Assessing Solar Potential and Battery Instalment for Self-Sufficient Buildings With Simplified Model

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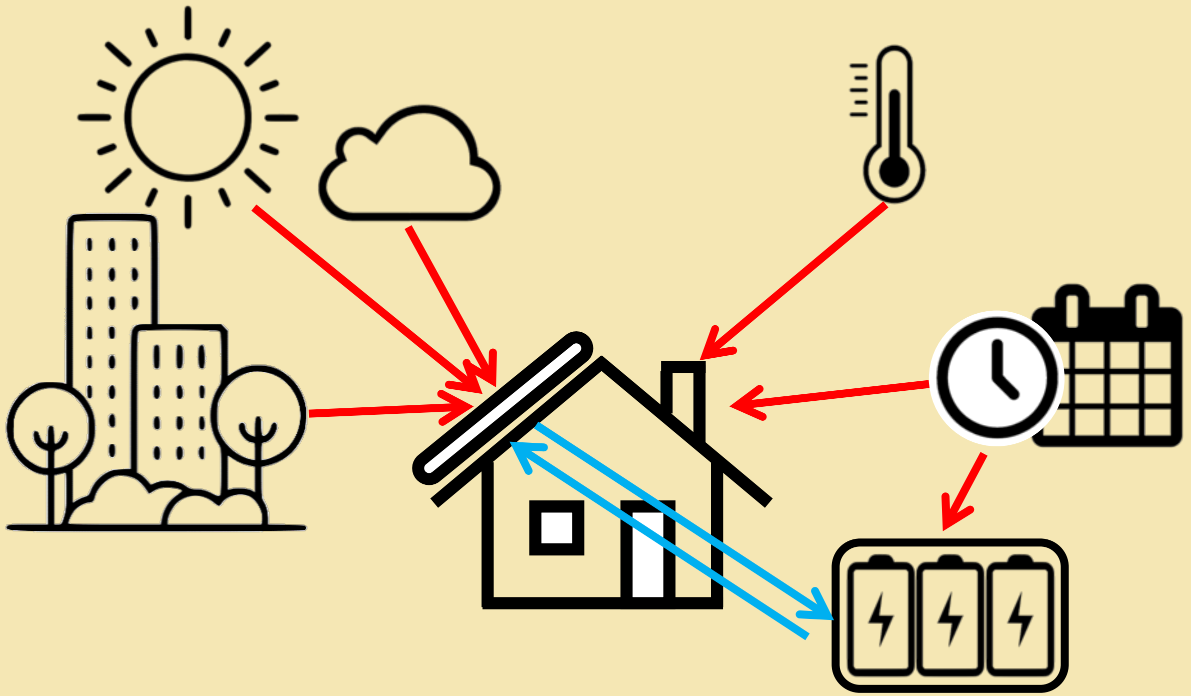
Introduction

Photovoltaics: multiple influences on household energy balance



However:

Not everybody is happy

- Electricity providers
- Home owners

{ Need to master additional knowledge
Current models:
very sophisticated but also demanding

A question: *how much does it cost*?

Yes, yes, but how...

Listen to old masters:

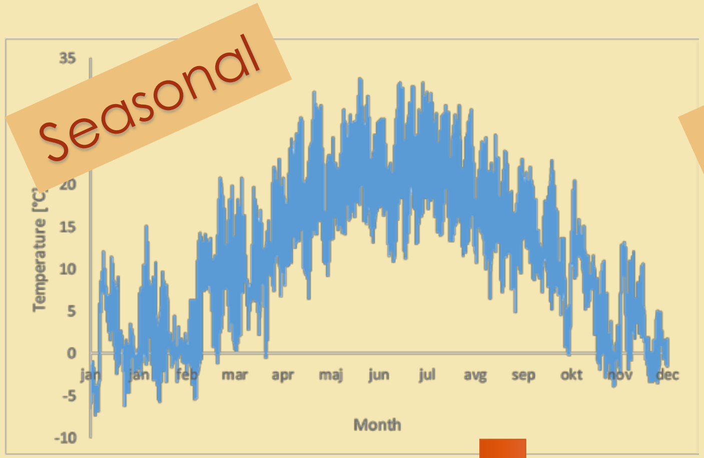
Everything should be made as ***simple*** *as possible, but not* ***simpler****.*

From Albert Einstein (AKA Master Yoda of Photovolotaics), Nobel laureate for Physics 1921 "for ... his discovery of the law of the photoelectric effect".

