

31/05/2012

The Life Cycle Energy Consumption of Zero-Energy Houses

ERSCP, Bregenz, May 2012

Marlies Van Holm, MSc Engineering and architecture

VITO - Flemish Institute for Technological Research

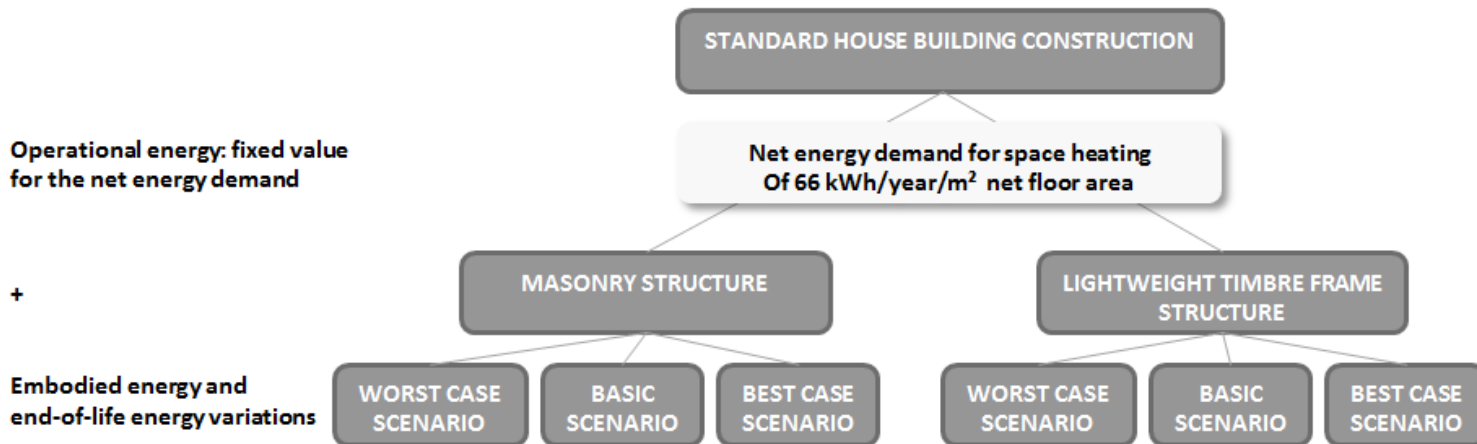
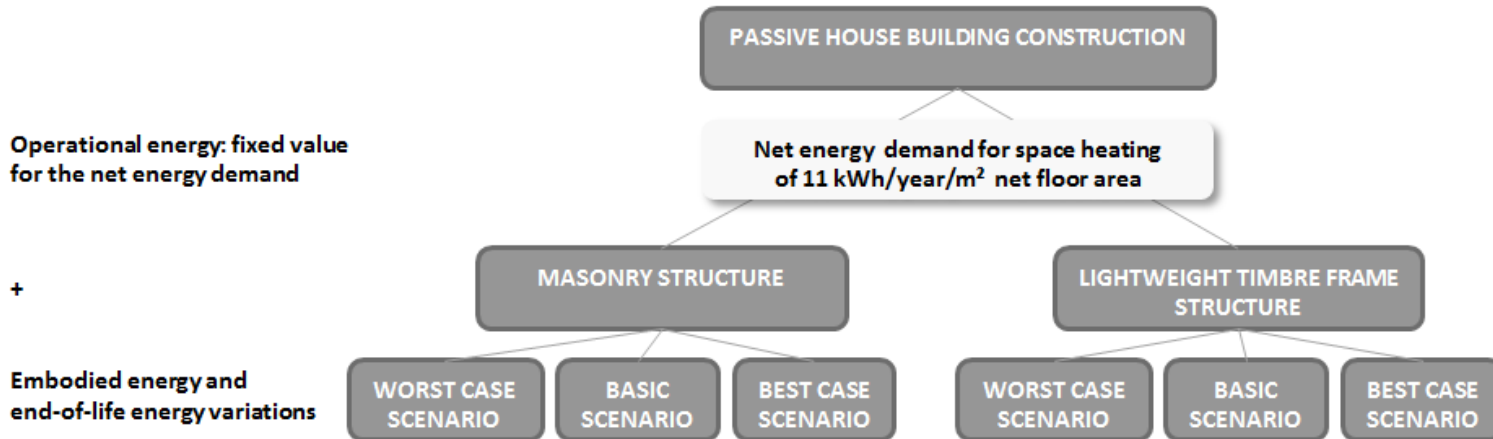
Key questions

