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IS HEAT STORAGE WITH A POSSIBILITY OF DISTRICT HEATING BENEFICIAL TO SOLAR PLUS MICRO GRIDS

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Abstract

- Solar plus (PV panel + battery) price drop: easier to adopt in households.
- Especially with scattered populated areas (e.g. Slovenia)
- More sources into an energy mix – the better, however Slovenia: limited wind, hydro …
- Local sources even better: District heating, Biomass
- Quick & dirty feasibility and economics study of the model

Intro

- Most Self-sufficient homes: Solar plus (PV panel + battery): price drop, however still expensive.
- Other types of energy for household energy mix, e.g. **heat.**
- Solar thermal installments is cheaper.
- Additional heat by local provider e.g., district biomass heating.

- Model: Solar (PV + thermal) + district heating for single house or small house cluster.
- Model: Based on a already established PV model: simplified w/ significant parameters.
- Small number of parameters enables assessments of micro-grid installments.
- The used approach is a way to increase energy efficiency – regarding the cost and/or regarding the use of renewables.

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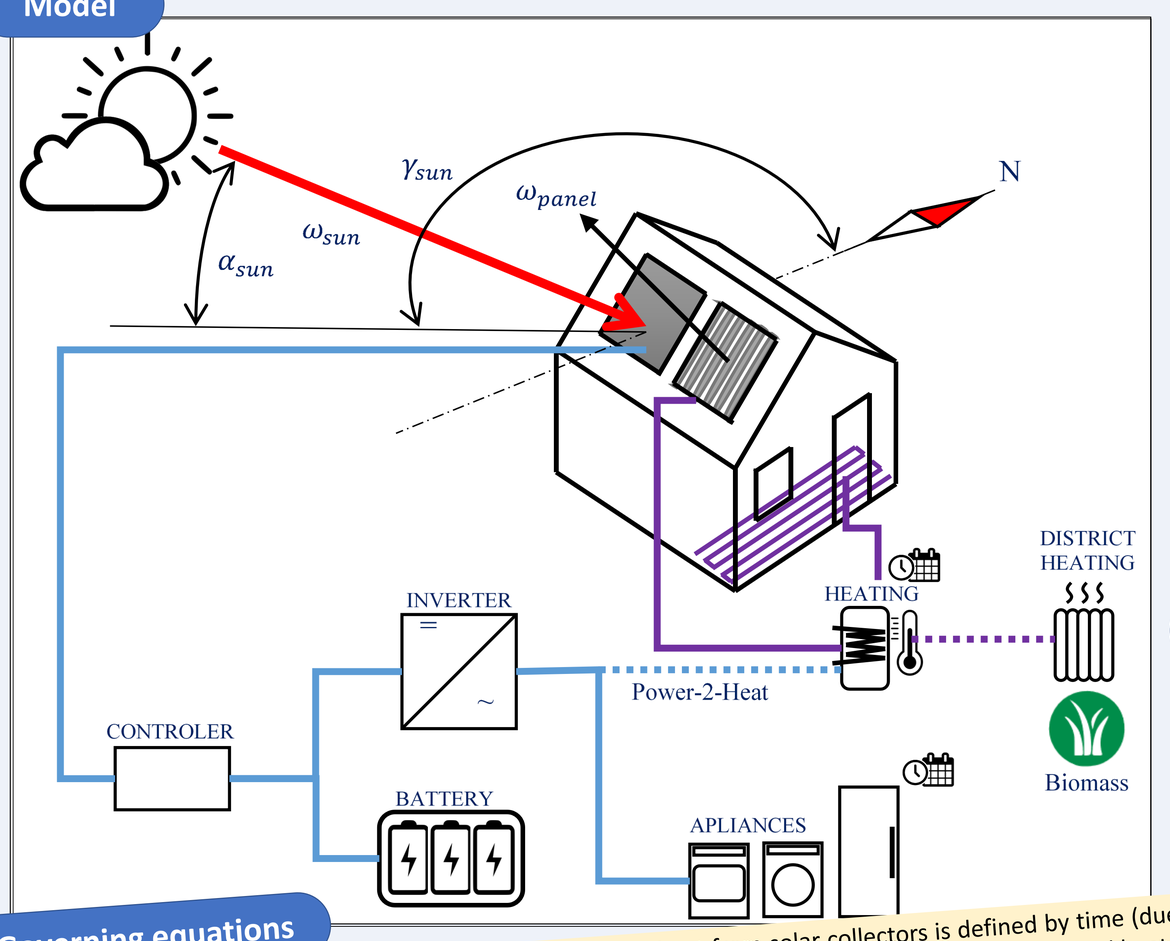
Model



