



Cost optimal analysis of PEBs/PEDs

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Overview



- EXCESS project overview
 - General overview of the project
 - Overview of four demo cases (Spain, Austria, Finnland, Belgium)
- Cost optimal analysis overview of method
- Results of Cost optimal analysis of EXCESS demos
 - Overview of all demo results
 - Detailed analysis of Spanish pilot case
 - Conclusion







- EXCESS FleXible user-CEntric Energy poSitive houseS
- EU Horizon2020 project with 21 partners from 8 countries, 2019-2024
- Main aim is to show how nZEBs can be transformed into PEBs
- Four demo sites in four different climate zones
- Focus on innovative technical solutions (deep boreholes for seasonal storage, PVT, multifunctional facade element, ...)





EXCESS demo case Spain/Valladolid



- Historical palace from 16th century
- Located in the historical center of Valladolid
- Mediterrane climate
- Insulation without change of facade
- Change from gas to aerothermal heat pump (40kW) and floor heating
- PV (51.4kWP) with battery (30kWh)
- PVT for DHW (2.8kW)
- Building will achieve PEB-level after renovation
- Construction works will be finished by end of this year











EXCESS demo case Austria/Graz



- Former feed production silo in former industrial area of Graz
- Continental climate
- Renovation to an area with mixed uses including offices,
 sport facilities and restaurants
- Renovation with highly insulated prefabricated multifunctional façade elements (component activation, insulation, BiPV)
 - 88kWp building integrated PV
- Cascadic heat pump system for heating and cooling
- Building energy management system
- PEB level will achieved after renovation





EXCESS demo case Belgium/Hasselt



- Social housing complex in Hasselt
- Demo building includes four apartment with 20 dwellings
- Oceanic/Coastal climate
- Change to multisource geothermal heat pump
- 44kWp PV for renewable electricity
- 44kWp PVT panels for electricity, heatpump and recharge of bedrock
- Small wind turbine on the roof (5kWe)
- Building energy management system
- PEB level can be achieved after renovation







EXCESS demo case Helsinki/Finnland





- New building in Kalasatama district, city of Helsinki
- 8 floors, mixed-use building including residential apartments, commercial spaces and a restaurant
- Nordic climate
- Hybrid geothermal energy system
- ~600m deep boreholes
- 67 kW multisource heat pump with high COP
- 87 kWp building integrated PV
- 79 kWp PVT for the heatpump and recharging the bedrock
- PEB level cannot be achieved





Cost-optimal analysis of PEBs



- Target: Define cost-optimal technologies and technology packages for PEBs
- Development of cost-optimal calculation framework
 - Based on cost-optimal framework acc. (EU) No 244/2012 supplementing guideline to EPBD
 - Guideline defines a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements
 - Comparison of global costs and net primary energy demand
- Cost-optimal analysis of pilot cases in EXCESS project
 - Definition of technology packages
 - Cost/Energy curves for several technology packages of each pilot case
 - Identification of cost-optimal technical solutions and technology packages for pilot cases



Cost-optimal analysis method



Global costs include

- Investment costs
- Replacement cost (if expected technology lifetime is lower than the calculation period)
- Residual value (if expected technology lifetime is higher than the calculation period)
- Maintenance and operation cost for complete calculation period
- Energy cost and revenues from RES feed-in for complete calculation period
- All values as NPV (discount factor 3%)

Net primary energy demand includes

- Annual energy demand for heating, cooling, air-conditioning, DHW and lighting
- Annual electricity production from RES
- Energy demand/production in terms of primary energy

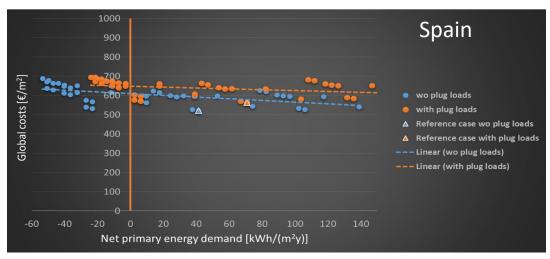
Calculation parameter

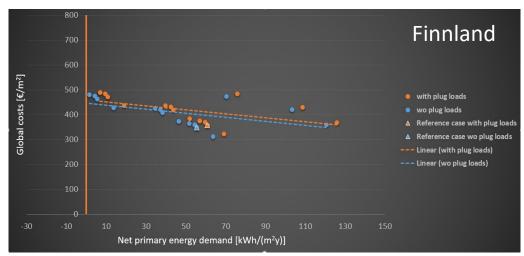
- Calculation period: 30 years (according cost-optimal framework EU No 244/2012)
- Discount factor: 3%

