

Hydrogen-lithium energy storage for a stand-alone microgrid

Alberto Berrueta, Idoia San Martín, Pablo Sanchis, Alfredo Ursúa

Dept. of Electrical and Electronic Engineering, Public University of Navarre

Institute of Smart Cities, Public University of Navarre

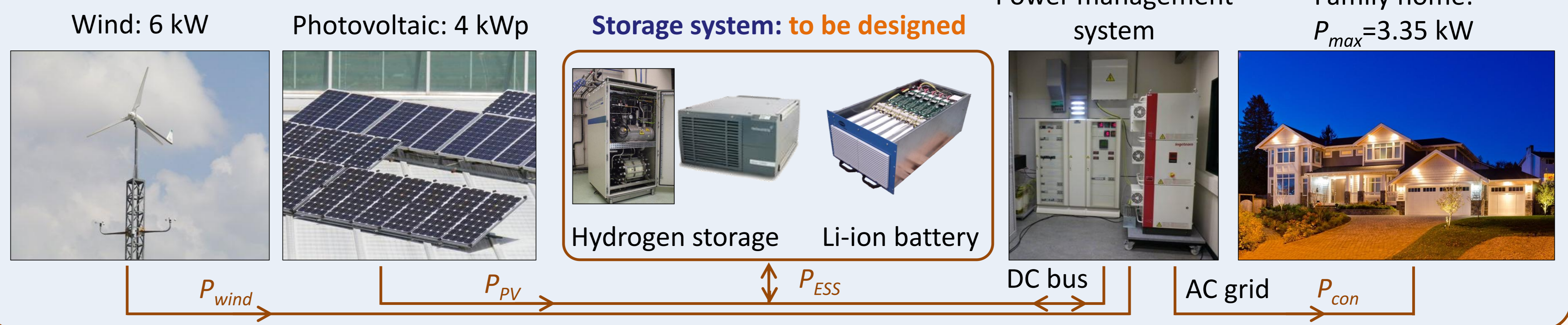
Campus Arrosadía, 31006, Pamplona (Spain).

PURPOSE

Sizing of the storage system for a stand-alone application

- Satisfaction of technical requirements
- Based on real data from an experimental microgrid
- Long lifetime
- Lowest price

MICROGRID DESCRIPTION



PROBLEM DETAILS

Storage elements

Alkaline water electrolyser (WE)

- Widely used
- Safety
- Reliability
- Life cycle

Pressurized H₂: 30 bar

- Output pressure of the WE

PEM fuel cell (FC)

- Fast response
- Compactness
- Lightness

Li-ion battery

- High power
- Energy efficiency

Unit	Efficiency	Cost
WE	0.7*	\$ 940 / kW
FC	0.5*	\$ 1100 / kW
Battery	0.9	\$ 500 / kWh
H ₂ tank	1	\$ 15 / kWh