Governing equations

The possible production of electric energy from PV panels and heat from solar collectors is defined by time (due to the orientation of the sun ω_{sun}, the orientation of the PV panel ω_{PV}, solar radiation *sol_rad(t)*). The battery and heat storage can fulfill the electric energy demand, while not thoroughly depleted. This also sets the goal used in the optimization: the demand should be outweighed by the sum of production and reserve from battery and heat storage at any time as shown in eq. (1a) and (1b):

$$\forall t; P_{PV\_production}\left(\omega_{sun}(t), \omega_{PV}, sol\_rad(t)\right) + P_{battery}(s) \geq P_{apl}(t,T) \quad (1a)$$

$$\forall t; P_{production}\left(\omega_{sun}(t), \omega_{PV}, sol_{rad(t)}\right) + P_{heat\_storage}(s) \geq P_{heat}(t,T) \quad (1b)$$

Electric energy demand for appliances $P_{apl}(t,T)$ varies over time of the day and is defined by average demand P_{ave} and demand factor $\beta(t)$, the latter is time-dependent. Demand for heating $P_{heat}(T(t))$ depends on the outside temperature (if that is lower than desired) and is defined by temperature deficit $\Delta T^*(t)$ and specific heating demand C^* as described in eq. (2):

$$P_{apl}(t,T) = P_{ave} \cdot \beta(t) \text{ and } P_{heat}(t,T) = \Delta T^*(t) \cdot C^* \quad (2)$$

The temperature deficit $\Delta T^*(t)$ and specific heating demand C^* are defined as shown in eq. (3):

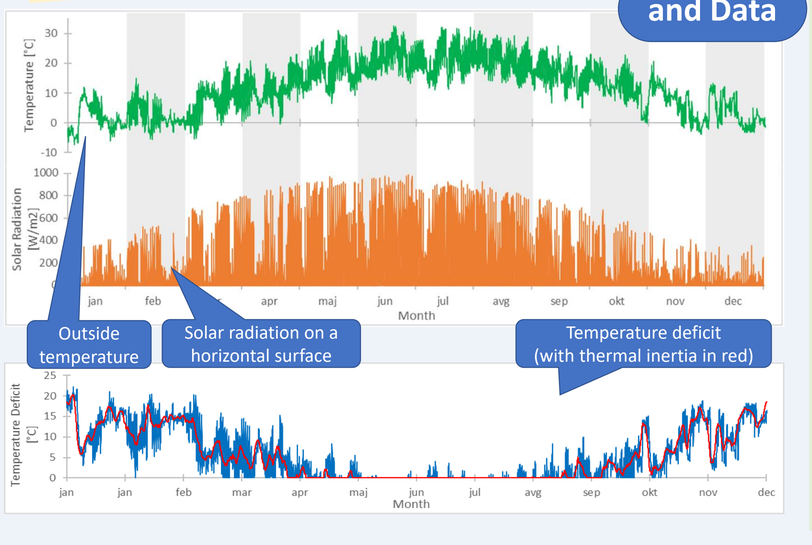
$$\Delta T^*(t) = min\{T_{out}(t) - T_0, 0\} \text{ and } C^* = \frac{Q_{heat,year}}{\sum_t \Delta T^*(t)}. \quad (3)$$

The storage (battery or heat) state for the next time slot is calculated from the previous one adjusted for efficiency (due self-depletion). The calculation of energy production from PV and collectors does not account for shading, due to the small impact on the overall energy production.

The research is concentrated on the main criterion for the house self-sustainability: eq. (4) shows the single minimum of energy reserve $E_{reserve\_min}$ over the whole year for battery and heat storage:

$$E_{reserve\_min} = min\left\{P_{battery}(s)\big|_t, P_{heat\_storage}(s)\big|_t\right\}. \quad (4)$$