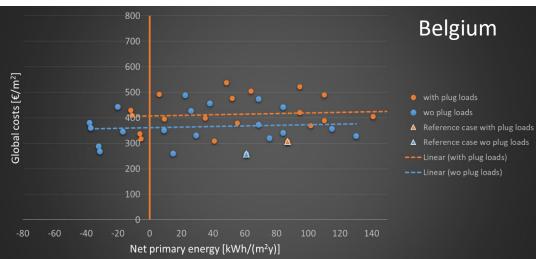


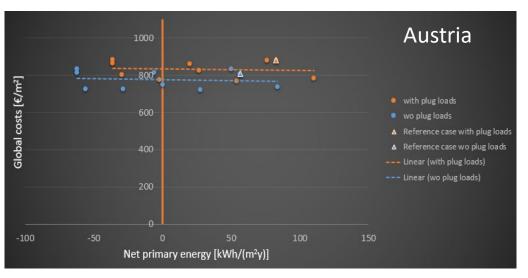
Cost-optimal analysis of EXCESS demos













EXCESS demo Valladolid – scenarios and technology packages



- Scenarios for building elements (envelope, thermal system, PV, BEMS) defined
- Scenarios are combined to 42 technology packages and cost-optimal framework applied

	Scenario	Description	Investment costs [€]	Investment costs per unit [€/(m² or kW or kWh)]	Expected technology lifetime [y]
	DO	Baseline Spanish regulation envelope; U-value of envelope [W/(m² K)]: walls 0.41, roof 0.35, floor 0.65, windows 1.8	143 700	131 €/m²	50
Building envelope	D1	High efficiency envelope; U-value of envelope [W/(m² K)]: walls 0.13, roof 0.1, floor 0.27, windows 0.87	269 100	247 €/m²	50
	D2	High efficiency envelope D1 plus heat recovery unit (EXCESS scenario)	318 600	292 €/m²	50
	TS0	Gas heating with boiler and solar thermal for DHW	78, 300	348 €/kW	15
Thermal system PV facility	TS1	Aerothermal heat pump (40 kW) with floor heating	156 200	3905 €/kW	20
	TS2	Aerothermal heat pump (40kW) with PVT (2.8kW) for DHW (EXCESS scenario)	164 600	3905 €/kW HP 3000 €/kWp PVT	20
	PVO	no PV	0	0 €/kWp	n.a.
	PV1a	22.75 kWp (70 panels each 375Wp), no storage	48 000	2110 €/kWp	25
	PV2a	51.38 kWp (70 panels each 375Wp), no storage	95 900	1866 €/kWp	25
	PV2b	51.38 kWp (70 panels a 375Wp), 30kWh battery energy storage (EXCESS scenario)	149 900	1866 €/kWp PV 1800 €/kWh bat.	25
Building management system	CS0	Baseline monitoring - control for heaters	4 100	n.a.	30
	CS1	Standard monitoring - control for space heating/cooling floor	15 000	n.a.	30
	CS2	Advanced Building Energy Management System (EXCESS scenario)	58 500	n.a.	30

