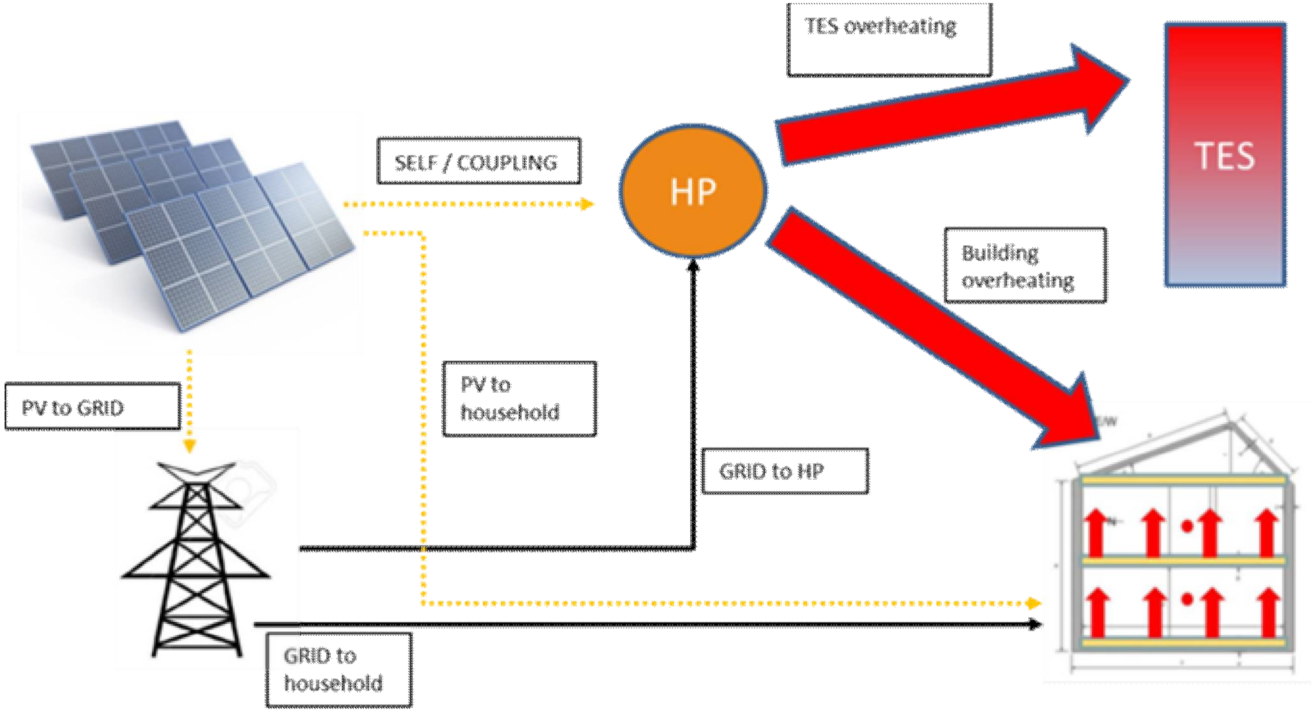
TheBat

PV coupled with HP

Building mass or a water store as **THE**rmal **BAT**tery

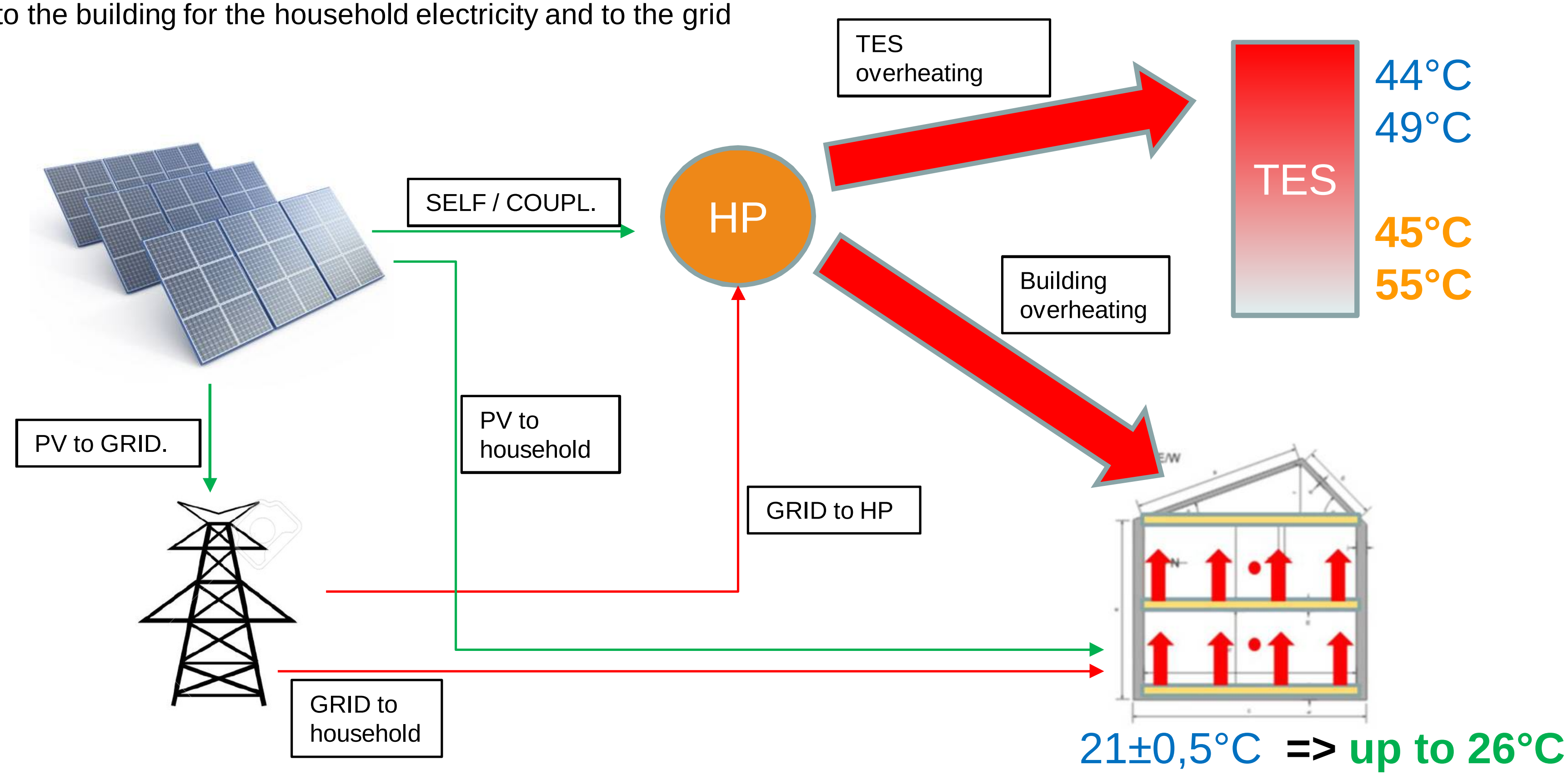


Alexander Thür, Toni Calabrese - University of Innsbruck

New control strategies: Overheating of the building and of the TES (REF w/o PV / SELF / BUI / TES / BUI+TES)

The PV electricity goes:

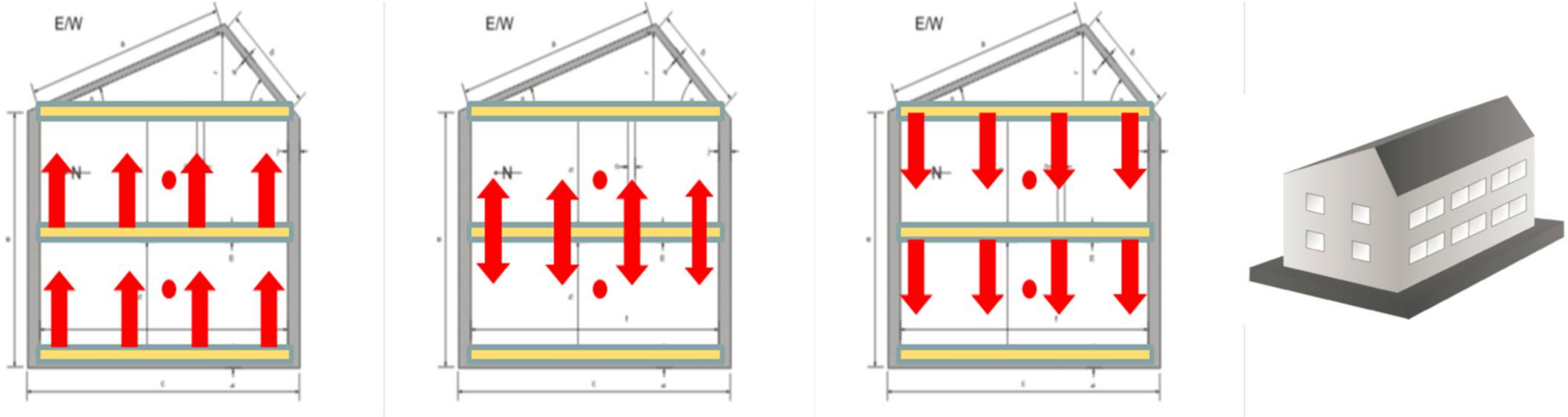
1. to the heat pump in modality **[SELF]** or in modality [COUPL] to overheat first the building (during the heating season, until 26°C) **[COUPL_BUI]** and then overheat the TES (UNTIL 55°C) **[COUPL_TES]**
2. to the building for the household electricity and to the grid



Reference Buildings

(based on IEA SHC Task44, Report C1 Part B)

RES45 | RES15 | OFF45



„RES45“: Residential, Low Energy: „heavy“ – floor heating (48 kWh/m^{2}a)

„RES15“: Residential, Passiv House: „heavy“ - concrete core floor activation (17 kWh/m^{2}a)

„OFF45“: Office, Low Energy : „light“ - concrete core ceiling activation (52 kWh/m^{2}a)

		RES15	RES45	OFF45
Space Heating (SH),	kWh/a:	2330	6700	7282
Domestic Hot Water (DHW),	kWh/a:	2175	2175	0
Cooling (C),	kWh/a:	0	0	1796

PV + HP - Concept

De-Superheater: 50°C

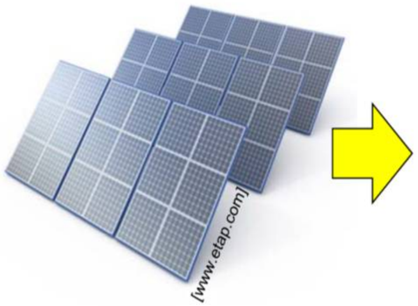
PV-System:

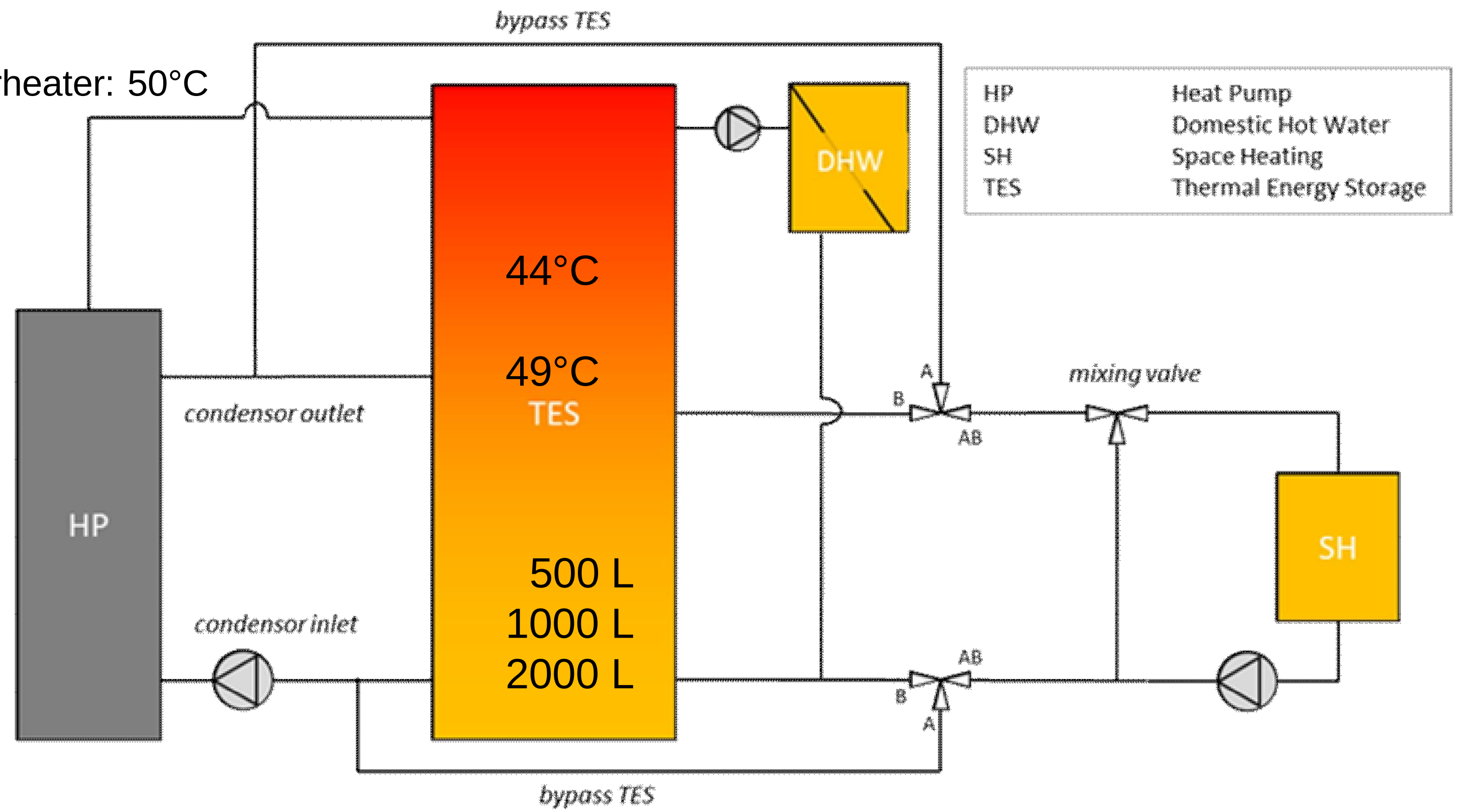
PV20 = 20m² = 2.5kW$_p$

3640 kWh/a

PV40 = 40m² = 5.0kW$_p$

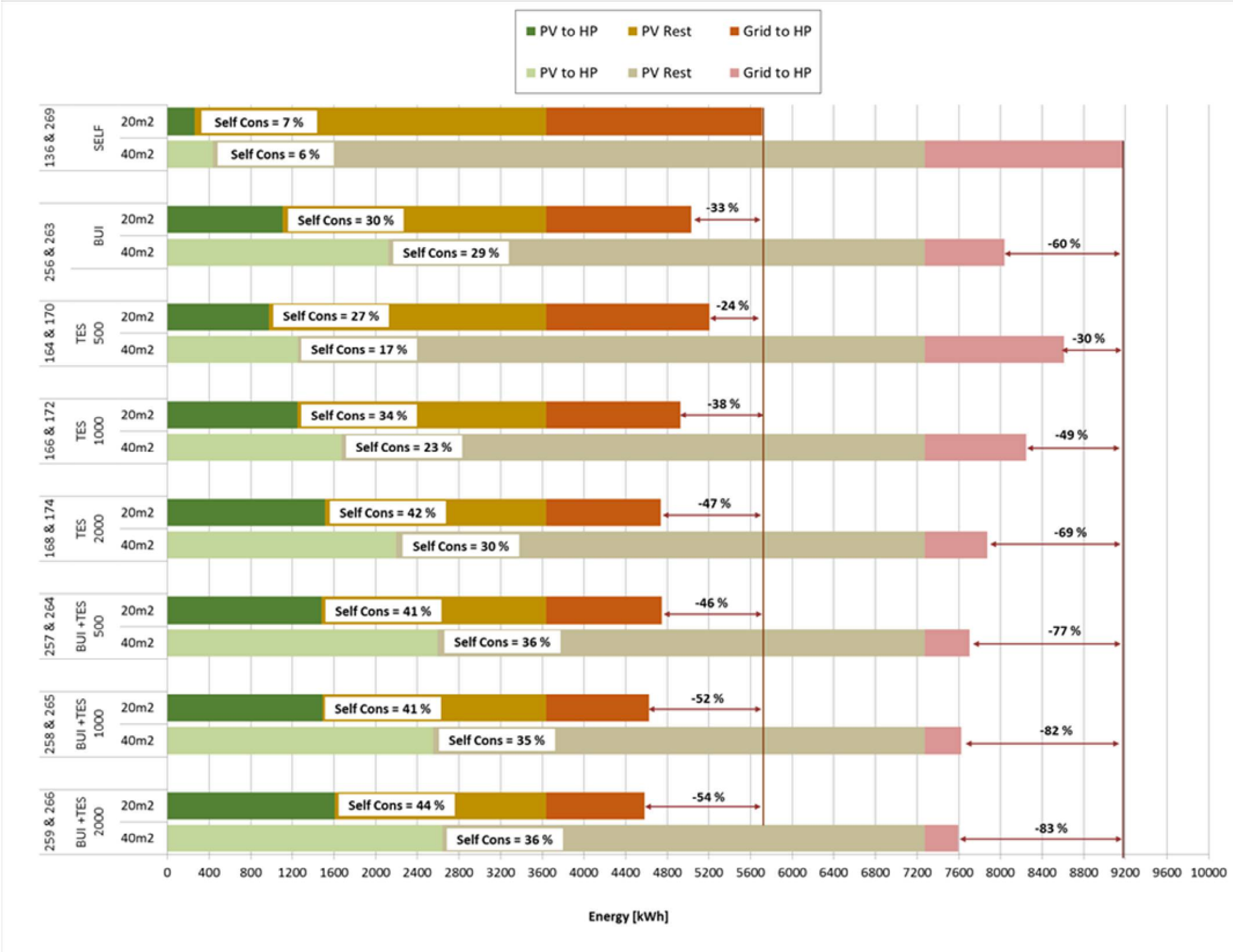
7275 kWh/a



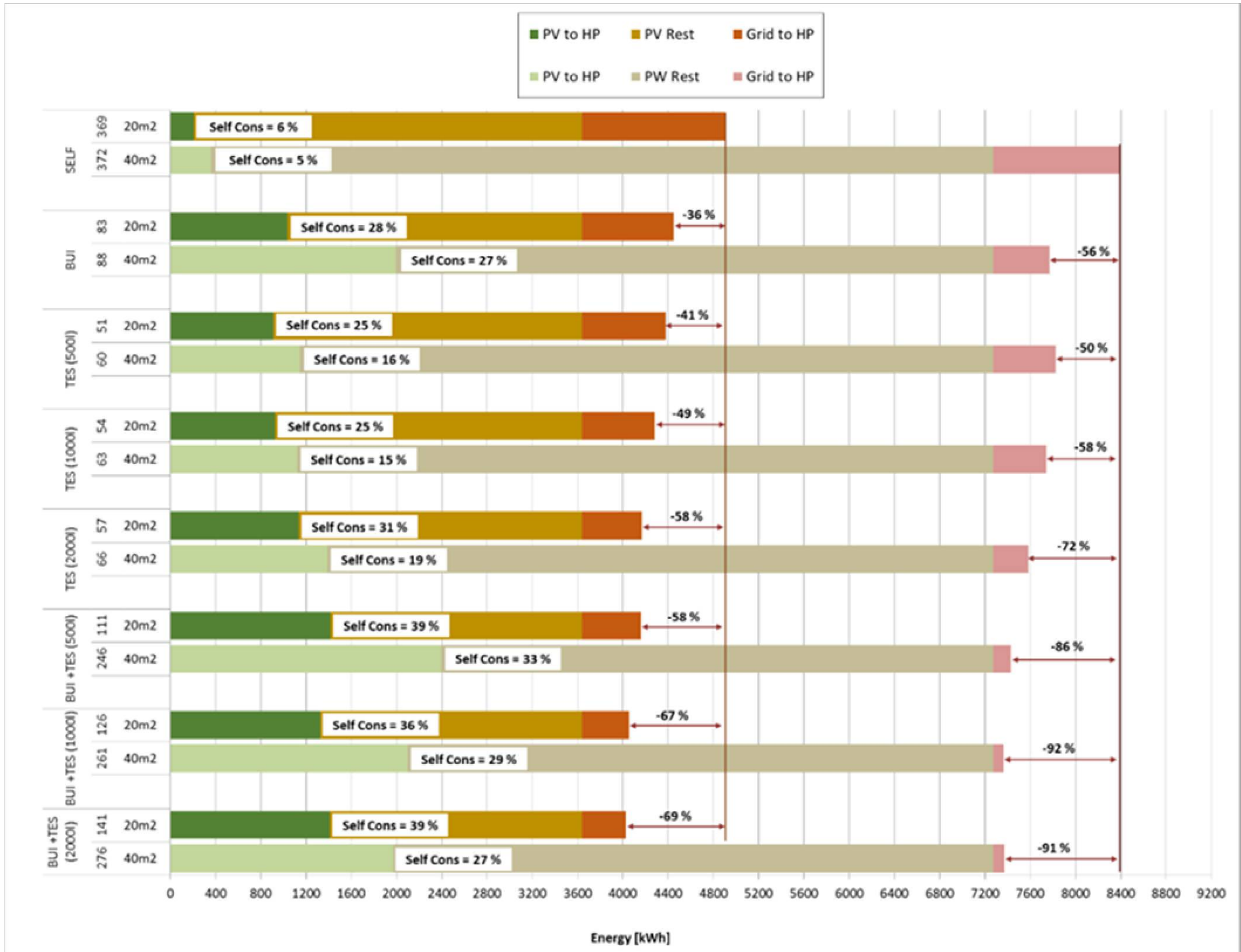


10kW$_{th}$ – Soil-Heat Pump – Power Controlled

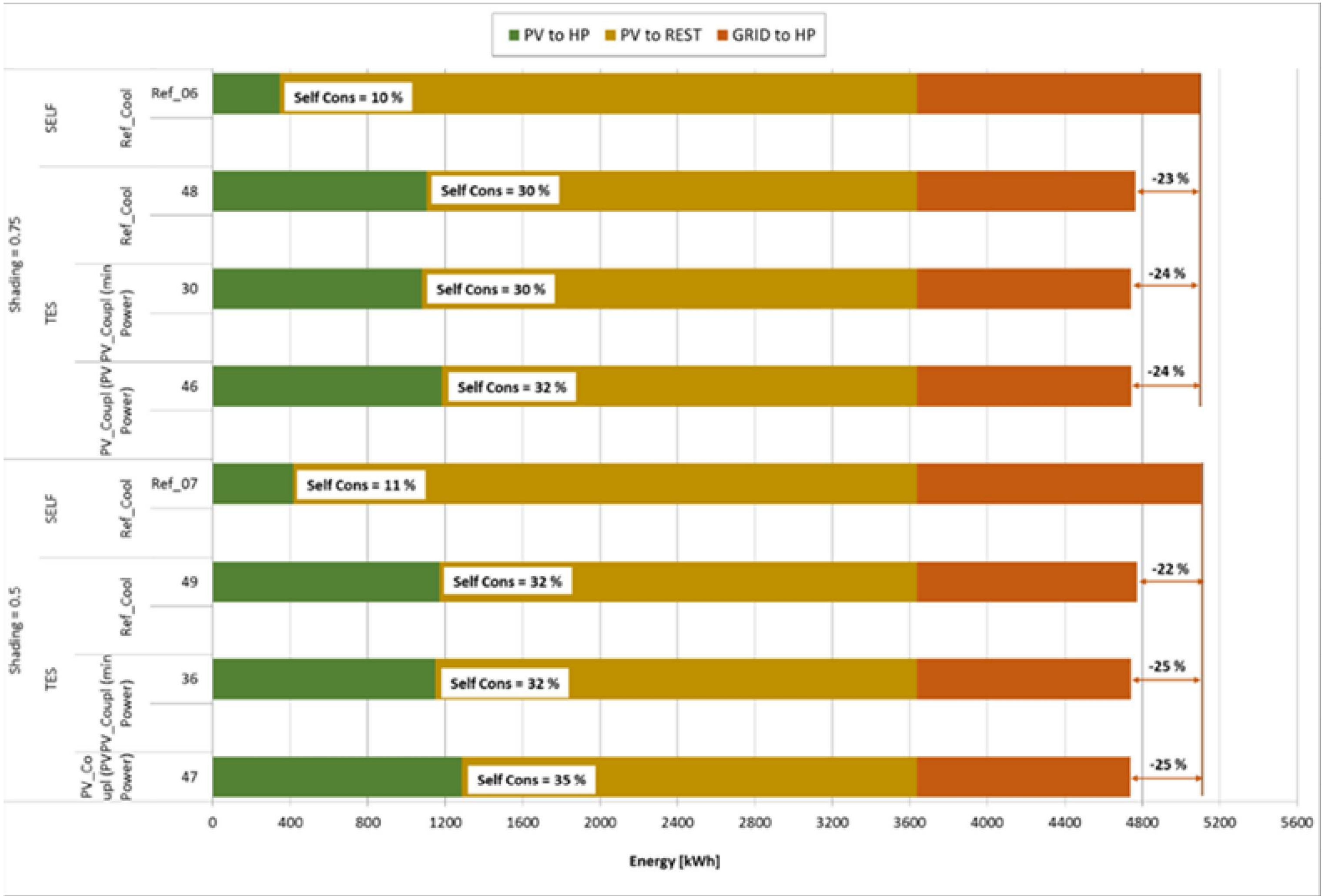
RES45: PV20 / PV40, Control concepts: SELF, BUI, TES, BUI+TES (TES volumes: 500, 1,000 and 2,000 liter) „PV to HP“ + „PV Rest“ = total PV production



RES15: PV20 / PV40, Control concepts: SELF, BUI, TES, BUI+TES
