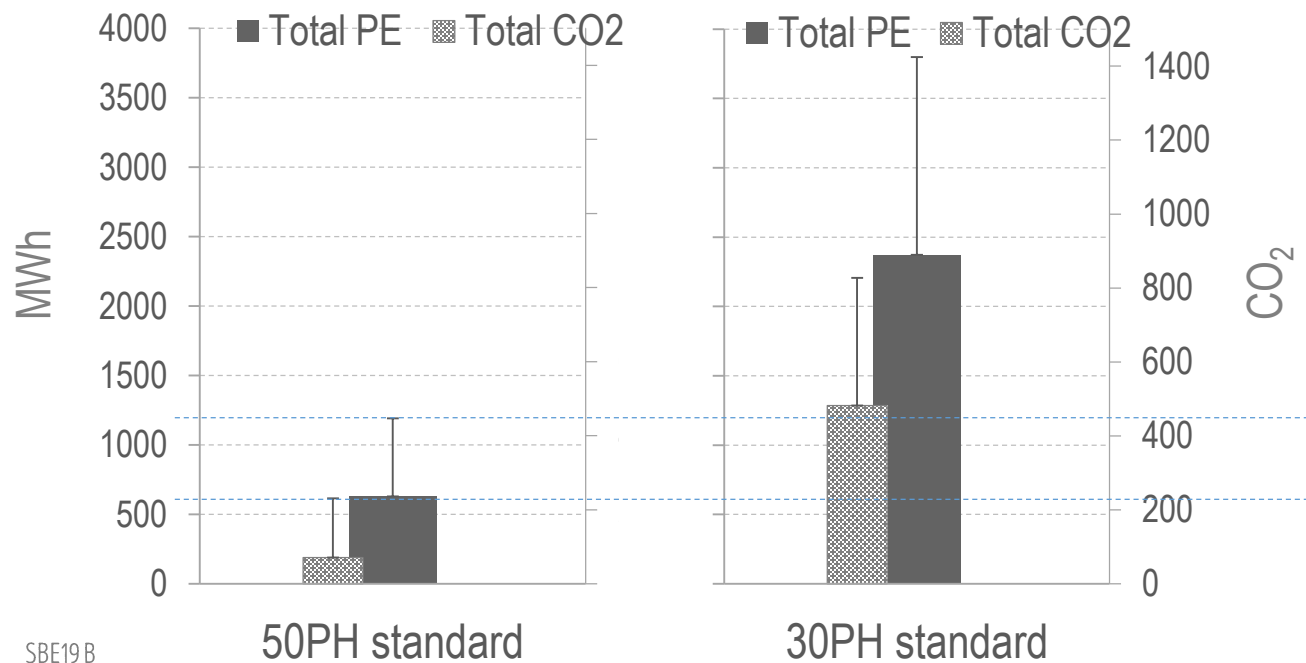
Answering to research questions

1. What are the energy and carbon implications of retrofitting a building?

Additional primary energy use and carbon emissions, depending on the passive house target and on the use of building materials.

2. What if we assume different passive house standard?

The 30PH buildings results in X6 primary energy and X11 carbon emissions compared to the 50PH buildings, due to additional retrofitting measures.



