Energy Management System - Needs for Optimization

- Investment decisions:
  - Is it worth adding insulation to the outer walls of a house?
  - Is the profit higher when buying an additional PV panel or when investing in a battery system?
  - …
- Control
  - Is the surplus electricity injected to the grid or used to charge a battery?
  - Is the heat pump driven during the day or during the night?
  - …

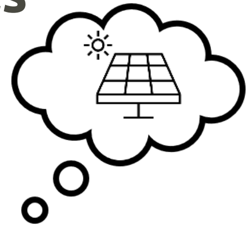
Original idea: optimization based on mixed integer linear programming (MILP)

Investment decisions – Building Sizing loop

Aims to reduce costs and maximize profits in an economic sense.

In a later stage, CO_2 emissions, self consumption rates, and other parameters of interest will enter the optimization.

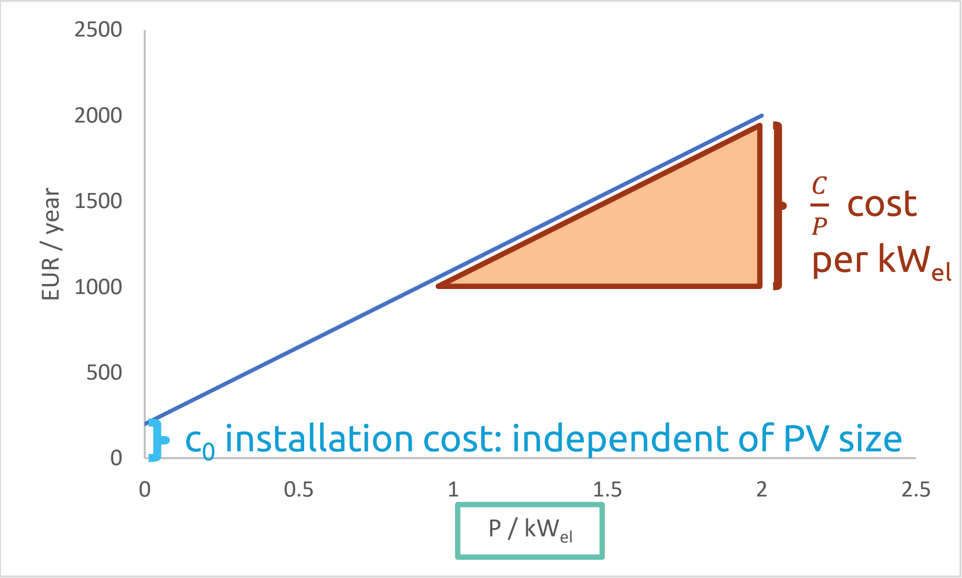
Example: investment in PV panels



Decision variable:

- 0 if no PV is bought
- 1 if PV is bought

$$\textbf{investment:}\ D \cdot \left(P \cdot \frac{C}{P} + c_0\right)$$

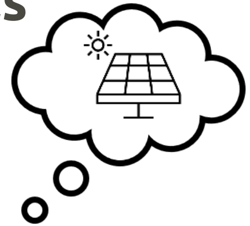


mixed integer linear programming (MILP)

Optimization problems consist of an objective function and constraints.

Non linear problems can be "linearized" by adding constraints.

Example: investment in PV panels



Non – linear formulation:

$$D \cdot \left(P \cdot \frac{C}{P} + c_0 \right)$$

Linear formulation:

Objective: $P \cdot \frac{C}{P} + D \cdot c_0$

Constraint: $P \leq M \cdot D$

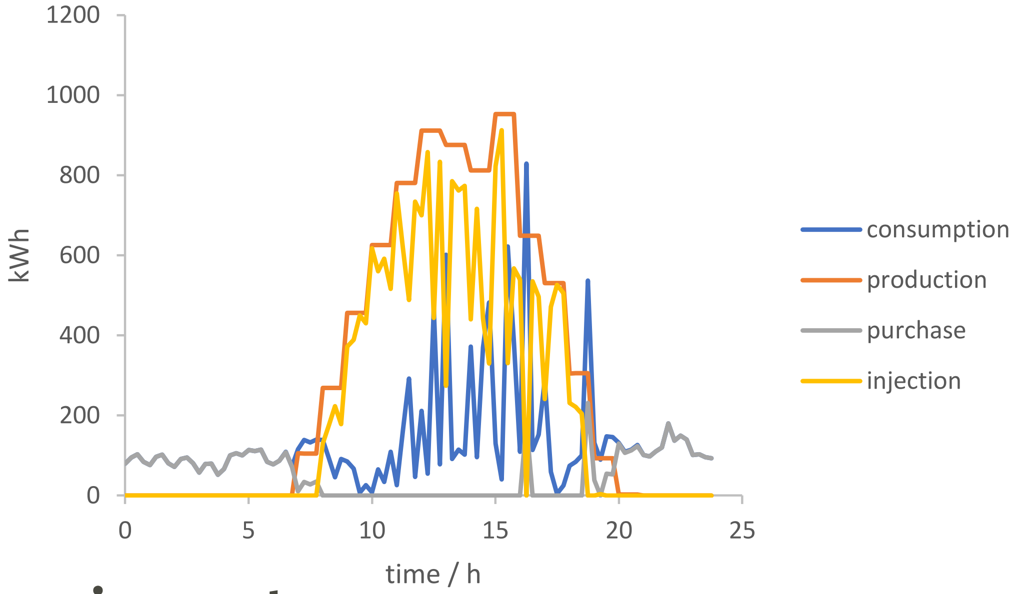
P ... *peak power*

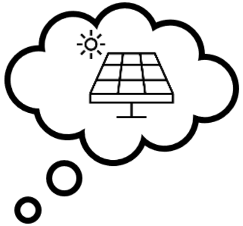
D ... *decision variable*

M ... *upper bound of maximum capacity*

$\frac{C}{P}$ ... *power dependent cost*

c_0 ... *power independent cost*





running costs:

$$\sum_{t=0}^{365\cdot 24\cdot 4}\left(\, purchase(\,t\,)\cdot p_e - injection(\,t\,)\cdot r_e\right)$$

objective function:

$$\boldsymbol{min}(\,investment + running\ costs\,)$$

WHY

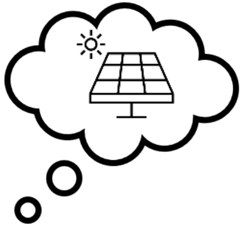
Variables:

$P \ldots peak\ power \rightarrow float\ variable$

$D \ldots PV\ yes\ or\ no \rightarrow decision\ variable$

$purchase \rightarrow float\ variable\ of\ size\ 35040$

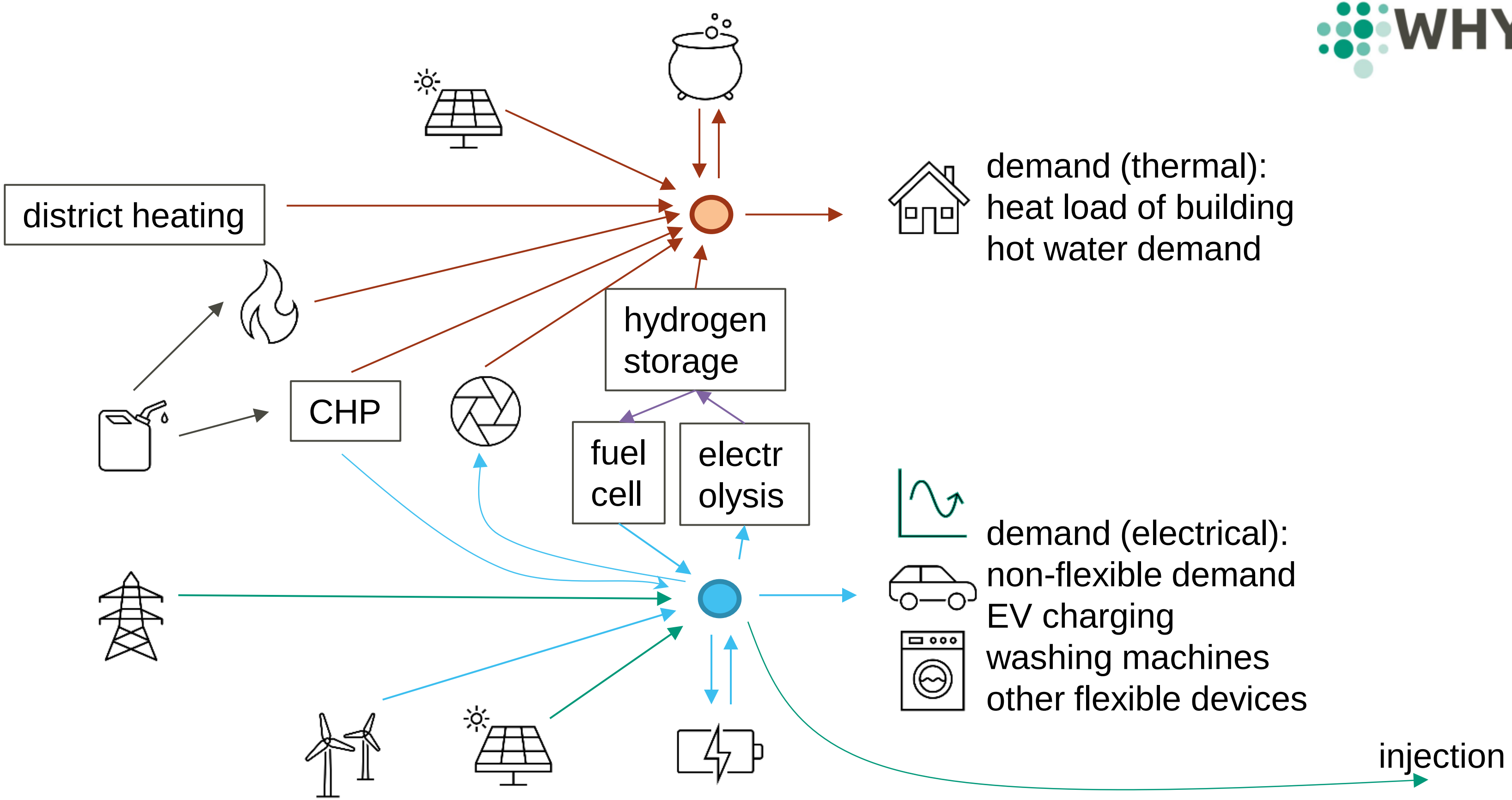
$injection \rightarrow float\ variable\ of\ size\ 35040$



objective function:

$$\mathbf{min}\left(\mathbf{P} \cdot \frac{\boldsymbol{C}}{\boldsymbol{P}} + \boldsymbol{D} \cdot \boldsymbol{c_0} + \sum_{t=0}^{365\cdot 24\cdot 4} (purchase(t) \cdot p_e - injection(t) \cdot r_e)\right)$$

Extending the system



Complexity

WHY

Variables: rough estimation

- float variables of size one:
  35
- decision variables :
  15
- float variables of size 35040:
  20

How to solve?

- decoupling of the system
- aggregation of time series
- reduction of number of Boolean variables
- …
- **clever choice of algorithms**