(TES volumes: 500, 1,000 and 2,000 liter) „PV to HP“ + „PV Rest“ = total PV production

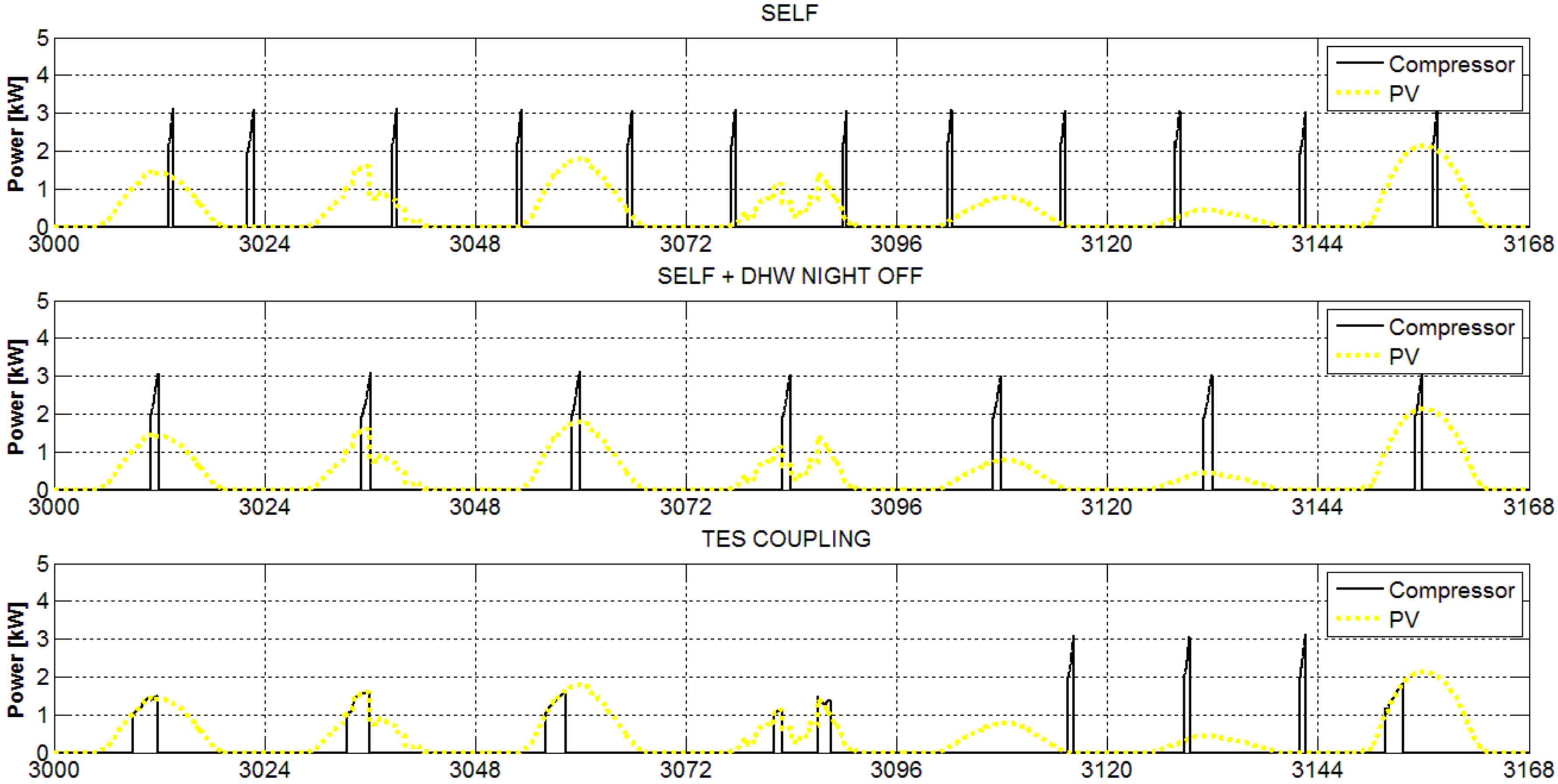


OFF45 (no DHW but Cooling): PV20 / ~~PV40~~, Control concepts: SELF, ~~BUI~~, TES, ~~BUI+TES~~
(TES volumes: 500, ~~1,000 and 2,000~~ liter) „PV to HP“ + „PV Rest“ = total PV production

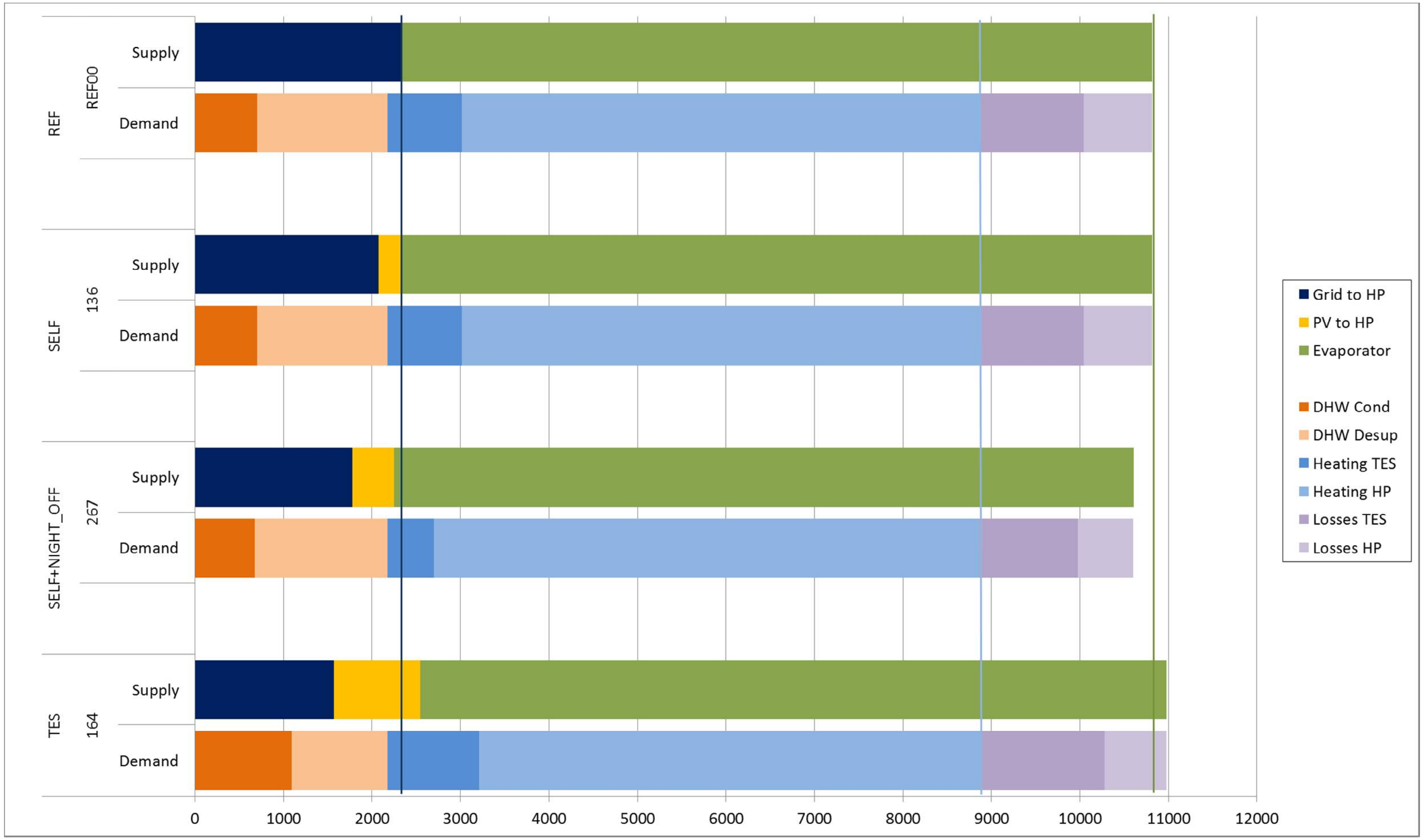


Control Concepts – DHW – RES45

SELF: Standard Control with 2 Temperature Sensors
SELF+DHW NIGHT OFF: HP blocked from 20:00 to 11:00 o'clock
TES COUPLING: HP Power controlled according PV-Production + SELF