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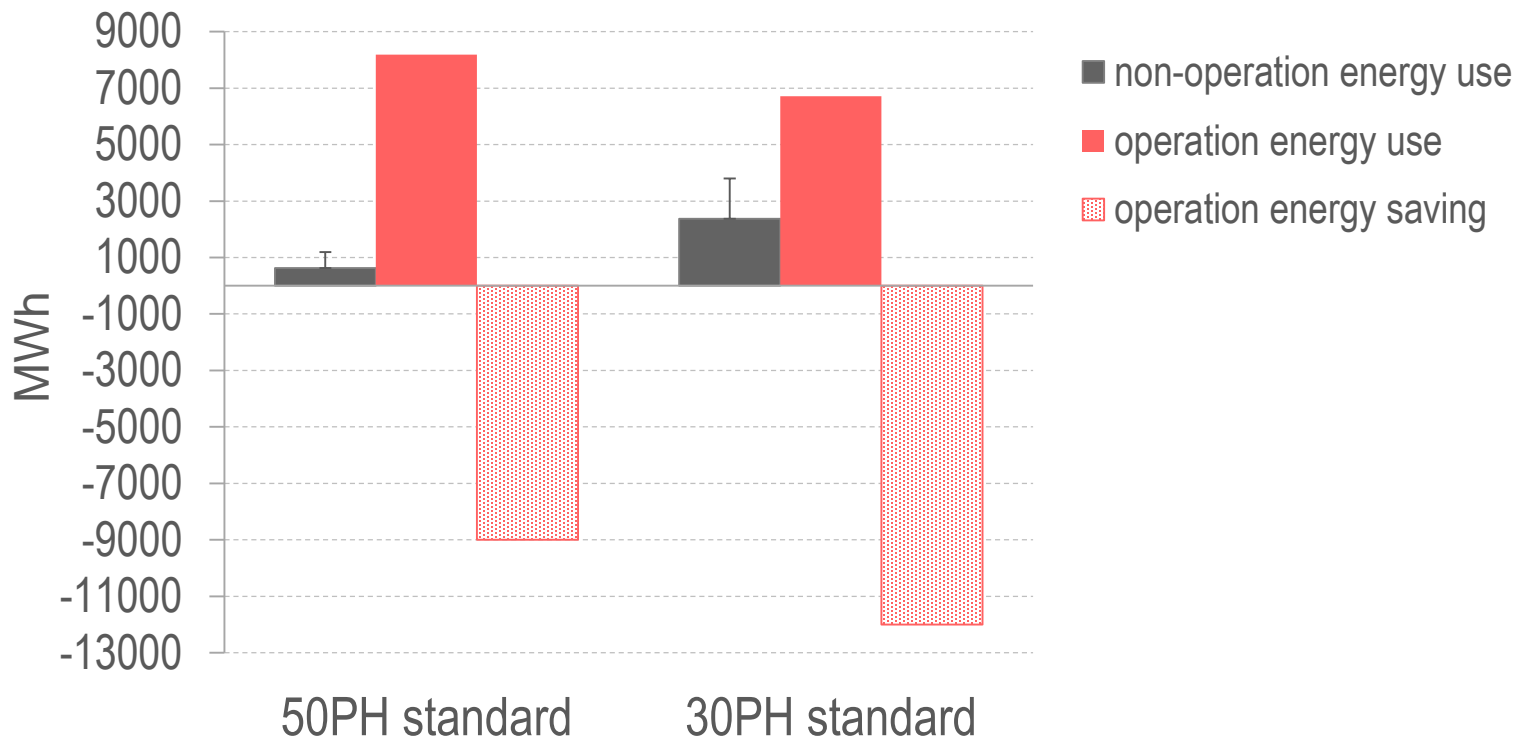


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Answering to research questions

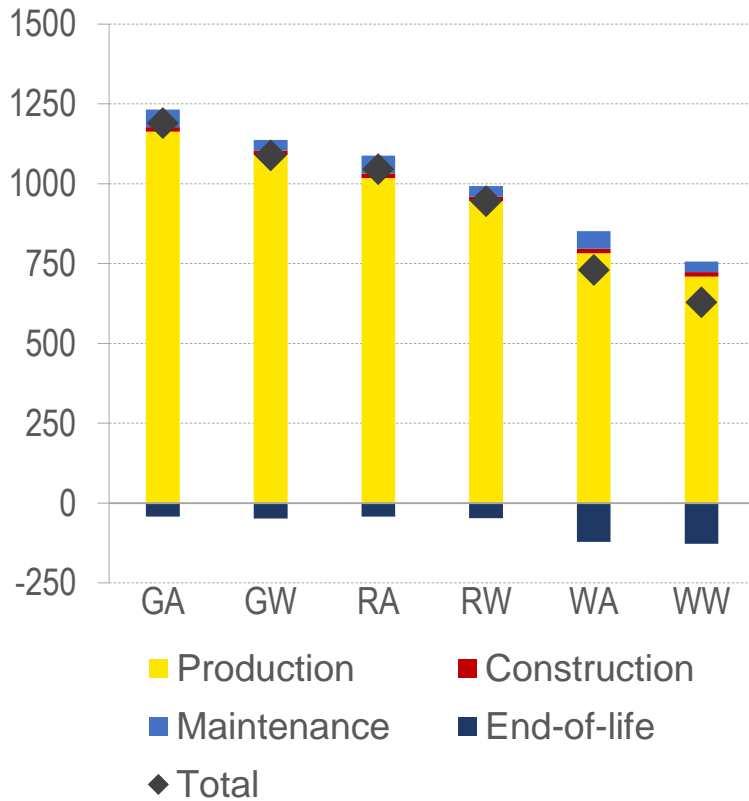
3. How much is the primary energy use for retrofitting a building compared to the operational energy saving?

The primary energy used to retrofit the 50PH and 30PH buildings accounts for 10% and 25%, on average, of the operation primary energy saving.