Optimization problem

ESS management strategy

- Battery: $f > f_c$
- Hydrogen: $f < f_c$

Technical requirements

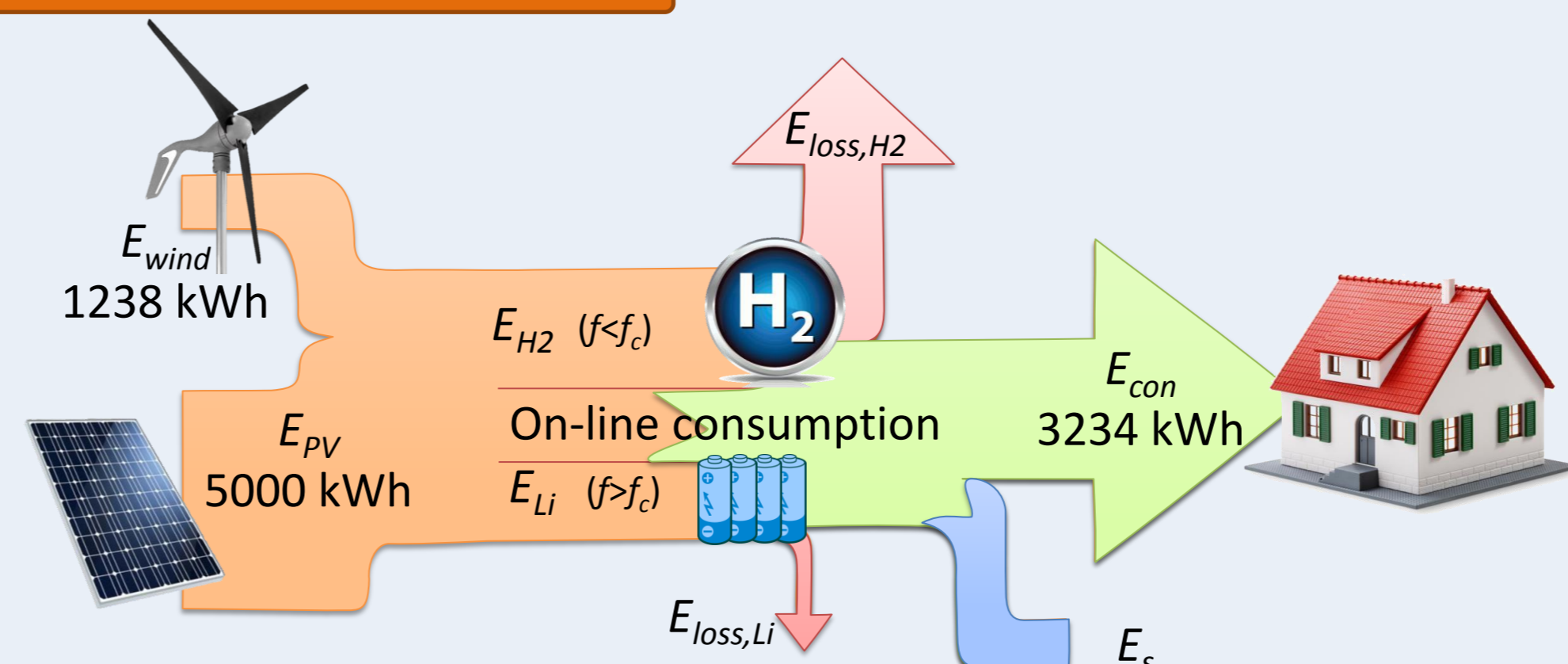