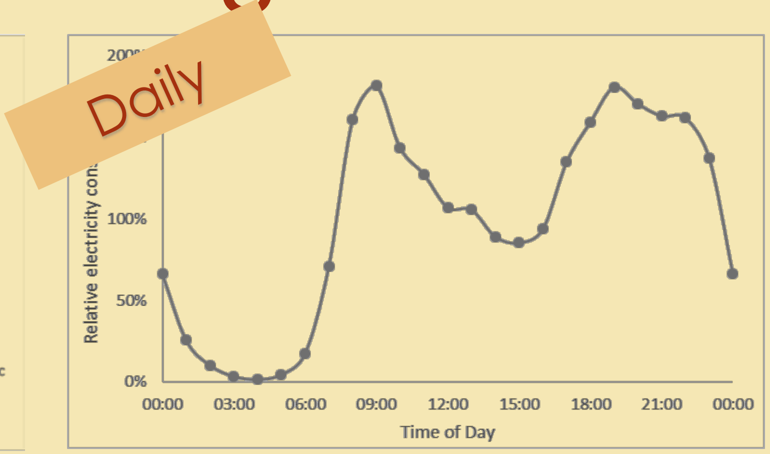
$$\forall t; P_{production}\left(\omega_{sun}(t), \omega_{PV}, sol\_rad(t)\right) + P_{battery}(s) \geq P_{demand}(t, T)$$

At any time:
production + energy in storage fulfills demands for heating and general (other) demands