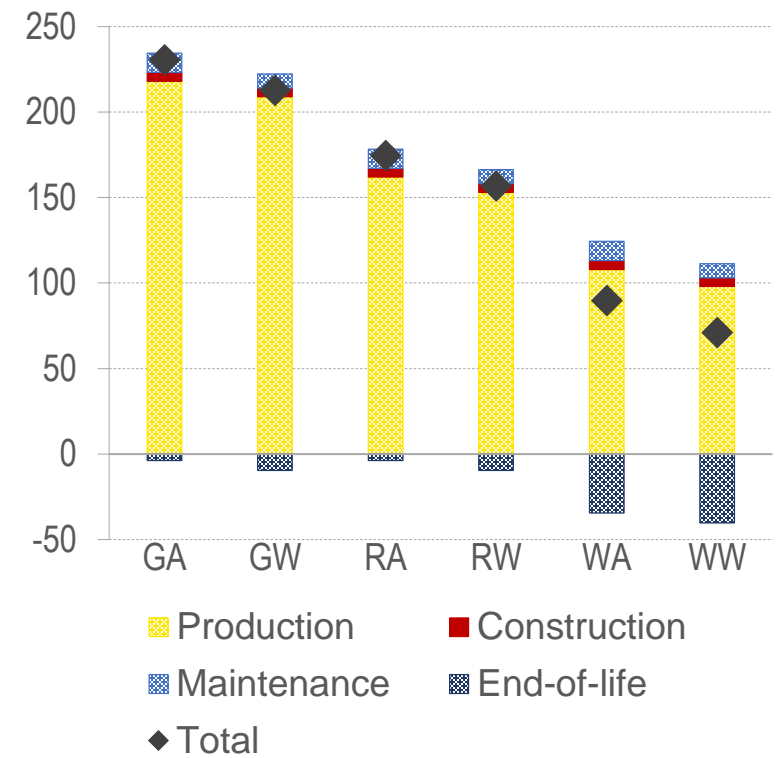


50PH retrofitted buildings

PRIMARY ENERGY



CARBON EMISSIONS

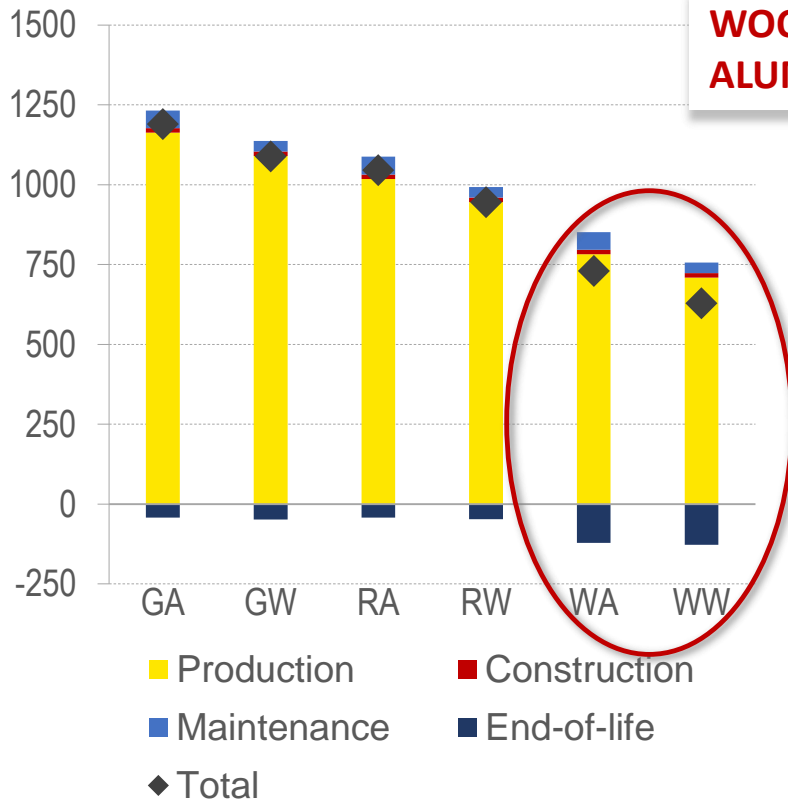


G=glass wool; R=rock wool; W=wood fibre/wood; A=aluminium