- » **Life cycle energy consumption of nearly zero-energy buildings** is an aspect of growing interest (EPBD recast 2010)
- » Life cycle energy consumption?
 - » **Life cycle embodied energy** (LC EE)
 - » **Life cycle End-of-life energy** (LC EOL)
 - » **Operational energy use** (OE)
 - » 60 yrs building use phase, with sensitivity analysis for 30, 120 yrs
- » Various scenarios examined for a **typical detached house**
 - » **Passive house** - net energy demand heating $< 15\text{kWh/a/m}^2$
 - » **Flemish EPBD requirements** - net energy demand $< 70\text{kWh/a/m}^2$
 - » **Zero-energy house scenarios** - net energy demand $< 15\text{kWh/a/m}^2$ or $< 70\text{kWh/a/m}^2$

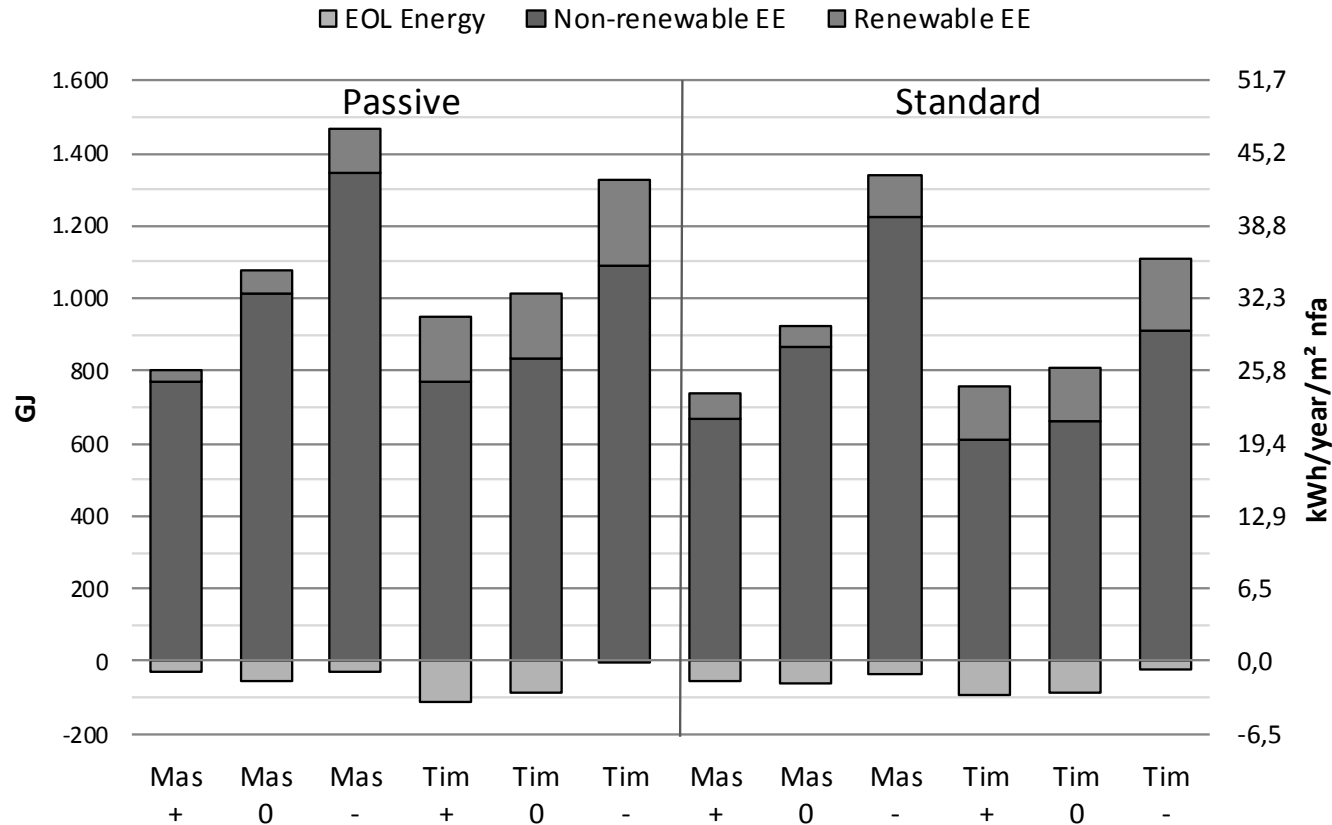
Typical Flemish detached house?