and Data



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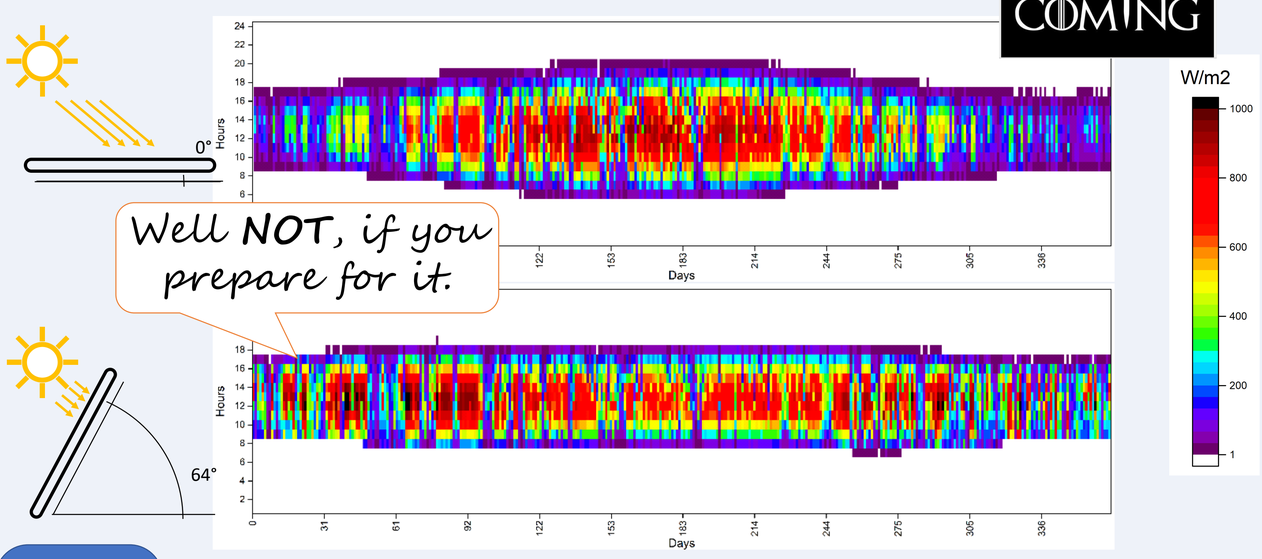
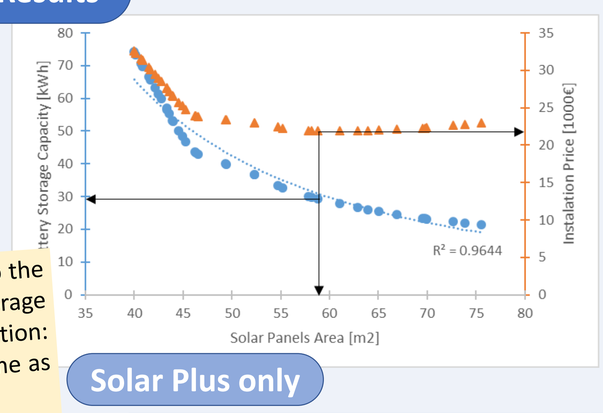
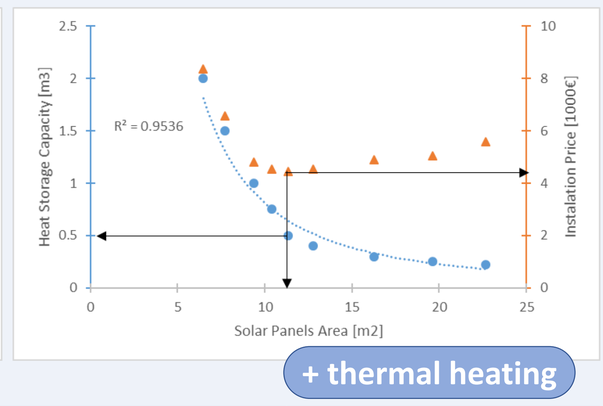


Results



Solar Plus only



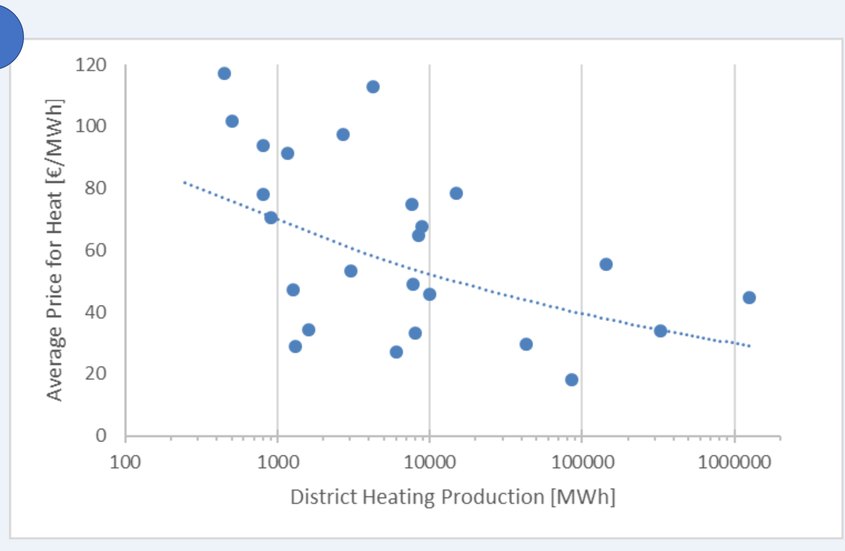
+ thermal heating

	Solar Plus only	+ thermal heating
PV + Solar Thermal Area	59 m^2	12 m^2
Battery + Heat Storage	30 kWh	0.5 m^3
Installation costs	22 000 €	4 200 €
Levelized Cost of Energy (LCOE)	0.25-0.30 €/kWh	0.08 €/kWh

Thermal heating and storage installation is quite cheaper and less complex compared to PV/Solar Plus. However, heating alone cannot fulfil all domestic energy needs therefore some mixture is necessary.

District heating

Local market analysis showed that district heating is quite economical solution for an additional heating needs with LCOE smaller that 0.1 €/kWh.



Conclusions

The quick progress of photovoltaic installations overshadowed the efficiency of other renewable sources. A combination of solar electricity, heat production and energy storage for the fulfillment of household energy needs was discussed.
Thermal power is still more economic than the usage of PV panels and electricity. From the obtained data the investment costs and LCOE for district heating are similar to the costs of individual solar thermal.