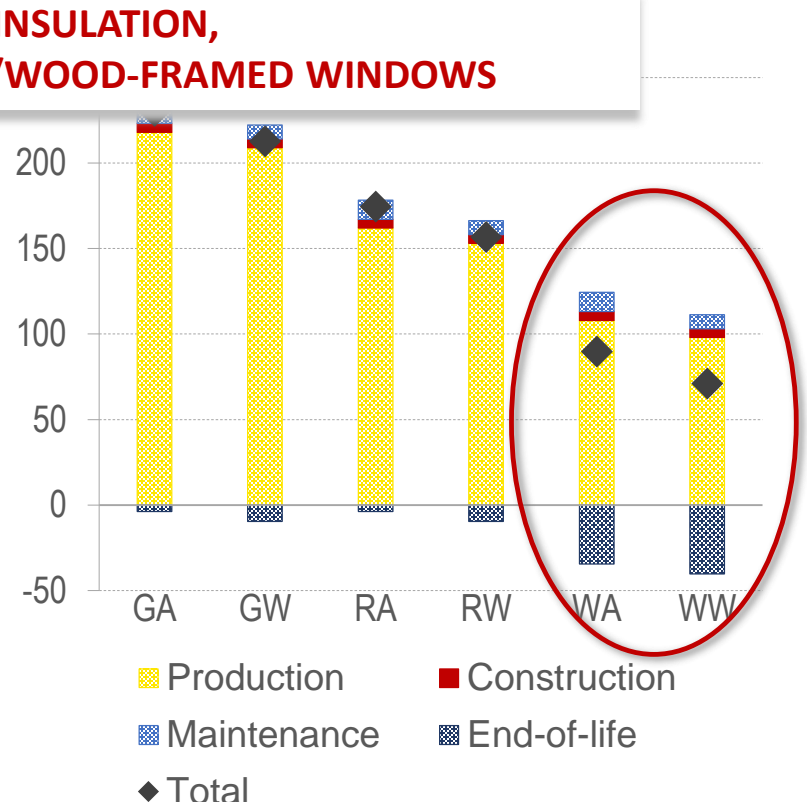


50PH retrofitted buildings

PRIMARY ENERGY



CARBON EMISSIONS

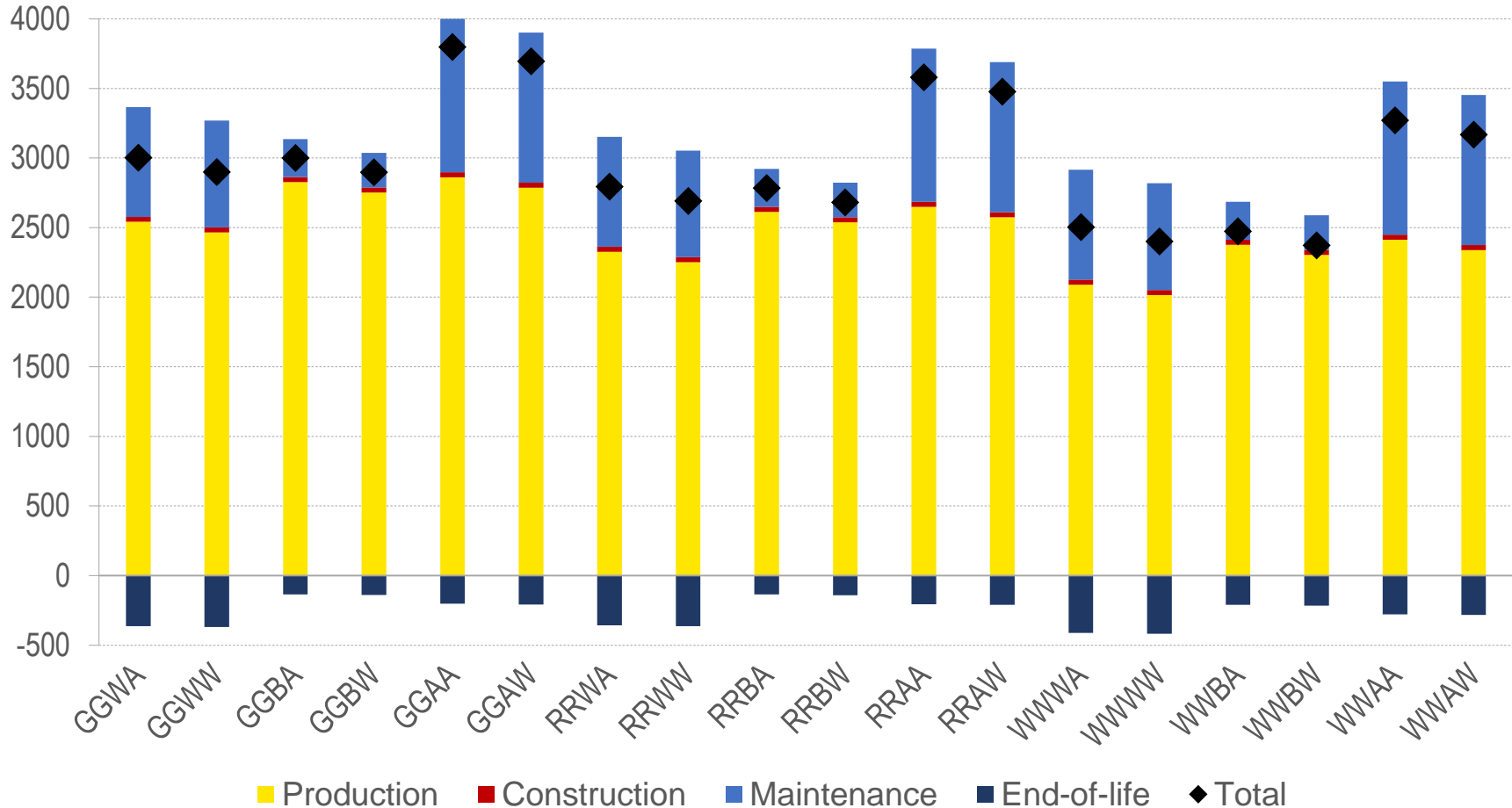


G=glass wool; R=rock wool; W=wood fibre/wood; A=aluminium