12 building construction scenarios

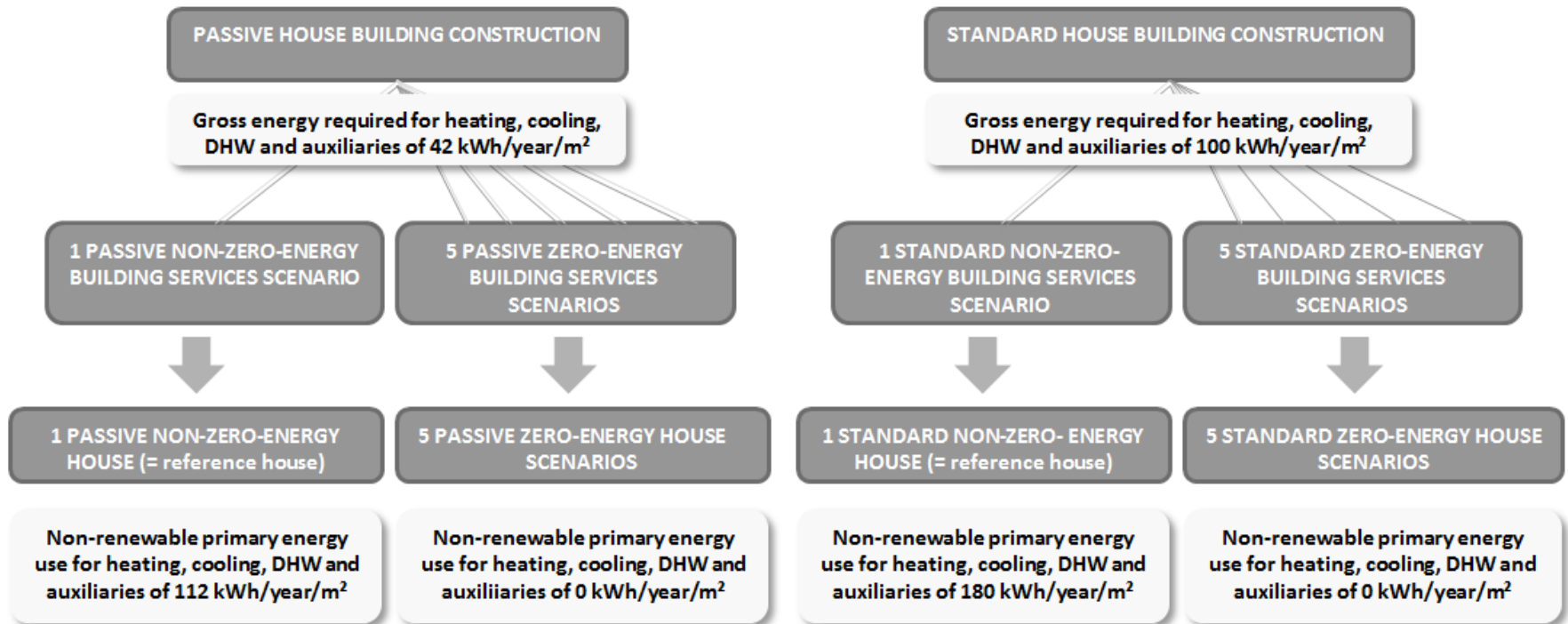


Results building construction



Non-renewable and renewable Embodied Energy (EE) and End-Of-Life Energy (EOLE) of Passive and Standard building construction scenarios composed of most (+), basic (0) and least (-) energy efficient masonry (Mas) and timber frame (Tim) material combinations (primary energy equivalents in GJ and kWh/m²/year).

12 building services scenarios



Overview of the scenarios for the building services

12 building services scenarios

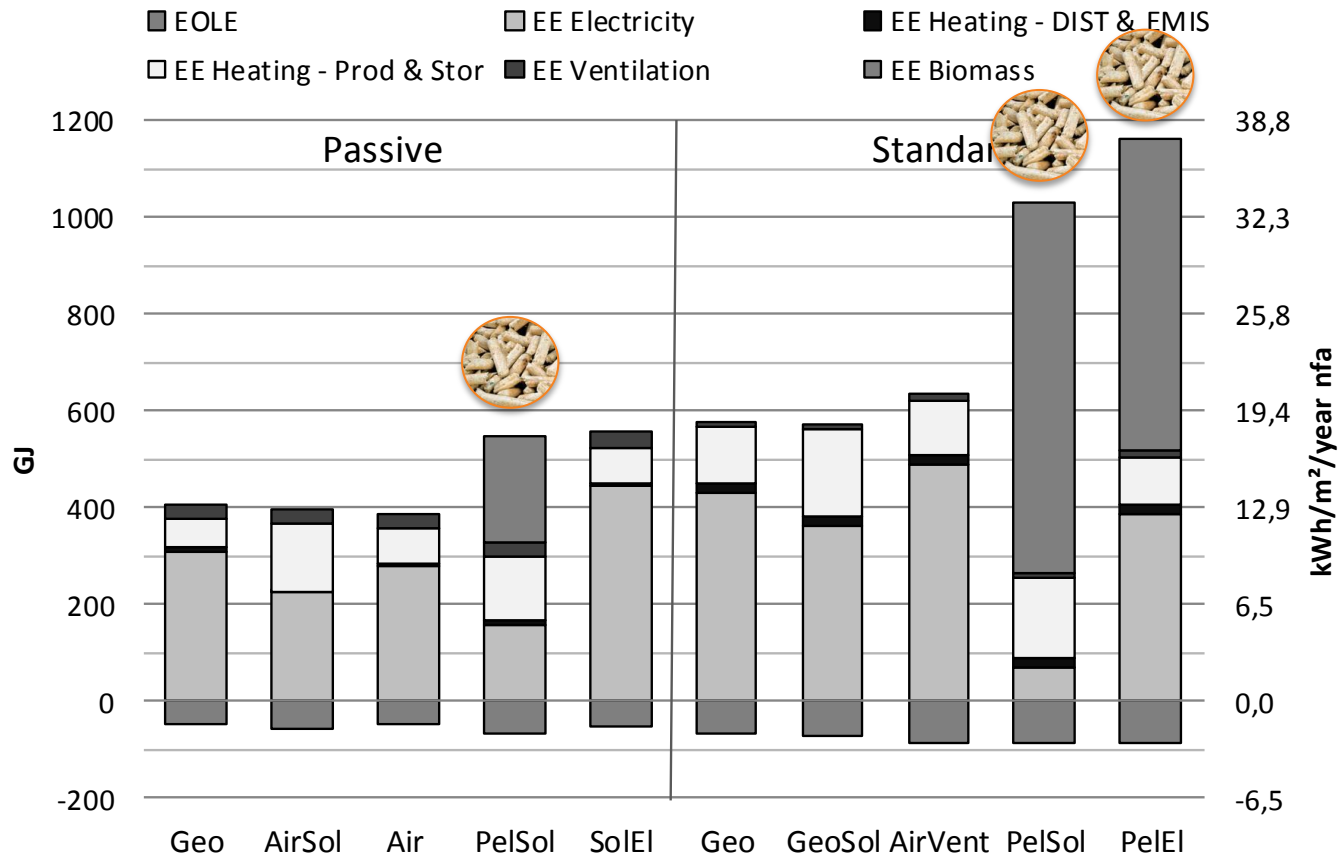
| | PASSIVE | STANDARD |
|------------------------------------|---------------------------|--|
| UNALTERED BUILDING SERVICES | | |
| VENT | Balanced ventilation | Demand-controlled simple exhaust ventilation |
| DIST | Central heating | Central heating |
| EMIS | Radiators* | Radiators* |
| ELEC | Photovoltaics** | Photovoltaics** |
| BUILDING SERVICES SCENARIOS | | |
| REF | GasCo | GasCo |
| HEAT | Condensing boiler (gas) | Condensing boiler (gas) |
| DHW | | |
| ELEC | National Electricity grid | National Electricity grid |
| ZERO | Geo | Geo |
| HEAT | Geothermal heat pump | Geothermal heat pump |
| DHW | | |
| ZERO | AirSol | GeoSol |
| HEAT | Air-source heat pump | Geothermal heat pump |
| DHW | | |
| DIST | | |
| ELEC | Solar thermal collectors | Solar Thermal collectors |
| DIST | Air heating | |
| ZERO | Air | AirVent |
| HEAT | Air-source heat pump | Air-source heat pump |
| DHW | | |
| DIST | | |
| ELEC | Air heating | Ventilation extraction air-source heat pump |
| ZERO | PelSol | PelSol |
| HEAT | Pellet furnace | Pellet furnace |
| DHW | | |
| ELEC | Solar thermal collectors | Solar thermal collectors |
| ZERO | EISol | PelEI |
| HEAT | Direct Electrical (PV) | Pellet furnace |
| DHW | | |
| DIST | | |
| ELEC | Solar thermal collectors | Direct Electrical (PV) |
| DIST | Air heating | |