Data Crunching

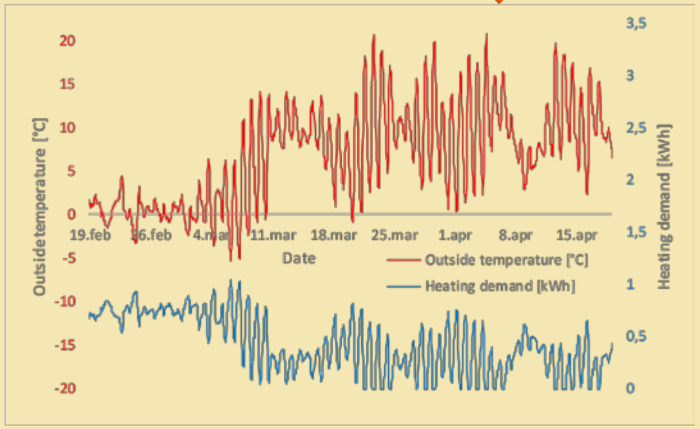


Outside temperature

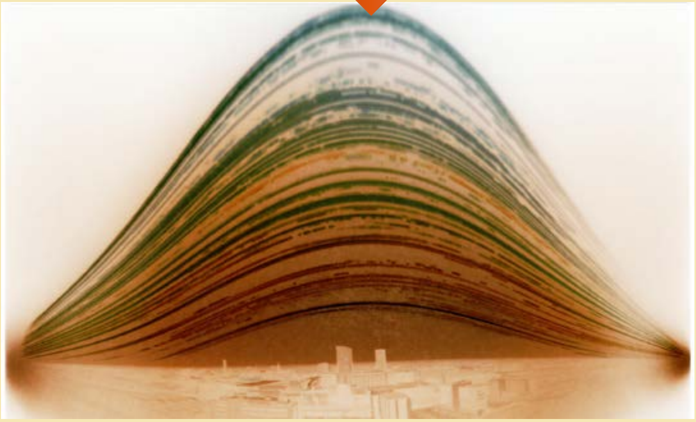


Household energy demand

Solar radiation



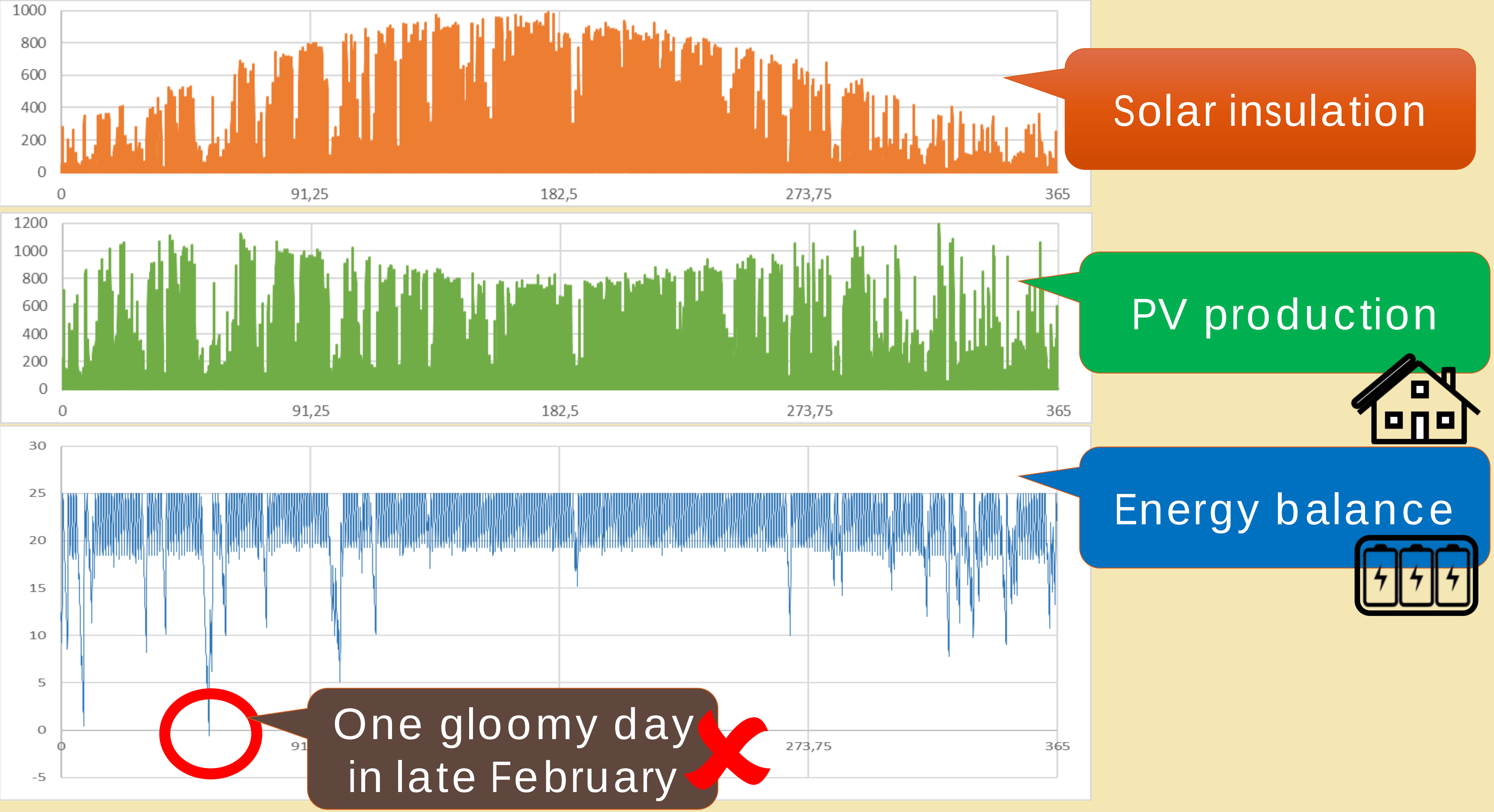
Temperature deficit



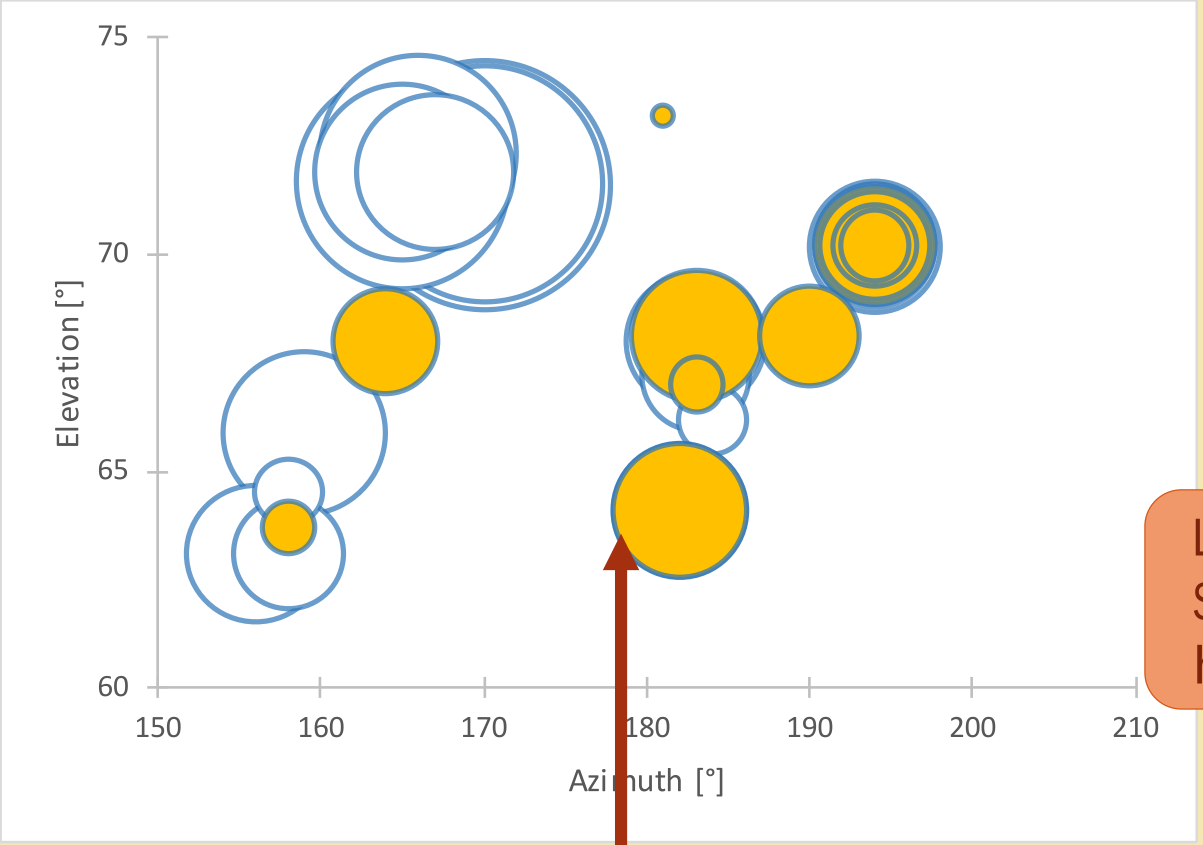
Solargraph (solar position)

*The **simplifications**: no long time effects of small impact: (1) Degradation of PV panels and battery cells, (2) Dust or other panel deficiencies, (3) Increased temperature and insulation etc.*