30PH retrofitted buildings

PRIMARY ENERGY



G=glass wool; R=rock wool; W=wood fibre/wood; A=aluminium; B=brick

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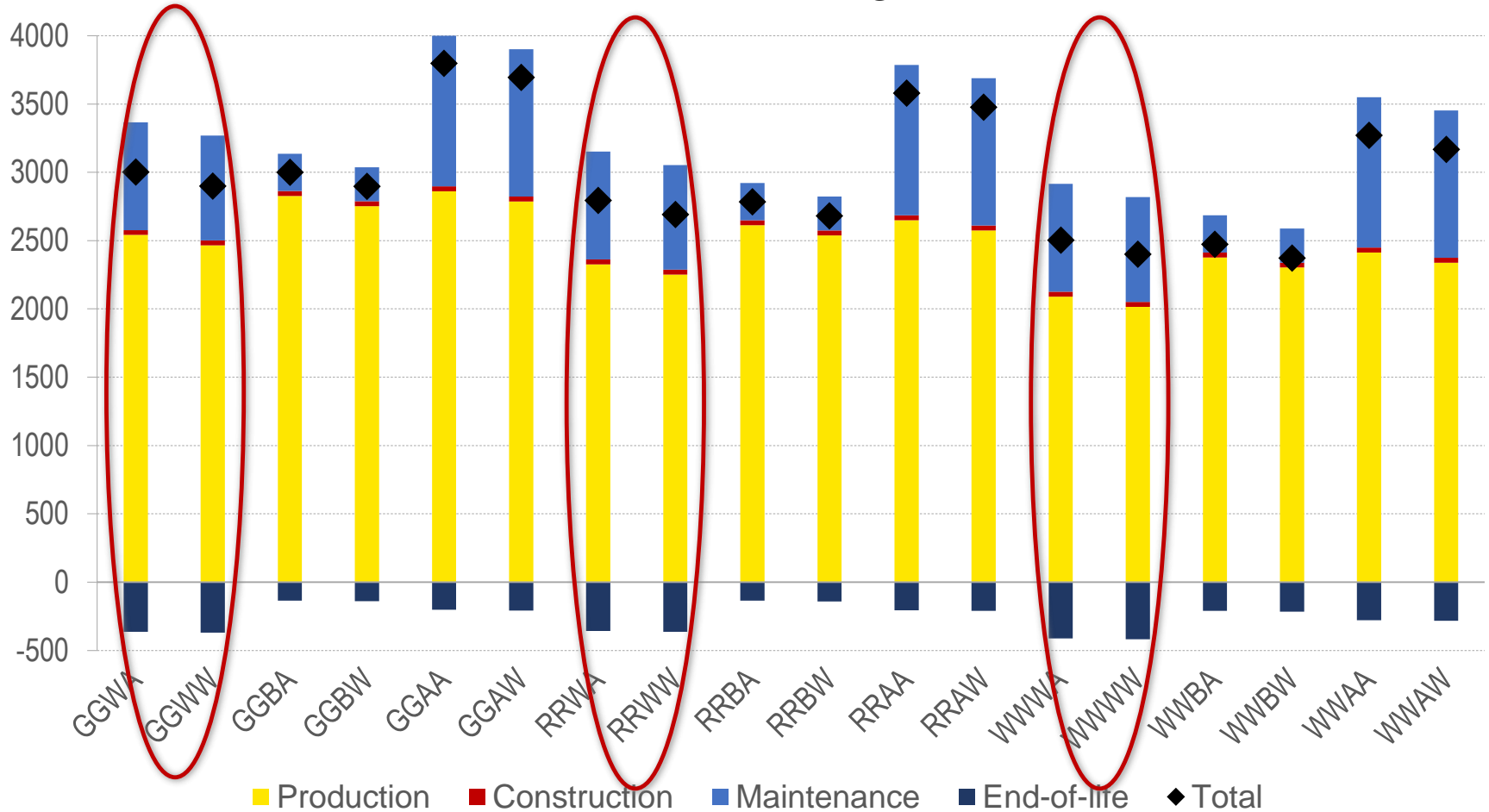