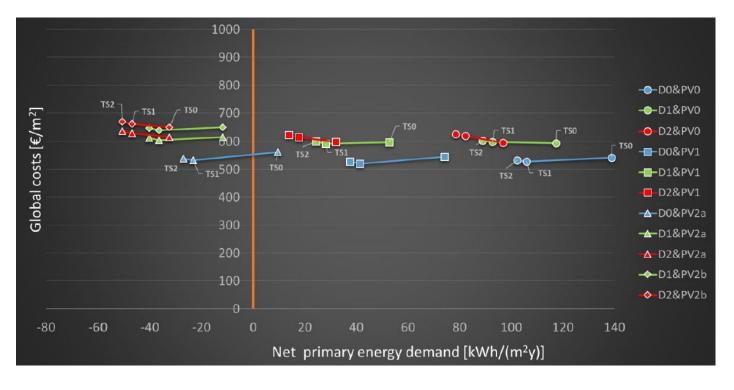


D1 TSO PVO CSO 60 36 22 0 117 671 D2 TSO PVO CSO 42 36 22 0 97 669 D0 TSI PVO CSI 0 64 50 0 106 587 D1 TSI PVO CSI 0 58 44 0 93 649 D2 TSI PVO CSI 0 53 39 0 82 679 D0 TSZ PVO CSI 0 63 49 0 102 582 D1 TSZ PVO CSI 0 56 42 0 87 674 D2 TSI PVO CSI 0 56 42 0 78 674 D2 TSI PVO CSI 0 51 37 0 78 674 D2 TSZ PVO CSI 0 51 37 0 78 674 D2 TSZ PVO CSI 0 56 42 31 74 650 D1 TSO PVIa CSO 77 36 22 31 74 650 D2 TSI PVIa CSI 0 64 50 31 41 587 D3 TSI PVIa CSI 0 64 50 31 41 587 D1 TSI PVIa CSI 0 58 44 31 28 651 D2 TSI PVIa CSI 0 63 49 31 38 684 D2 TSI PVIa CSI 0 63 49 31 38 684 D3 TSI PVIa CSI 0 53 39 31 18 682 D1 TSI PVIa CSI 0 53 49 31 38 594 D1 TSI PVIa CSI 0 56 42 31 24 648 D1 TSI PVIa CSI 0 51 37 31 14 679 D0 TSO PV2a CSO 60 36 22 62 10 680 D1 TSO PV2a CSO 60 36 22 62 -12 713 D0 TSO PV2a CSO 60 36 22 62 -12 713 D2 TSI PV2a CSI 0 58 44 62 -37 706 D3 TSO PV2a CSI 0 53 39 62 -47 706 D3 TSO PV2a CSI 0 53 39 62 -47 706 D4 TSO PV2a CSI 0 56 42 62 -12 713 D0 TSO PV2a CSI 0 56 42 62 -12 713 D2 TSI PV2a CSI 0 56 42 62 -12 713 D3 TSO PV2a CSI 0 56 42 62 -12 713 D3 TSO PV2a CSI 0 53 39 62 -47 706 D4 TSO PV2a CSI 0 56 42 62 -12 713 D2 TSI PV2a CSI 0 56 42 62 -12 713 D3 TSO PV2a CSI 0 56 42 62 -12 713 D3 TSO PV2a CSI 0 53 39 62 -47 706 D4 TSO PV2a CSI 0	Ervelope	Thermal system	PV fadiřy	Building management	Gas demand [kWh/(m²y)]	Electricity demand (incl. plug loads) [kWh/(m²y)]	Electricity demand w/o plug loads) [kWh/[m²y]]	Electricity production [kWh/(m²y)]	Net Primary Energy demand wo plug loads [kWh/(m²y)]	Global costs wo plug loads [€/m²]
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Analysis of heating system

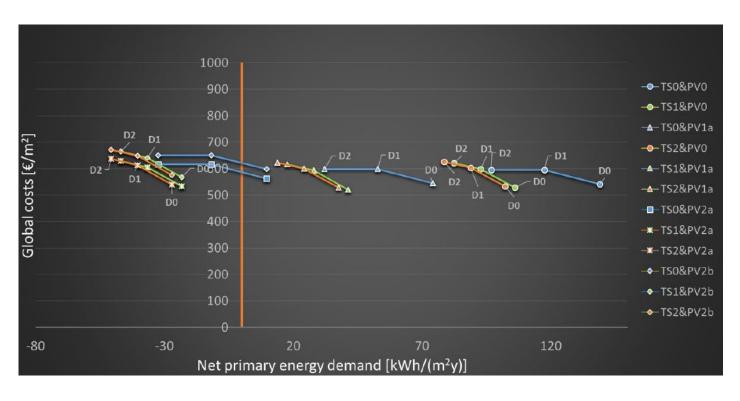


- TS0: Business as usual (gas heating system)
- TS1: Aerothermal heatpump
- TS2: Aerothermal heatpump + PVT (DHW)
- Change from TS0 to TS1
 - reduces net primary energy and global costs (for envelop D0 and D1)
 - Reduces net primary energy but increases global costs (for envelop D2)
 - => Cost effectiveness depends on quality of envelope
- Change from TS1 to TS2
 - Increases global costs => PVT not cost effective
- TS1 cost-optimal heating system scenario