Results


1000
800
600
400
200
0
0
91,25
182,5
273,75
365
Solar insulation
1200
1000
800
600
400
200
0
0
91,25
182,5
273,75
365
PV production
30
25
20
15
10
5
0
-5
0
91
273,75
365
Energy balance
One gloomy day
in late February

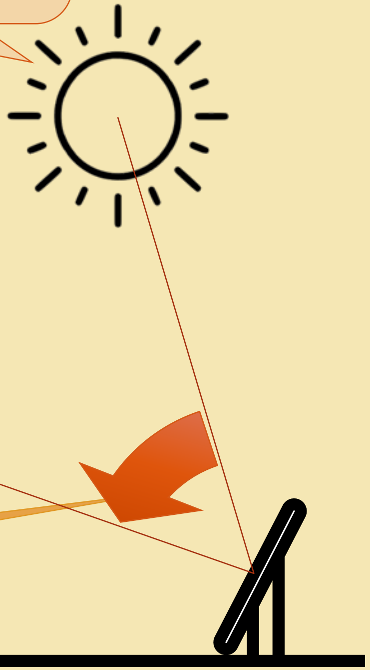
Results: Impact on PV orientation



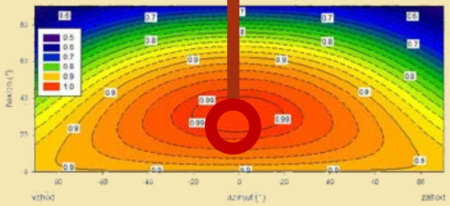
Optimal orientation of (single) PV panel