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30PH retrofitted buildings

RETROFITTING OPTIONS WITH WOOD CLADDING

PRIMARY ENERGY



G=glass wool; R=rock wool; W=wood fibre/wood; A=aluminium; B=brick

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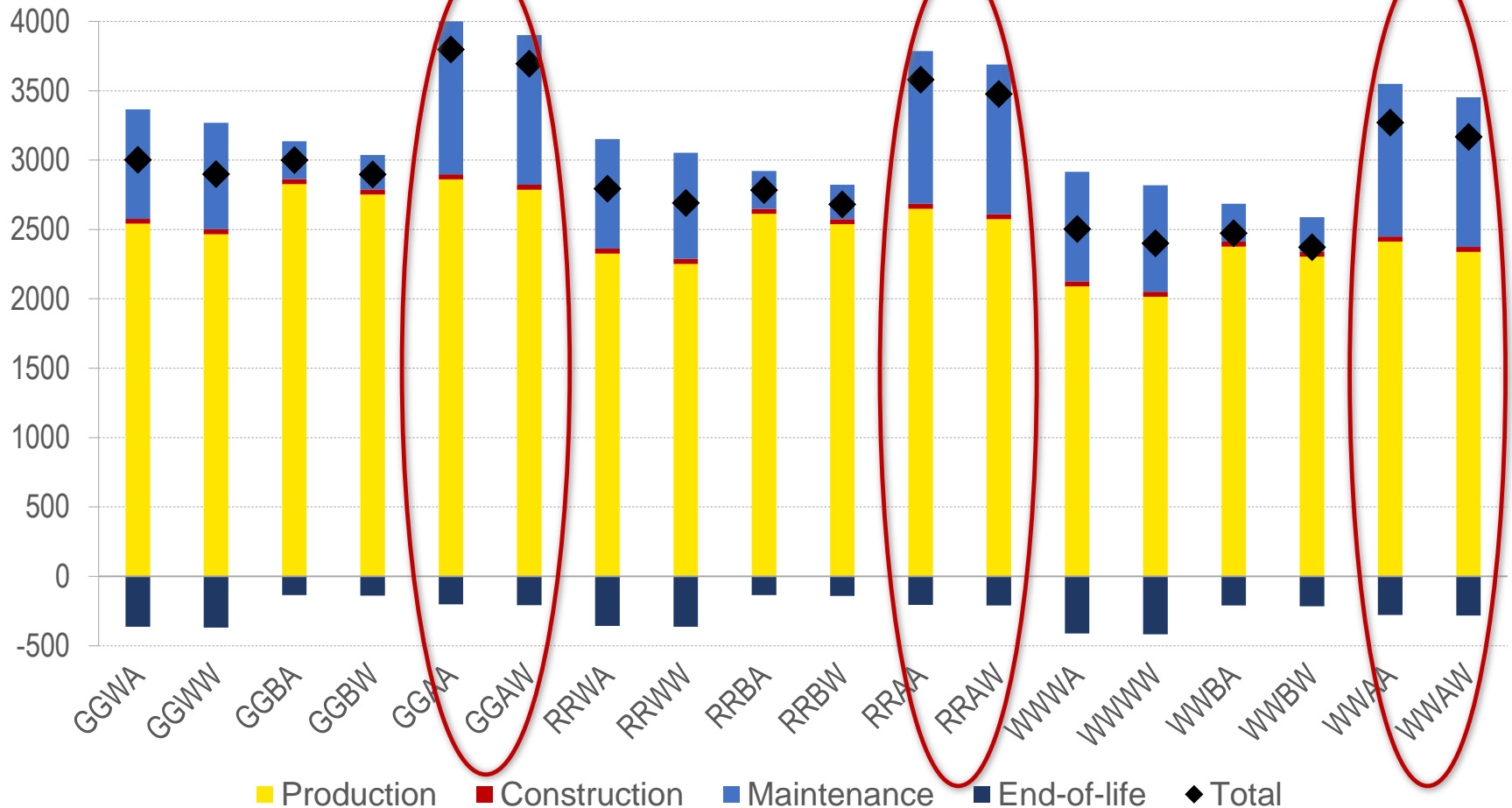