- Avoid energy depletion

$$E_s = E_{PV} + E_{wind} - E_{con} - E_{loss,H_2} - E_{loss,Li} \geq 0$$

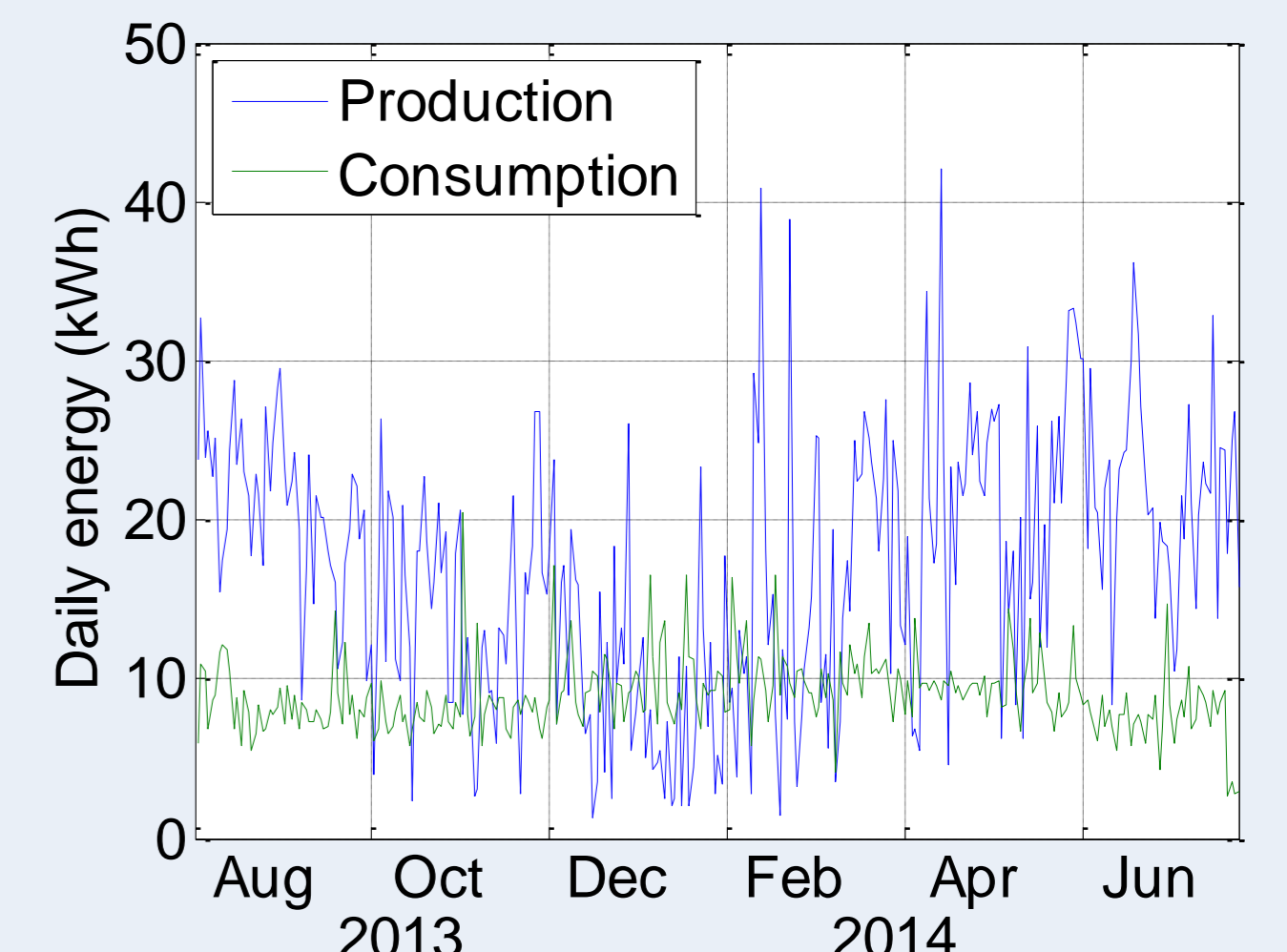
Parameters to be calculated:

- Cut-off frequency (f_c)
- Capacity of each unit } η_{ESS}
- Power of each unit } $\$_{ESS}$

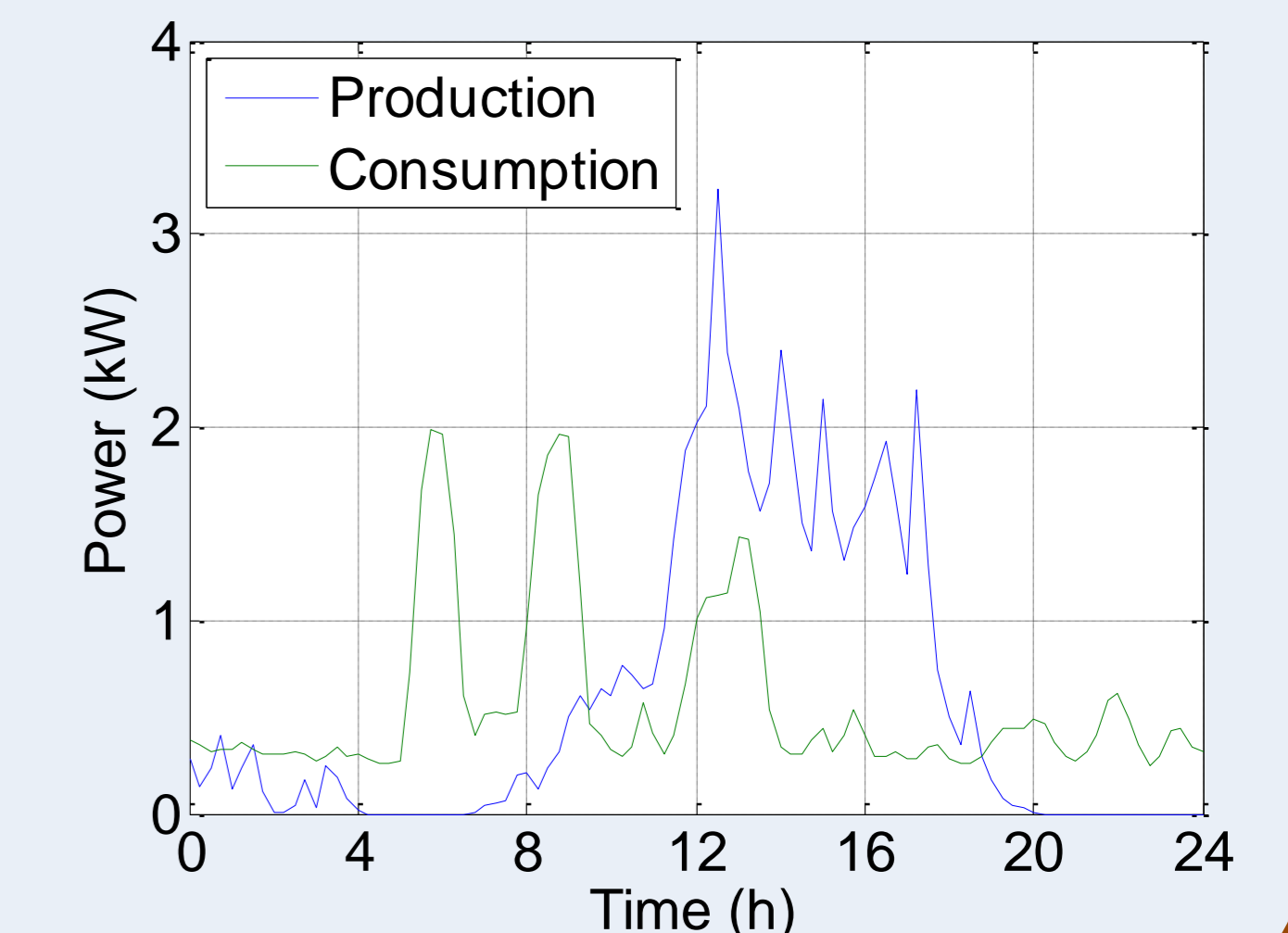