Energy Balance: RES45 – 500 Liter – PV20 – DHW preparation



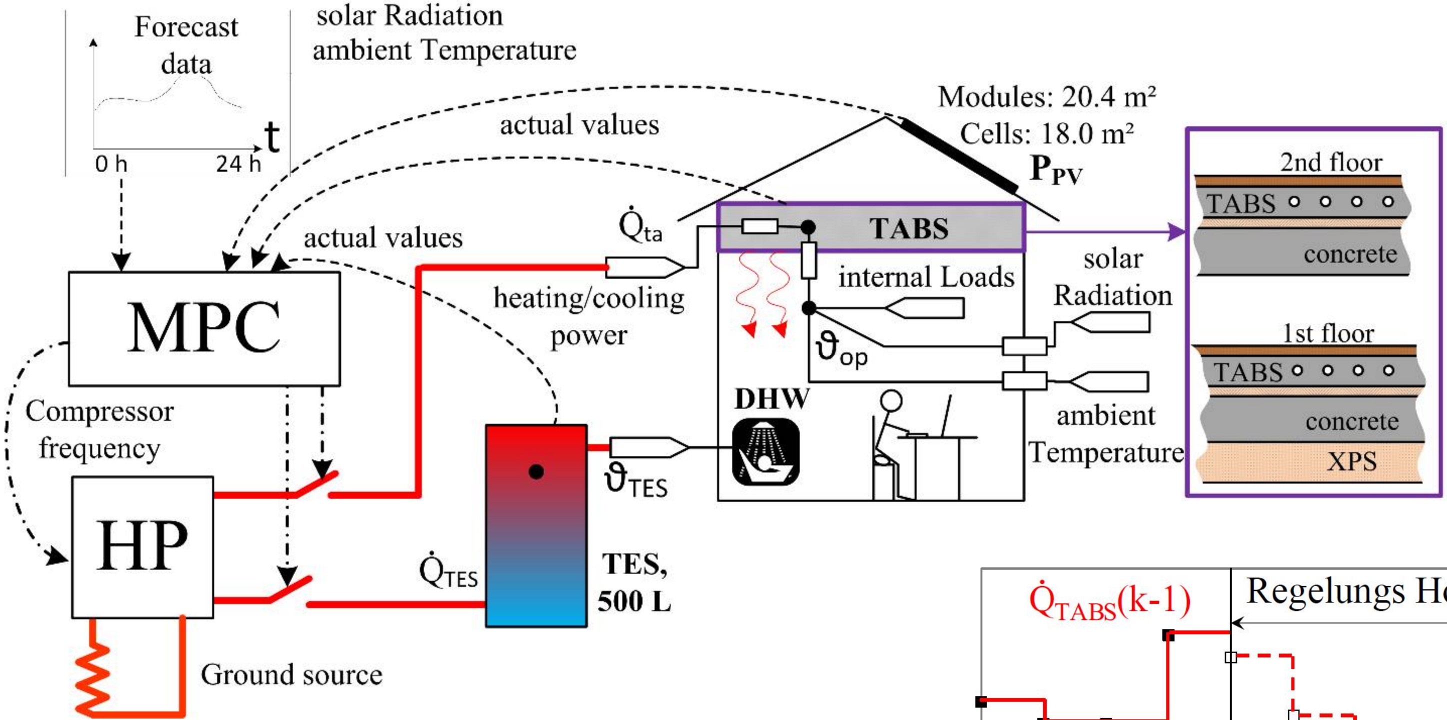
Grid to HP:

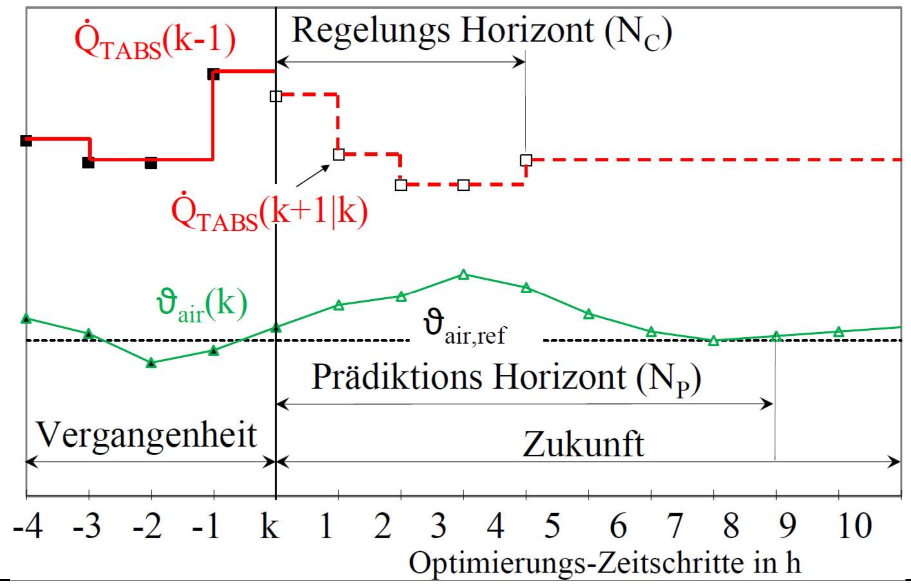
REF:
2336 kWh

SELF:
2075 kWh
-11 %

Night Off:
1777 kWh
-24 %

TES-coupling
1569 kWh
-33 %



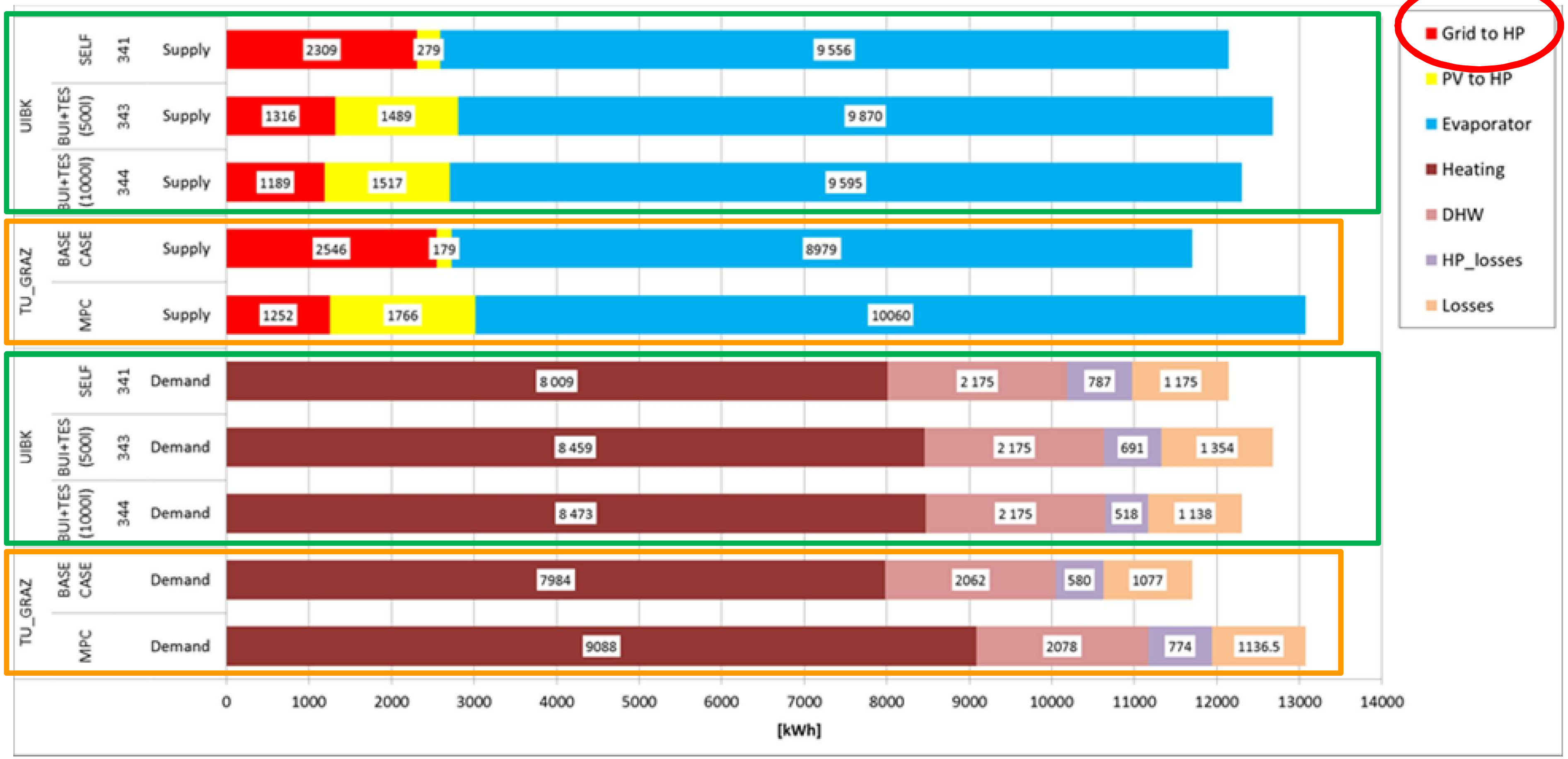


Model-Predictive-Control = MPC

by Martin Pichler, IWT - TU-Graz

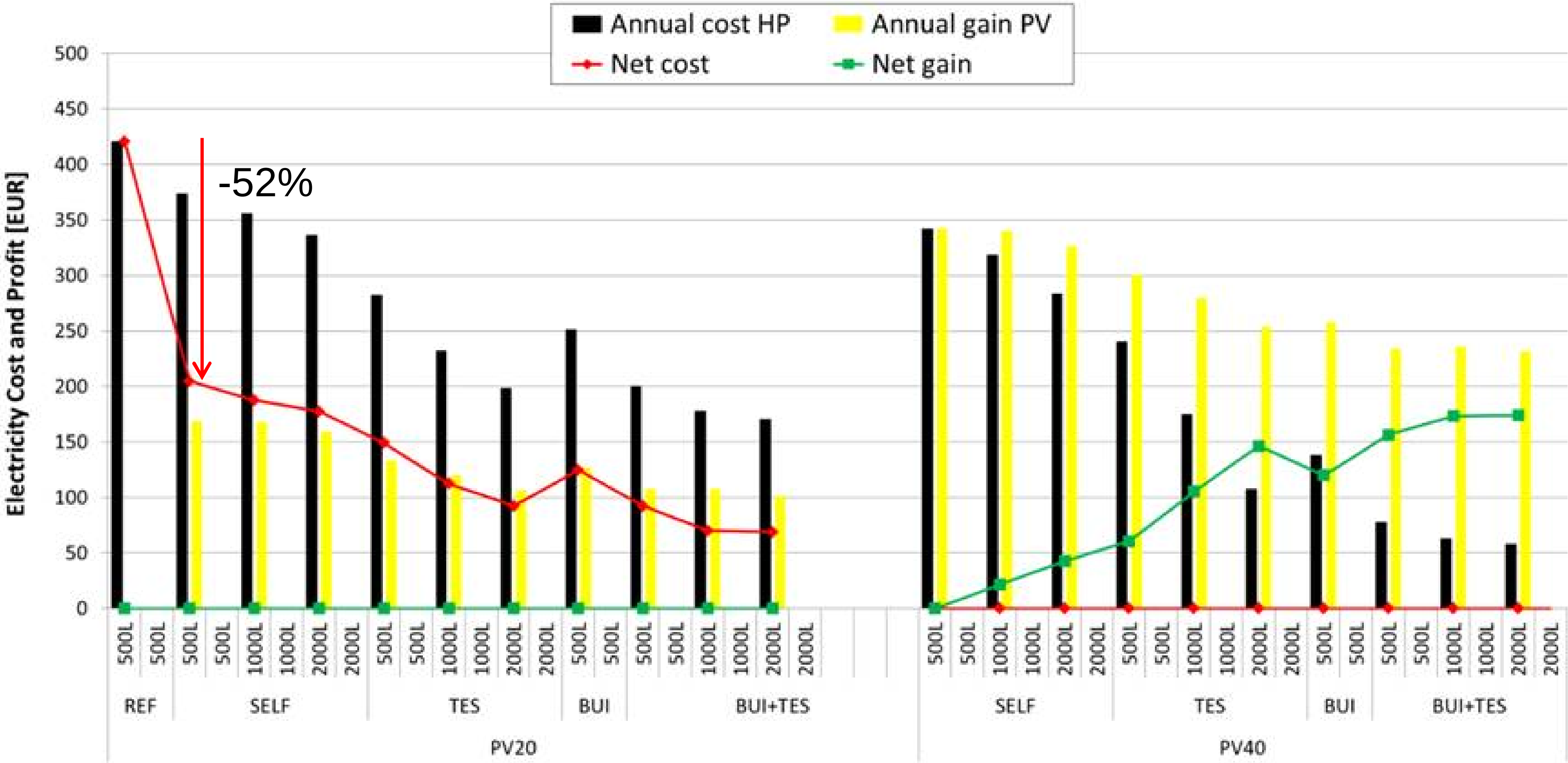
Comparison of Energy Balance for RES45:

Advanced Conventional Control (UIBK) ⇔ MPC (TU_Graz)



Operating cost for the RES45 building with a heat pump in combination with 20 m² (left) and 40 m² (right) PV area.

Grid cost = 18 EUR-cent/kWh ⇔ Feed in Tariff = 5 EUR-cent/kWh



Operating cost for the RES45 building with a heat pump in combination with 20 m² (left) and 40 m² (right) PV area.

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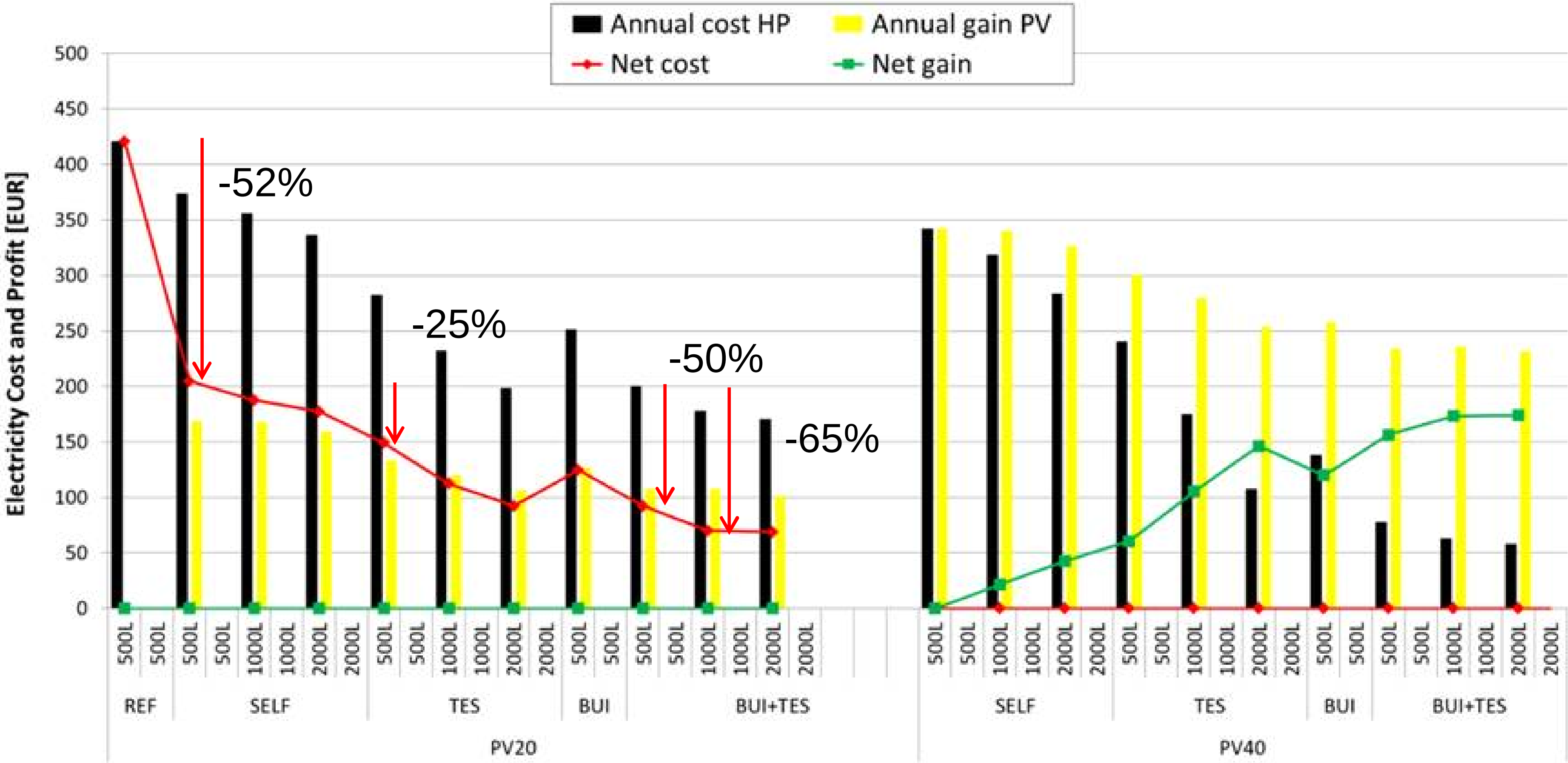
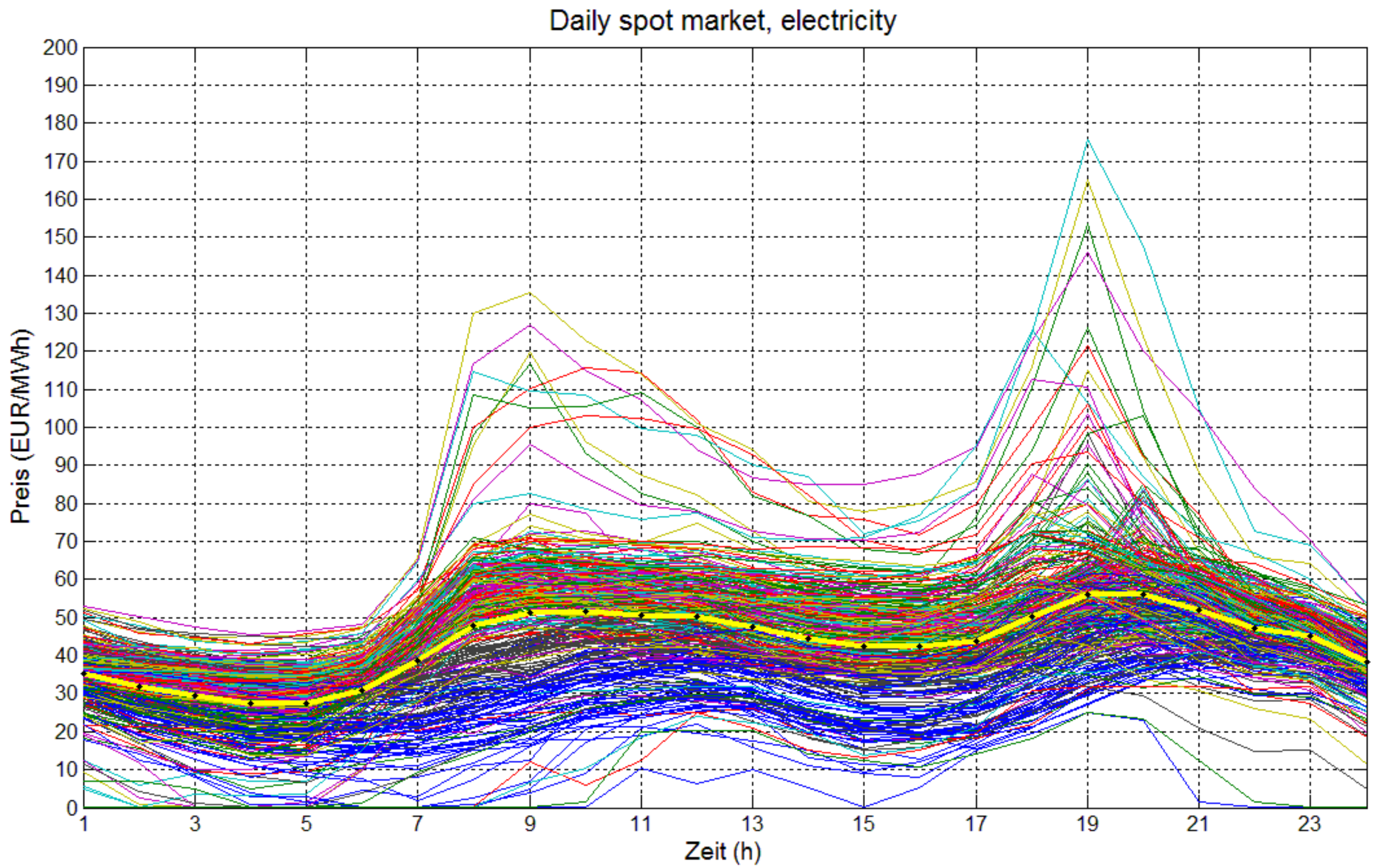