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30PH retrofitted buildings

RETROFITTING OPTIONS WITH ALUMINIUM CLADDING

PRIMARY ENERGY



G=glass wool; R=rock wool; W=wood fibre/wood; A=aluminium; B=brick

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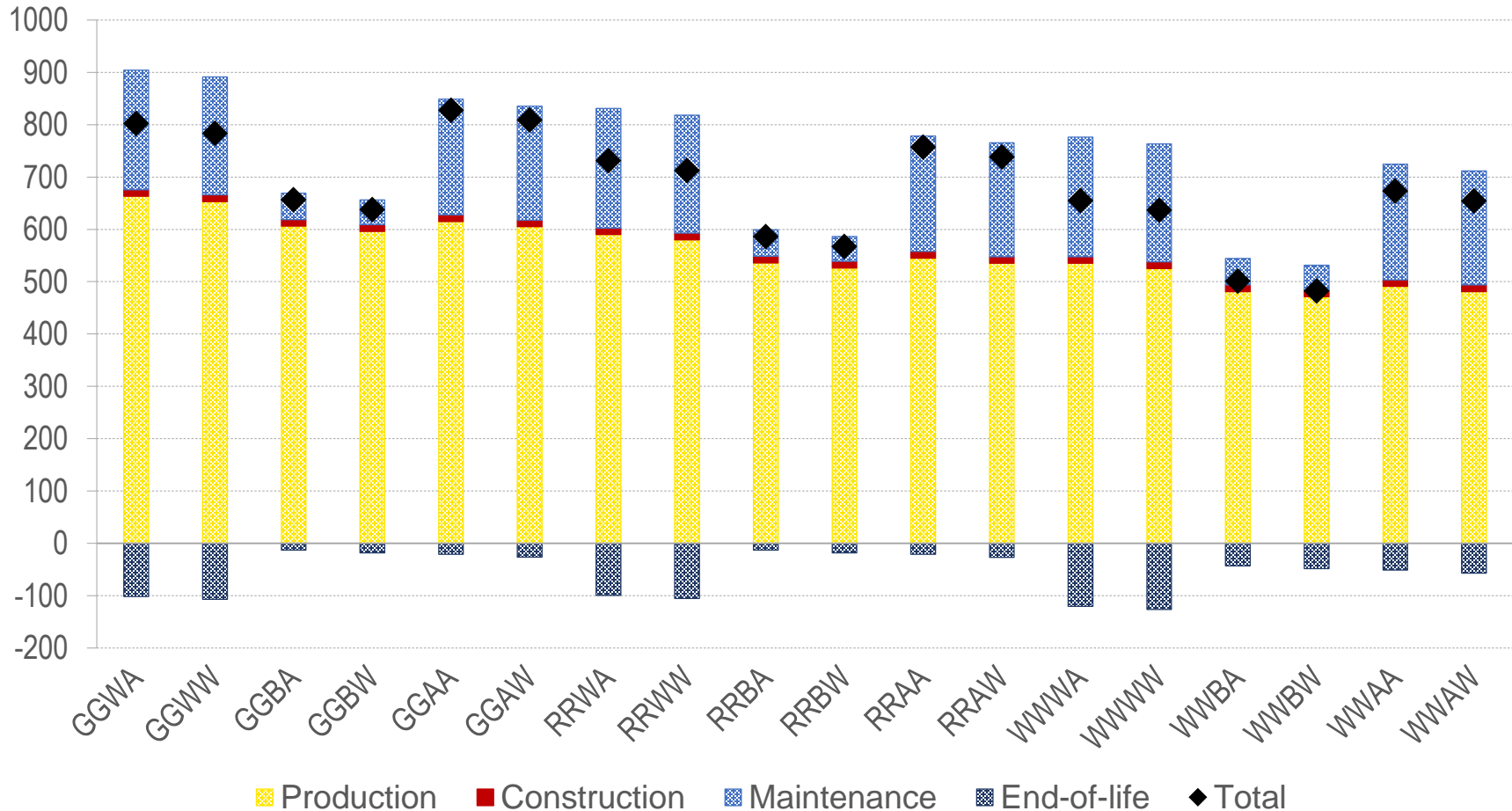
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30PH retrofitted buildings