High summer sun: Enough energy, lower demand

Low winter sun: Sparse energy, high demand



Optimal orientation for maximal net mettering



Change in elevation due to catching winter sun

Results: Data

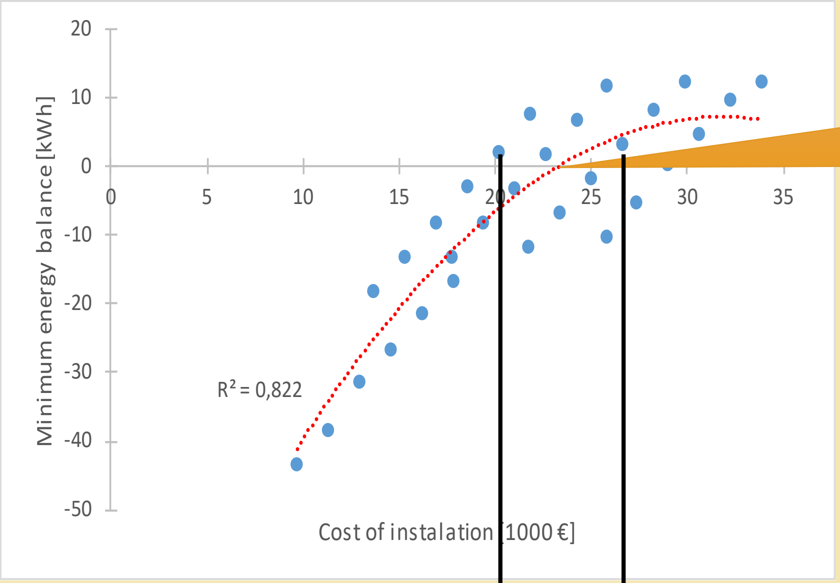
		Power of PV [kW_{el}]				
		3.0	4.5	6.0	7.5	9
Battery capacity [kWh]	5	-43.3	-18.0	-13.1	-11.8	-10.3
	10	-38.3	-13.0	-8.1	-6.7	-5.3
	15	-31.4	-8.0	-3.1	-1.7	0.3
	20	-26.7	-3.0	1.9	3.25	4.7
	25	-21.4	2.0	6.9	8.2	9.7
	30	-16.3	7.6	11.9	12.3	12.3

		Power of PV [kWel]			
		4.5	6.0	7.5	9.0
Battery capacity [kWh]	15	-40.9	-14.3	-5.3	-2.0
	20	-24.2	-6.5	0.6	3.0
	25	-20.5	-0.4	5.6	8.0
	30	-15.9	3.3	10.9	13.0
	35	-12.3	8.2	15.6	16.7

Positive minimum energy ballance

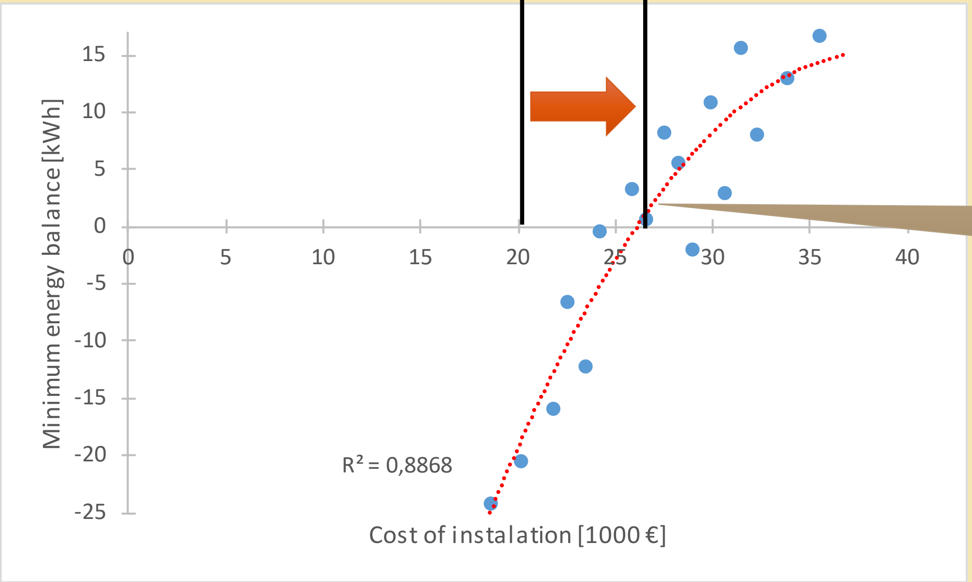
- **Small hut:**
  E_{gen} = 2500 kWh
  E_{heat} = 1000 kWh
- **Family house:**
  E_{gen} = 3000 kWh
  E_{heat} = 2500 kWh

Results: Cost efficiency



Most cost effective with positive minimum energy ballance

- **Small hut:**
  E_{gen} = 2500 kWh
  E_{heat} = 1000 kWh



Quite small shift in installation costs

- **Family house:**
  E_{gen} = 3000 kWh
  E_{heat} = 2500 kWh

Conclusions

- Understanding of fundamental principles of coupled PV electricity production and battery storage system are essential for more use of renewables where possible.
- Calculation ~~could~~ should be run in a spreadsheet.
- Colorful pictures (and simple models) are not just for managers.