Overview of the building service scenarios for passive and standard houses, including common characteristics, one non-zero energy reference scenario (REF) and five zero-energy scenarios (ZERO): space heating production (HEAT), domestic hot water production (DHW), ventilation system (VENT), space heating distribution (DIST) and electricity production (ELEC) excluding household electricity.

** Not applicable when air heating is used*

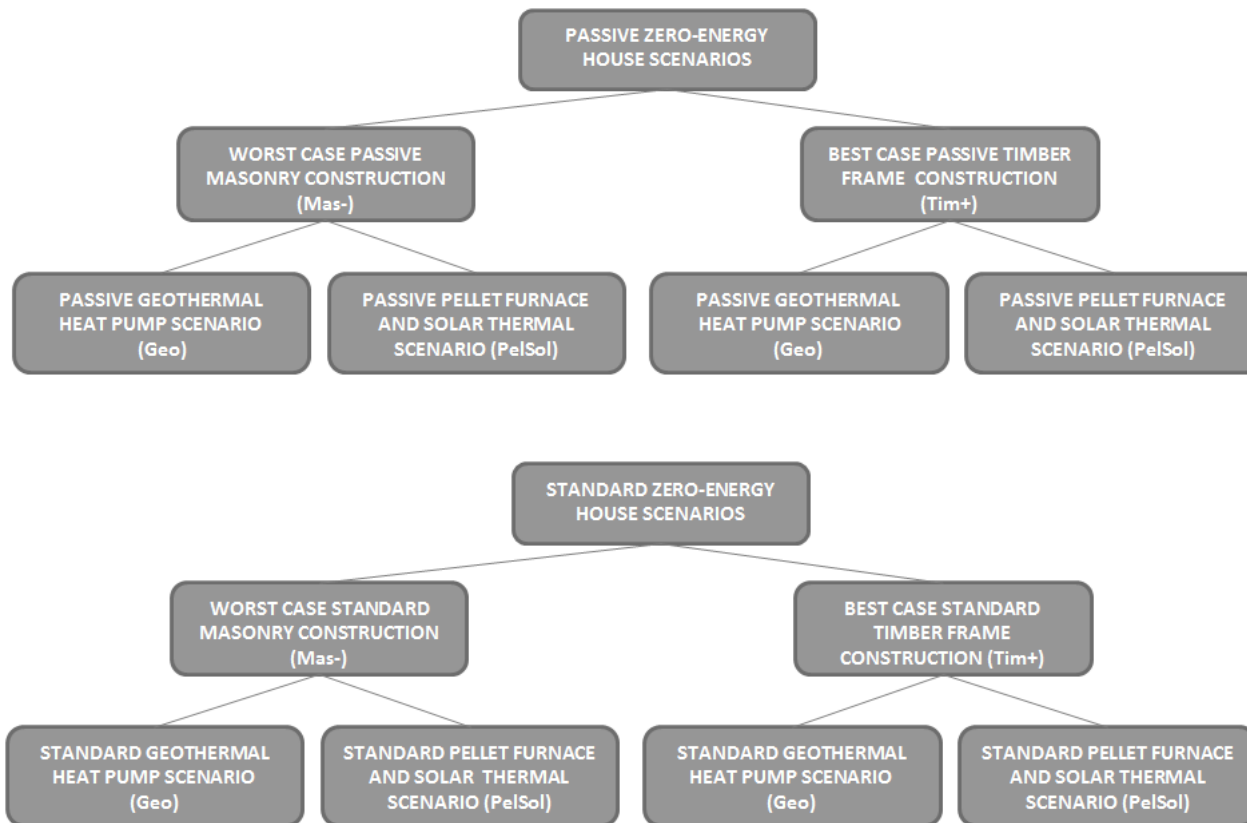
*** Not applicable to reference scenario (REF)*