Analysis of envelope

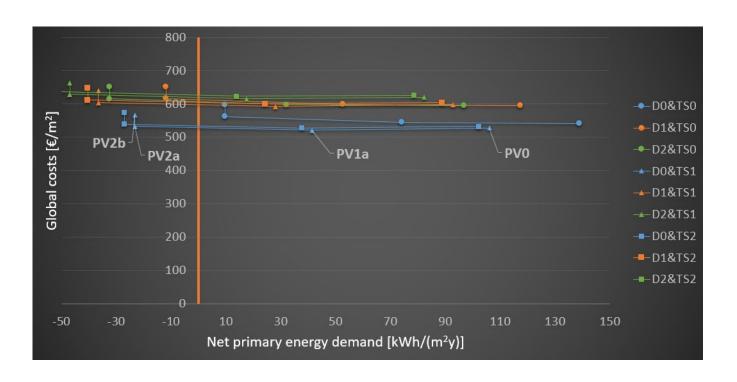


- D0: Baseline Spanish regulation envelope
- D1: Envelope high efficiency
- D2: Envelope high efficiency + heat recovery
- Change from D0 to D1 to D2
 - reduces net primary energy but increases global costs
 - => D0 is cost efficient technology in Spanish pilot case





Analysis of PV system

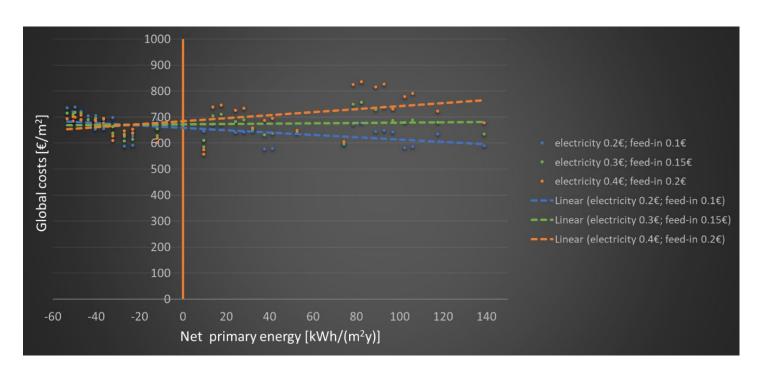


- PV0: no PV system
- PV1: 22.75 kWp PV, no storage
- PV2a: 51.38 kWp PV, no storage
- PV2b: 51.38 kWp PV, 30kWh battery storage
- Change from PV0 to PV1 to PV2a
 - reduces net primary energy without increase of global costs => cost efficient
- Change from PV2a to PV2b
 - No influence on net primary energy but increase of global costs => not cost efficient
- PV2a is cost efficient scenario





Sensitivity analysis



- High influence of electricity cost
- Slope of linear trendline decreases for electricity prices of 0.3€ and feed-in tariffs of 0.2€
- Electricity prices of 0.4€ turns almost all analysed PEB technologies into cost-efficient technologies that reduce global costs



Main Conclusions



- Not all PEB technologies reduce global costs with current energy prices and a 30 years calculation period => subsidies, grants, other support needed to upscale PEBs
- Results very sensitive to calculation parameters such as electricity prices, discount rate, calculation period, PEF
- PV and change of heating system (from gas to heatpump) are mostly cost-efficient (reduction of net primary energy and global costs)
- PVT, BiPV, Co-generation unit and envelop improvement are often not cost efficient if only energy demand/generation is considered
- Shape of building is a crucial parameter as PEB can be only achieved cost-efficient if there is enough area for PV
- Current PEB definition exhibits shortcomings => PEB possible just with PV if enough area is available



Main Conclusions



- Even if technologies may not be cost effective, they can be enabling technologies or provide additional benefits that were not considered in the analysis
 - PVT can be used in combination with geothermal heat pump to
 - Increases COP of heat pump
 - Regenerate the bedrock => amount and depth of boreholes can be smaller
 - Long-term reliability of thermal system (ground source) increased
 - Multifunctional façade element
 - Flexibility of building thermal mass increases self-sufficiency rate of the district
 - Non-intrusiveness
 - Higher comfort











Thank you for your attention

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