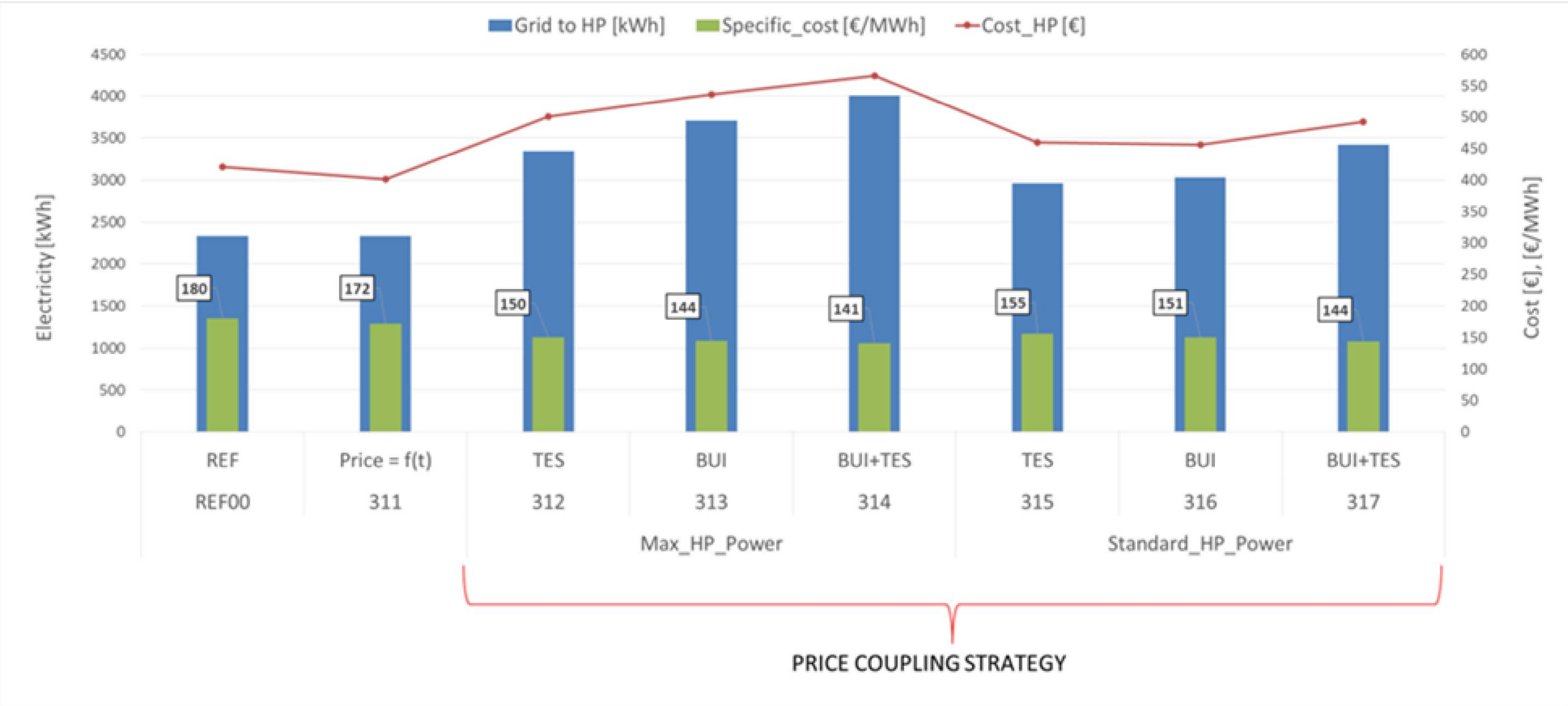
Grid-Electricity-Cost at the Austrian Daily Spot Market „hEXA 2012“

Normalized to 180 EUR / MWh as „Annual Average Electricity Cost“ which is the assumed constant „Reference Household Electricity Price“



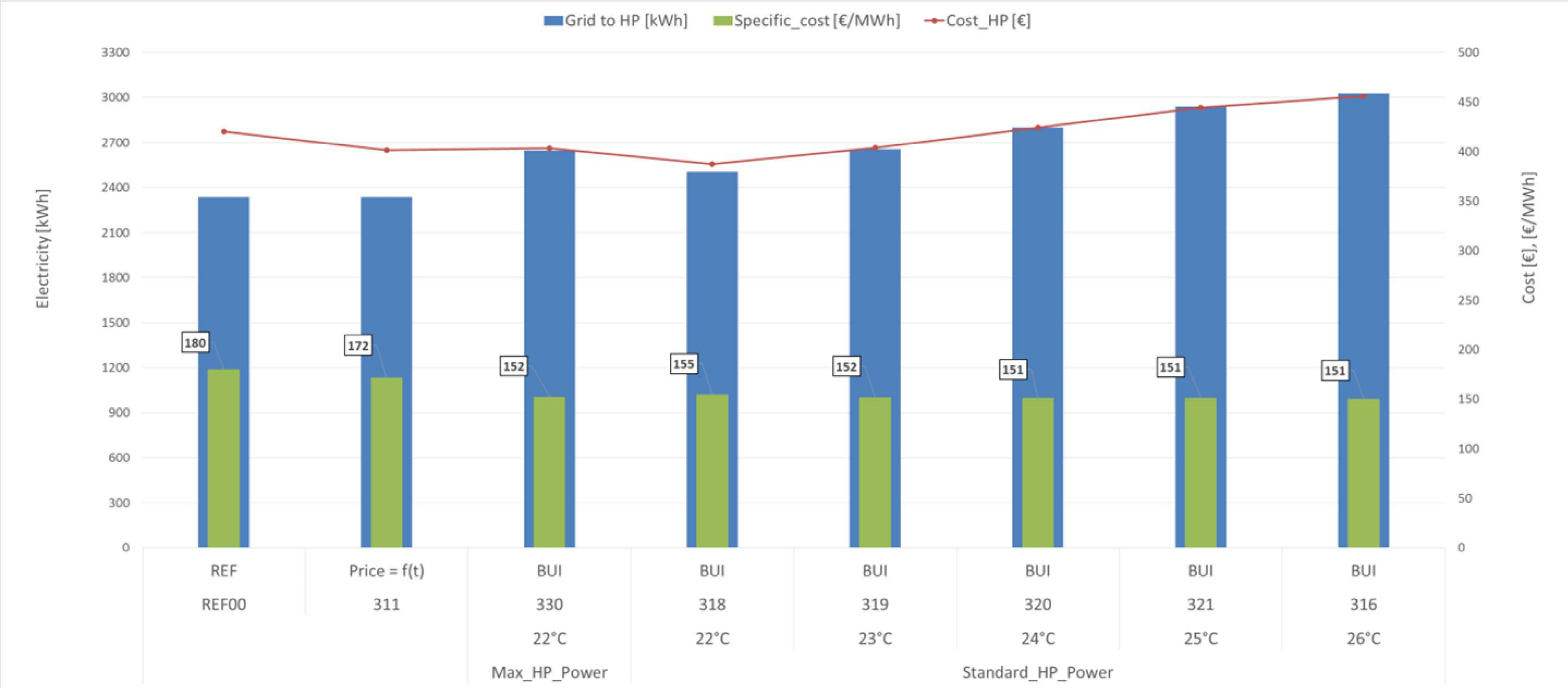
Grid-Electricity-Cost for RES45 (without PV) for constant (REF00) and variable Electricity-Cost (311 bis 317) with different Control Strategies of Price-Coupling

Additional HP operation, if electricity cost are less than daily average!

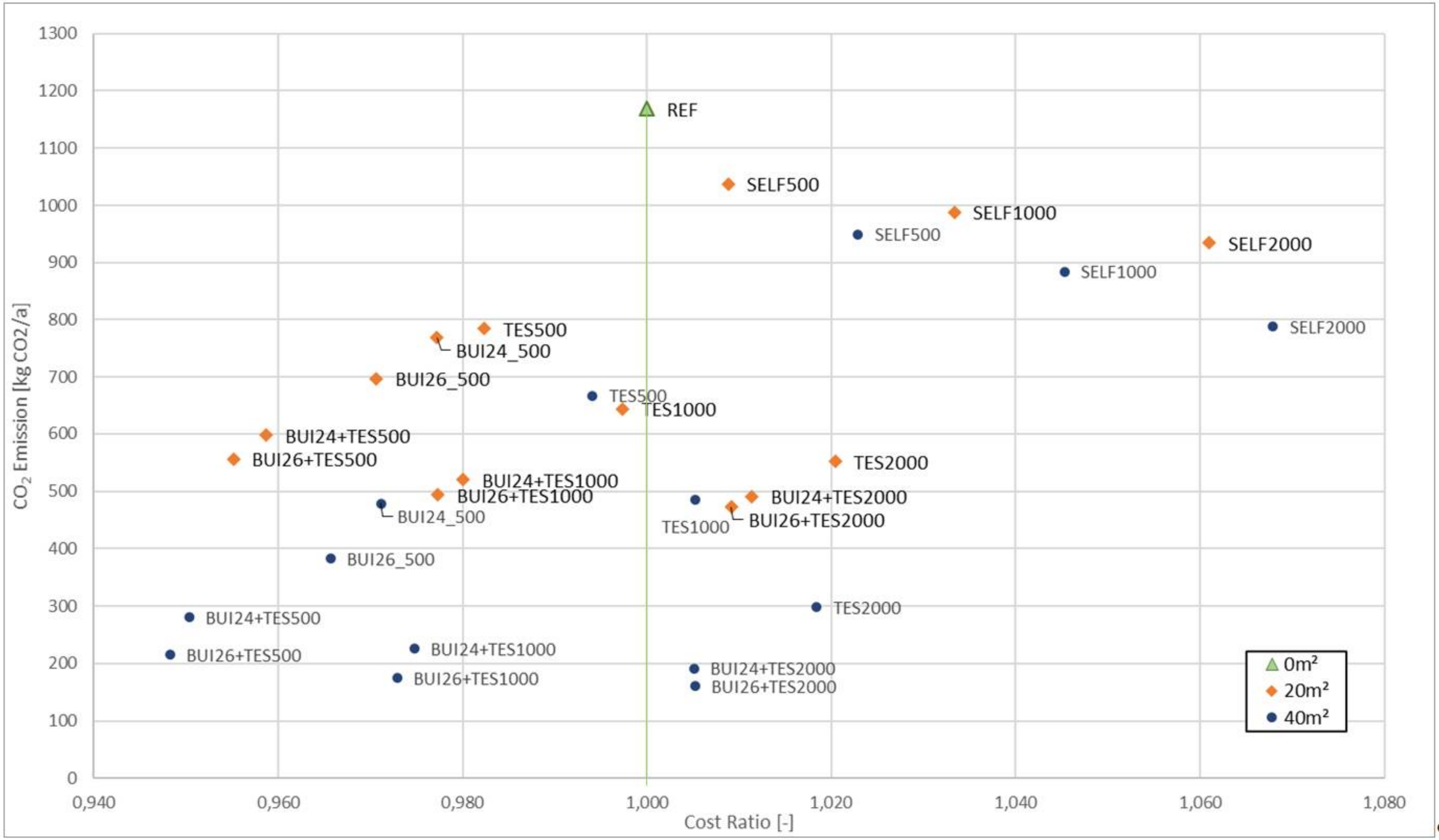


Grid-Electricity-Cost for RES45 (without PV) for constant (REF00) and variable Electricity-Cost (311) and with different Building Overheating Set-Temperatures (BUI)