Results building services – 10 zero energy scenarios



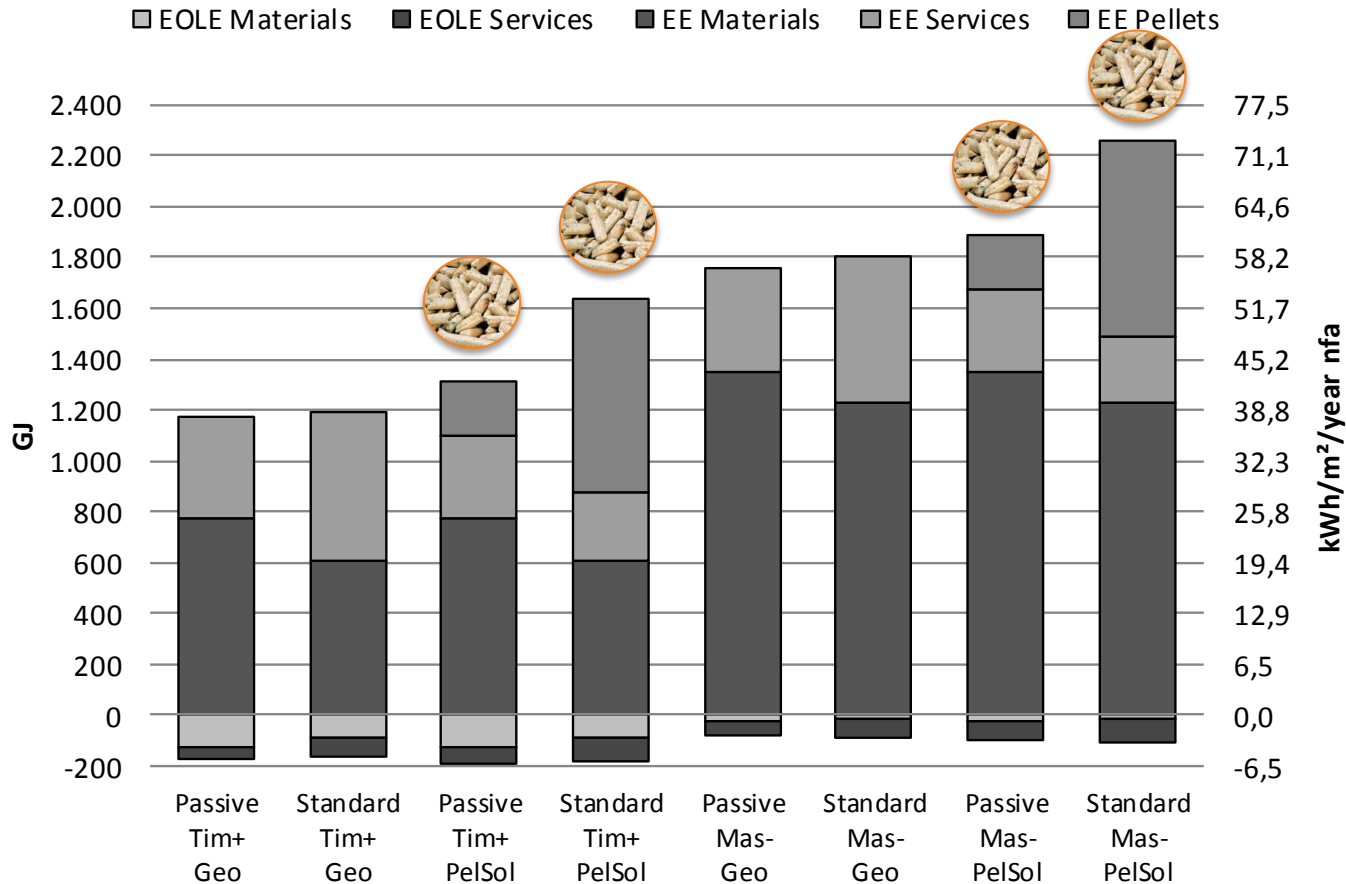
Non-renewable life cycle Embodied Energy (EE) per installation group and end-of-life energy (EOLE) of passive and standard building services scenarios, including the embodied energy in wood pellets (EE Biomass).