CARBON EMISSIONS



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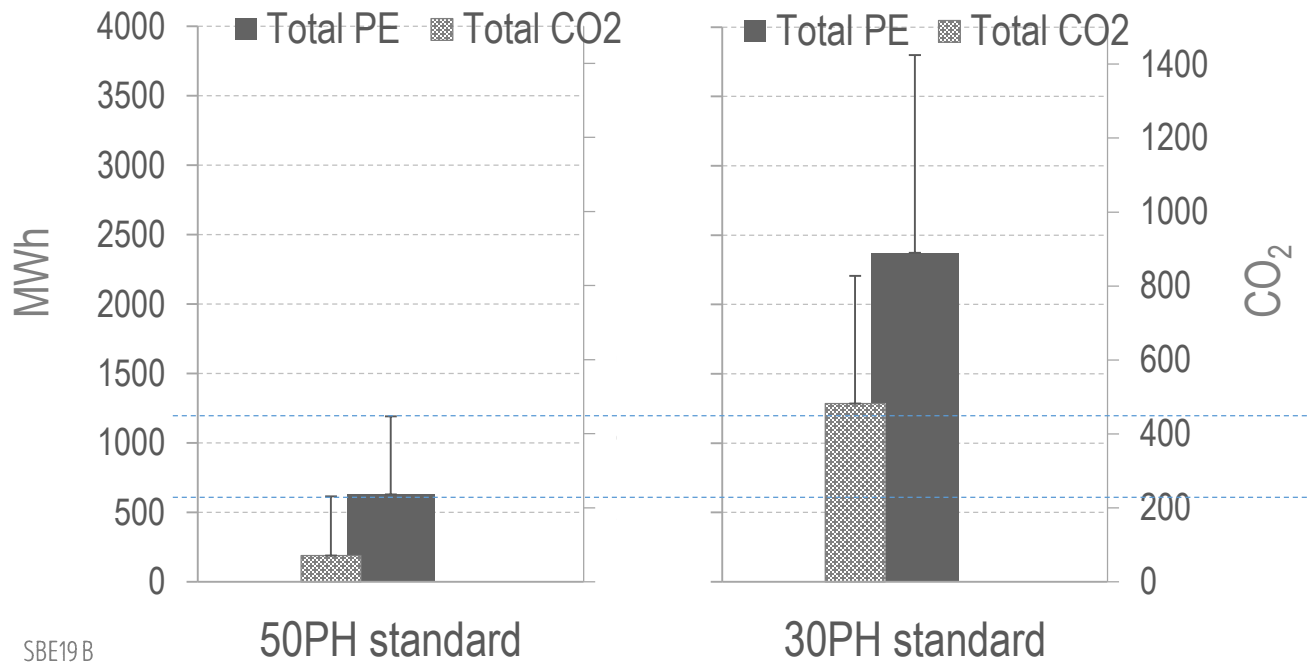
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Answering to research questions

...

4. What if we assume alternative building materials?

The choice of building materials is relevant. Maximizing the use of brick and wood can save up to 38% of energy and up to 42% of carbon emissions.



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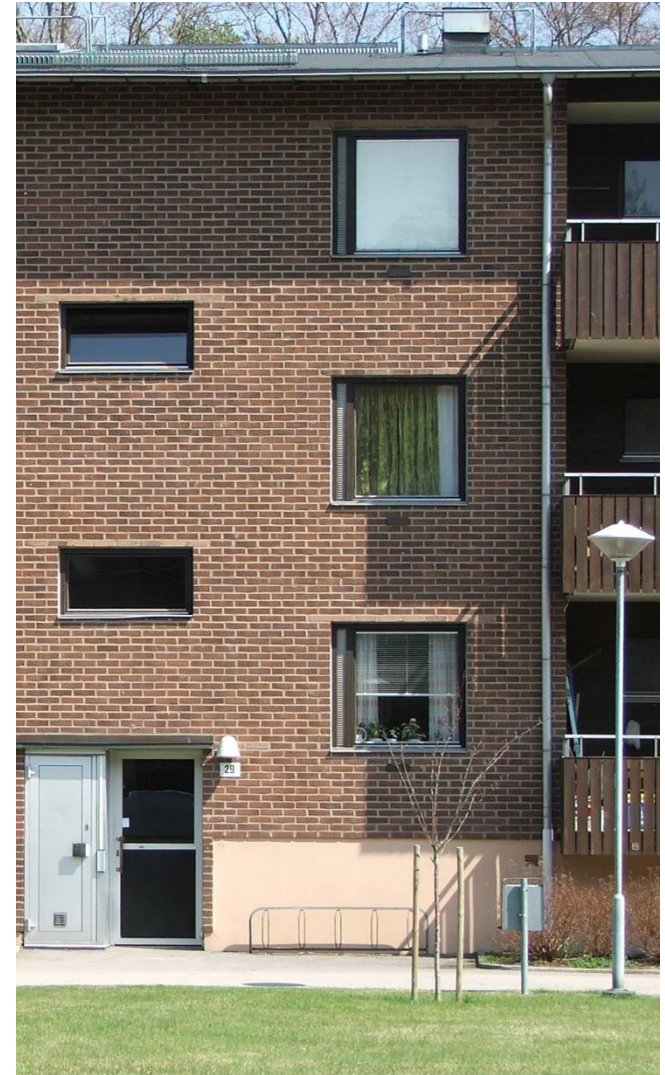
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Conclusions

- Design strategies should pay attention to the durability of building materials to reduce the maintenance need
- Design for disassembly could facilitate the disassembly of building parts in future, optimizing the efficiency of CDW recovery.
- Further studies on cost-effectiveness of the retrofitting measures should be investigated more deeply.



Thank you for your attention

Contacts:

chiara.piccardo@arch.unige.it

ambroose.dodoo@lnu.se

leif.gustavsson@lnu.se

uniben.tetty@lnu.se

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