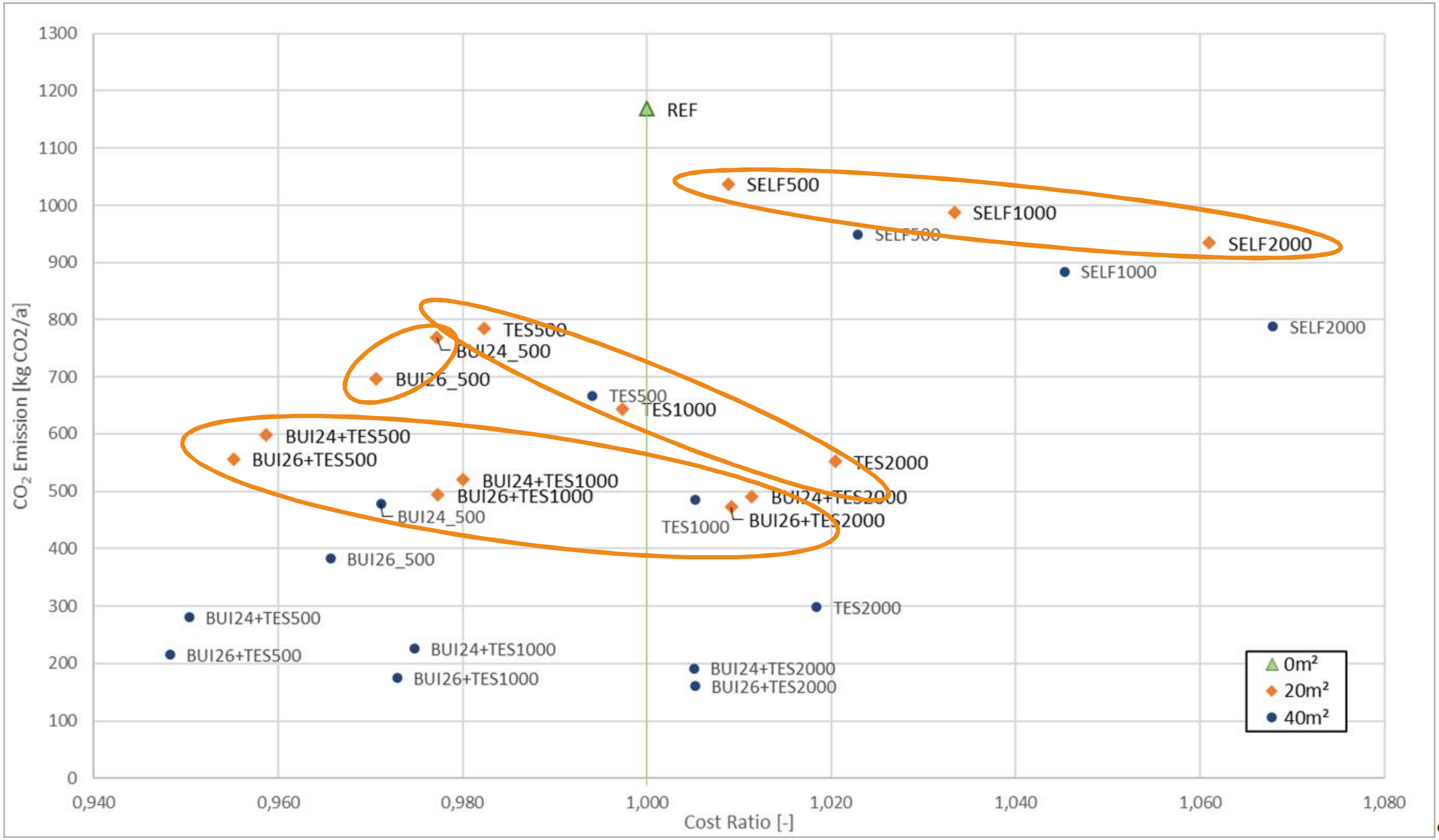
Additional HP operation, if electricity cost are less than daily average!



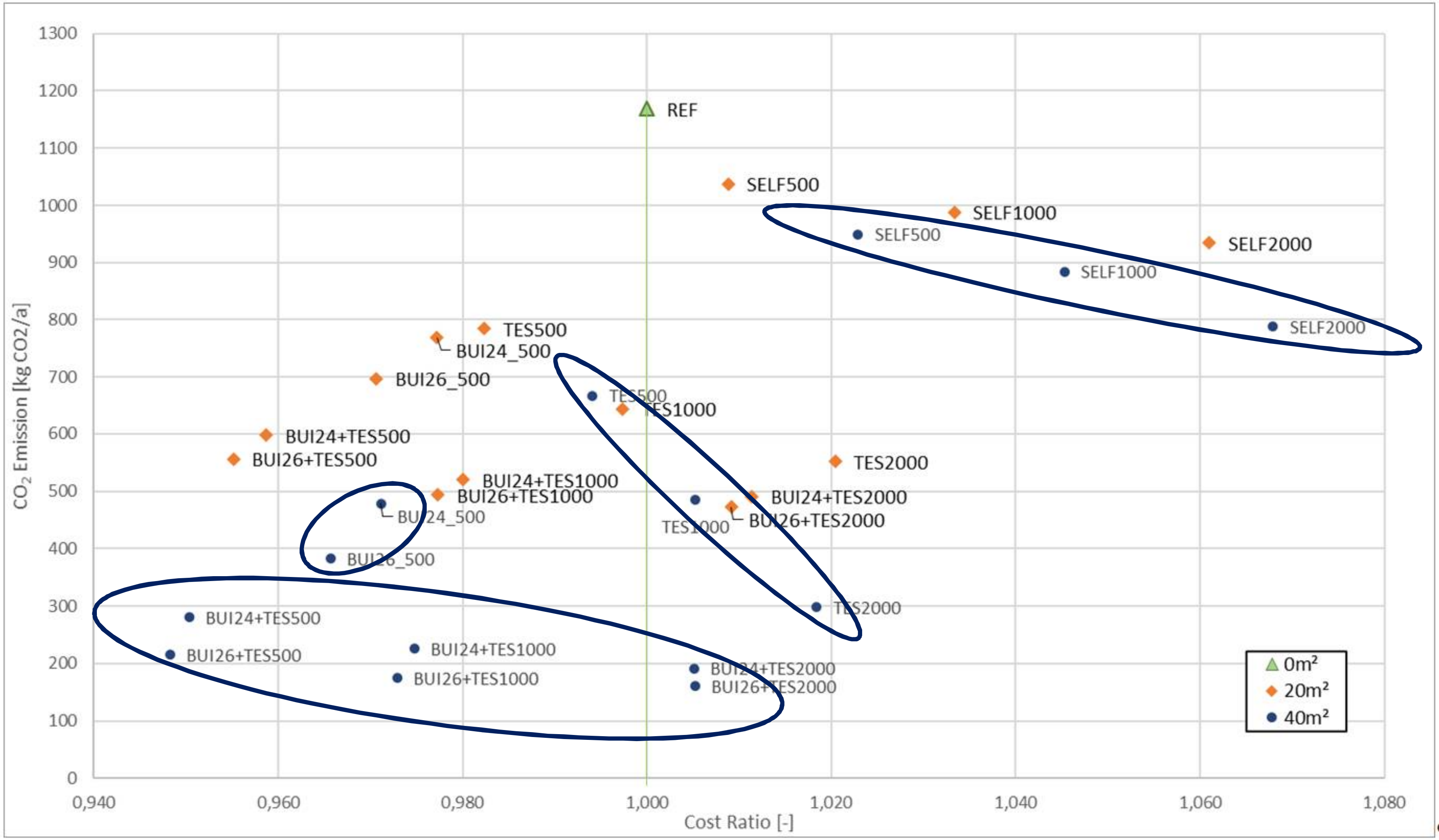
Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES45



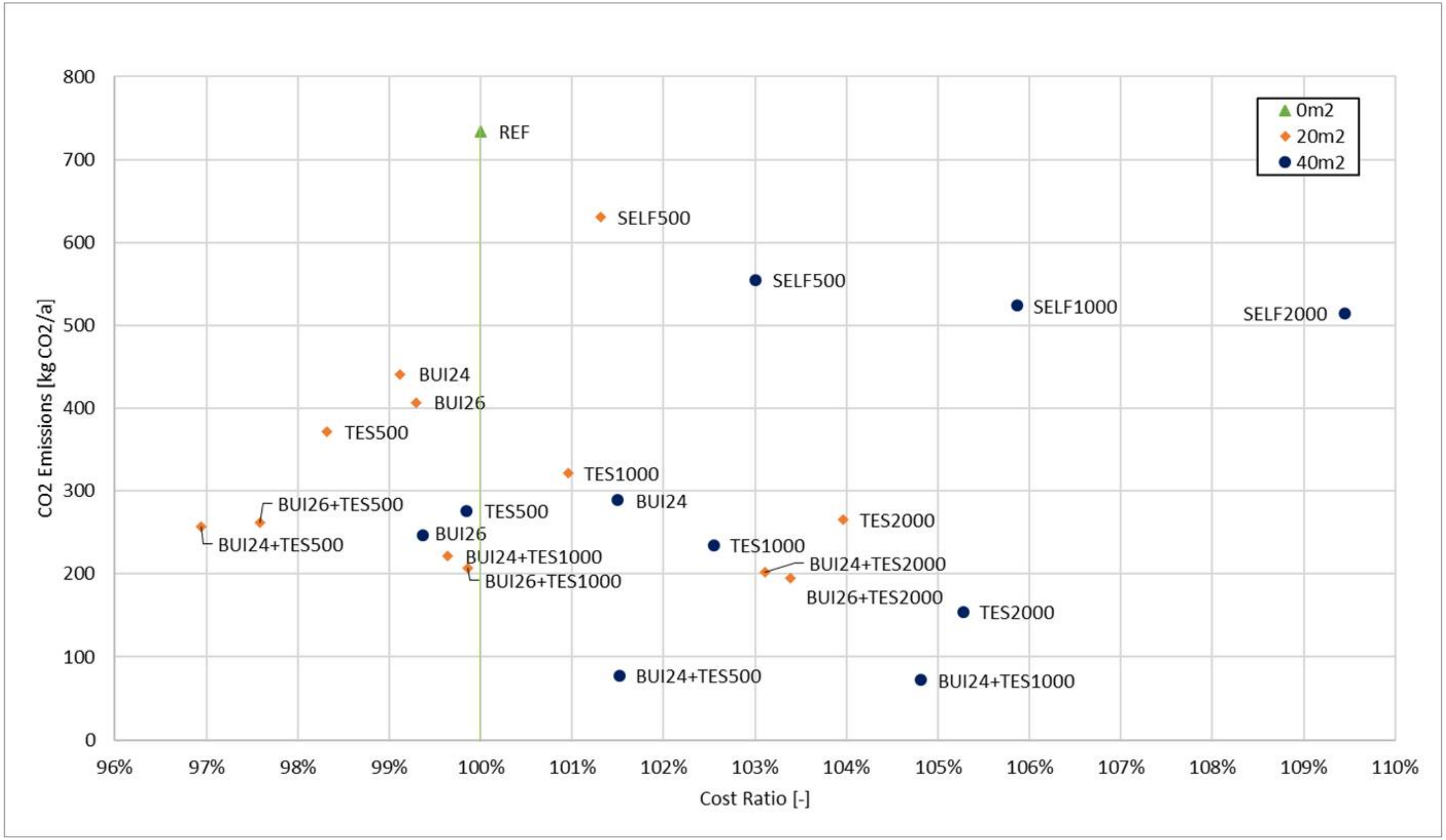
Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES45