8 zero-energy house – combinations of construction and services scenarios



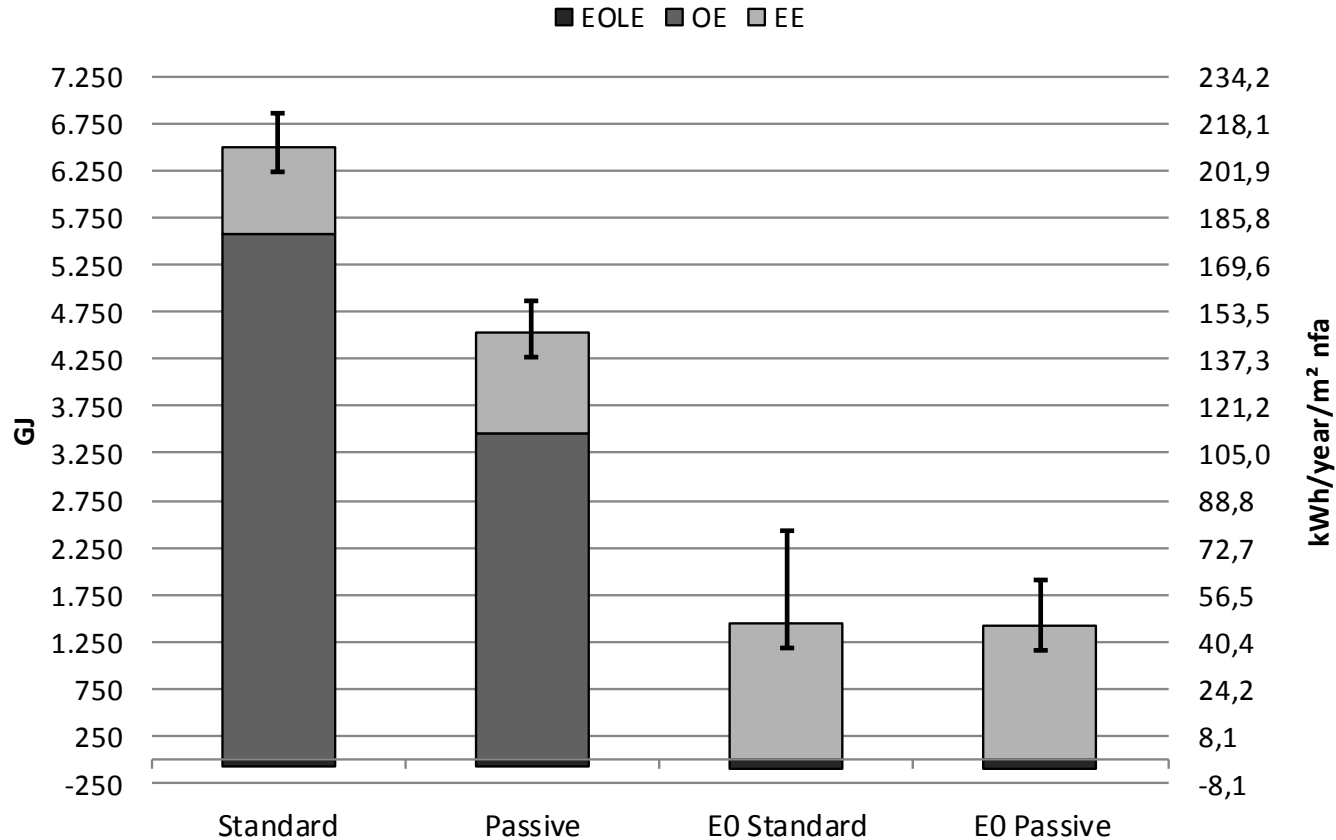
Overview of 4 passive and 4 standard zero-energy house scenarios

Results zero-energy house



Non-renewable Embodied Energy (EE) and End-Of-Life Energy (EOLE) of Passive and Standard zero-energy house scenarios composed of most (Tim+) and least (Mas-) energy efficient building material scenarios and a geothermal heat pump (Geo) or pellet furnace and solar boiler (PelSol)

Passive, standard and zero-energy house



Non-renewable embodied (EE), operational (OE) and end-of-life (EOL) energy for standard, passive, standard zero-energy and passive zero-energy houses. Variations in embodied energy due to different building material and services selection are depicted.

Main conclusions

- » Passive non zero-energy houses typically **2-4 times NRLCE consumption** of a zero-energy house
- » Standard non-zero energy houses **3-5 times NRLCE consumption** of a zero-energy house
- » NR LCEE consumption of zero-energy house scenarios varies between **37 to 72 kWh/year/m²** (net floor area)
- » 50% saving potential not related to a specific construction type (**Tim or Mas**) nor to the net energy demand (**standard or passive**)
- » But due to proficient choice of building materials and building services (**up to 30 kWh/year/m² savings**)
- » LCEE of **wood pellets and PV** of major importance - scenarios with heat pumps are favourable

Thank you

Himpe, E.², Trappers, L.^{2,3}, Van Holm, M.¹, Delghust, M.², Debacker, W.¹, Janssens, A.² and J. Moens², "*Life cycle energy analysis of a zero-energy house*", under review for Energy and Buildings.

- » ¹ Flemish Institute of Technological Research (VITO), Unit Transition Energy and Environment, Boeretang 200, B-2400 Mol, Belgium
- » ² Ghent University, Department of Architecture and Urban Planning, Jozef Plateaustraat 22, B-9000 Gent, Belgium
- » ³ Present affiliation address: Catholic University College Ghent, Department of Industrial Engineering, Gebroeders De Smetstraat 1, 9000 Ghent, Belgium
- »

Contact details

Marlies Van Holm – MSc Engineering and architecture

marlies.vanhholm@vito.be

+32 14 33 59 97