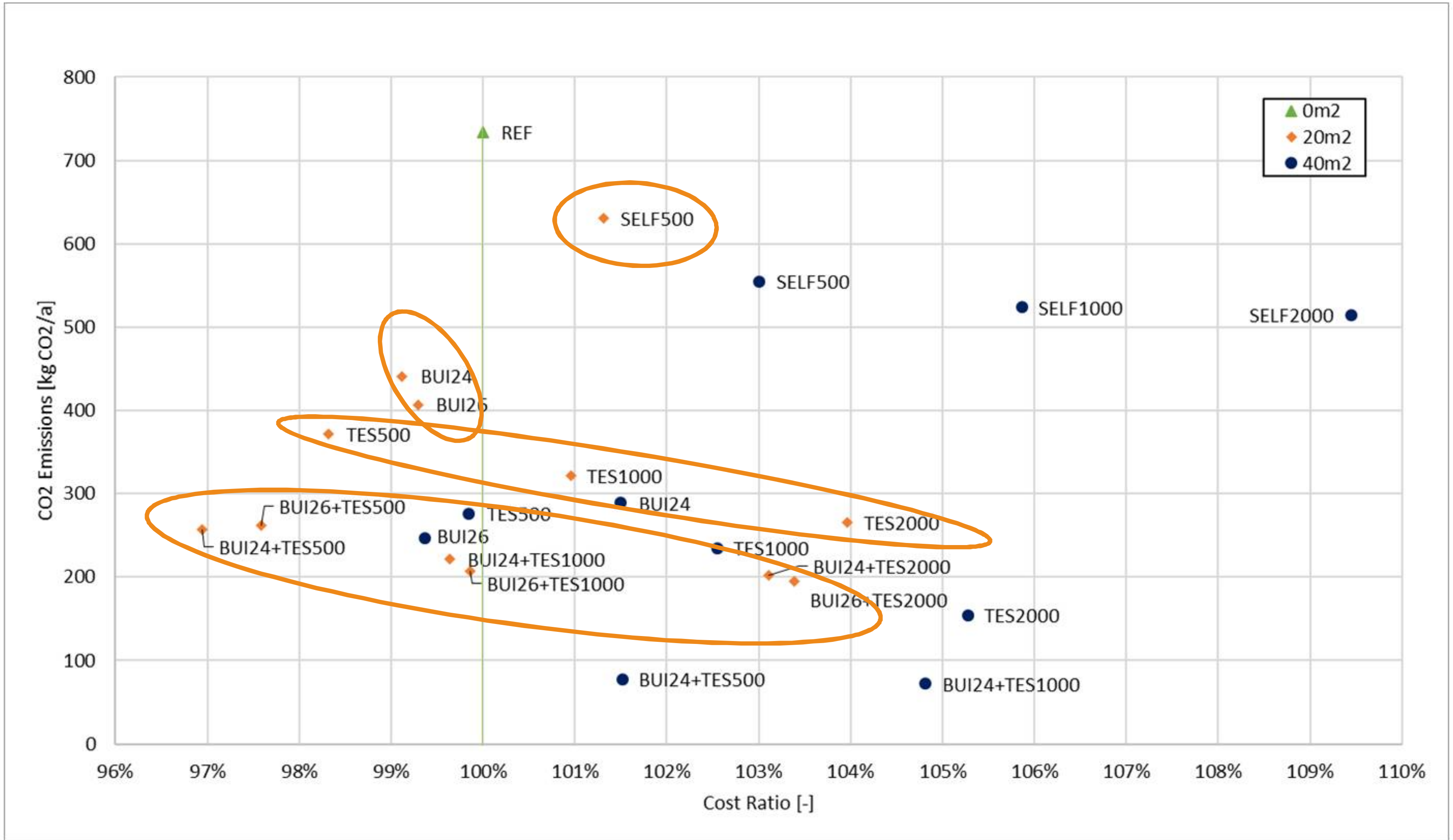
Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES45



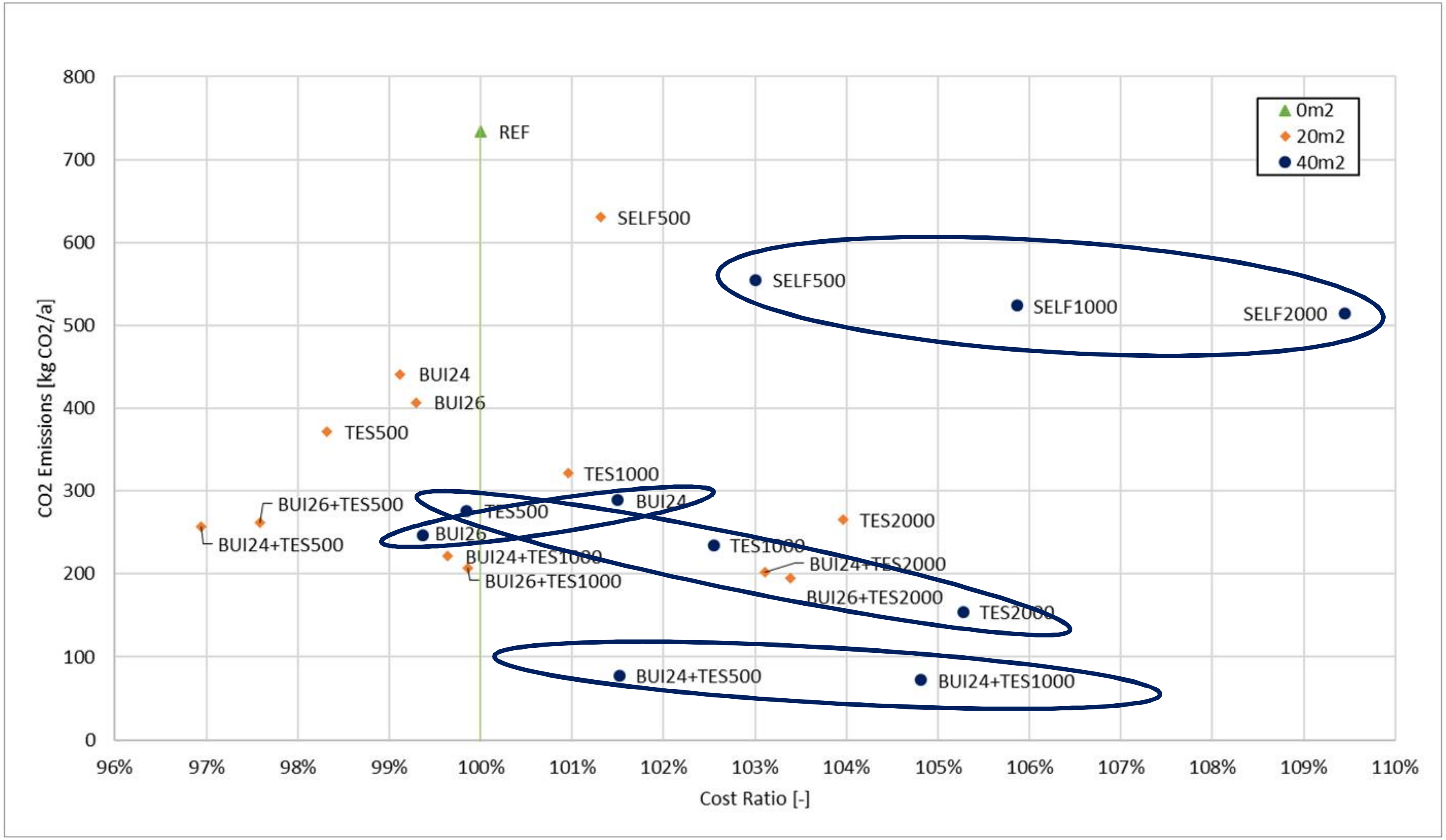
Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES15



Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES15

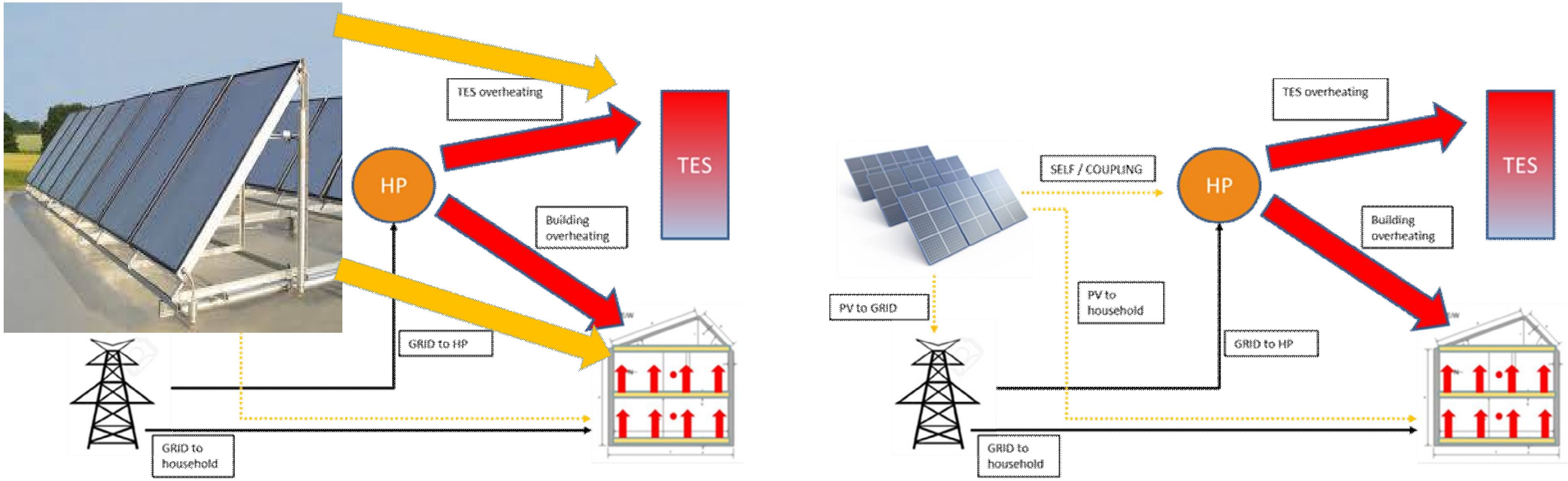


Potential of Reductions for CO2-Emissions vs. Cost Ratio for RES15



Competition:
ST + HP ⇔ PV + HP

- RES45
- Solar Area (PV or ST): 20m^2
- Buffer storage: 1000 Liter
- Hot Backup: Brine Heat Pump 10kW$_{th}$



Competition: Solar thermal vs. PV

- RES45
- Overheating of TES1000
- SPF_el_Grid = (DHW + SH_ref) / Grid_to_HP
  - Solar Thermal: SPF_el_Grid = 9,3 $Qsol_{th}$ = 370 kWh/m²
  - PV+HP: SPF_el_Grid = 6,9 $Qsol_{th}$ = 210 kWh/m²
- Investment Cost
  - PV: 1300.- / kWp => 3250 EUR
  - ST: 250.- / m² => 5000 EUR => +1750 EUR
- Required Saving: 1750 EUR / 0.18 EUR/kWh_{el} / 25a = 390 kWh_{el}/a
- Required excess ST Gain: 390 kWh_{el}/a x 4 (=SPF) = 1560 kWh_{th}/a
- Required excess ST Gain: 1560 kWh_{th}/a / 20m² = 78 kWh_{th}/m^2a

$Qsol_{th}$: ST – PV = 370 – 210 = 160 kWh_{th}/m^2 >> 78 kWh_{th}/m^2
=> Double excess ST-heat gain than needed for cost parity

Thank you for your attention !