Annual energy flow



Annual imbalance

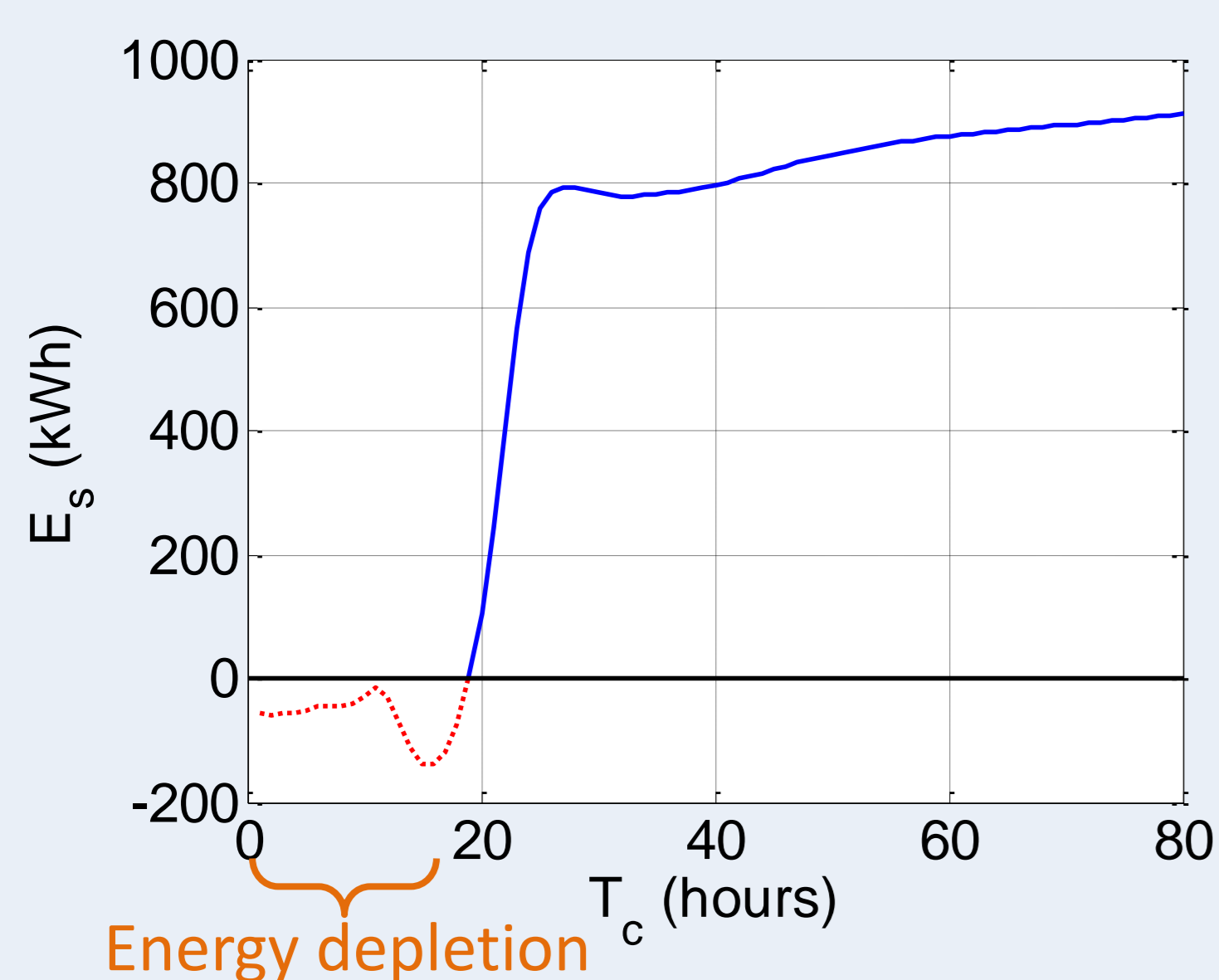


Daily imbalance

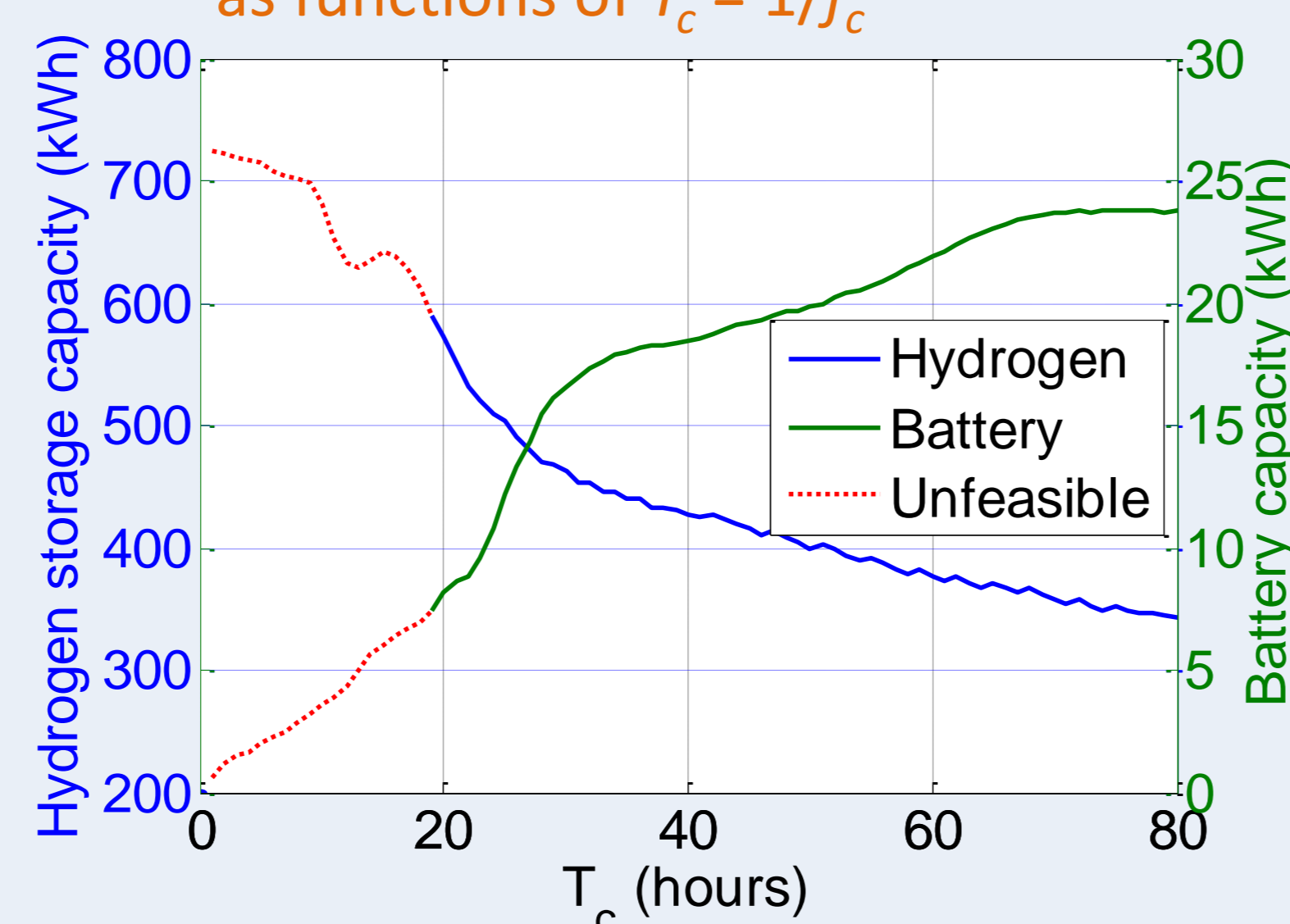


SIZING METHOD

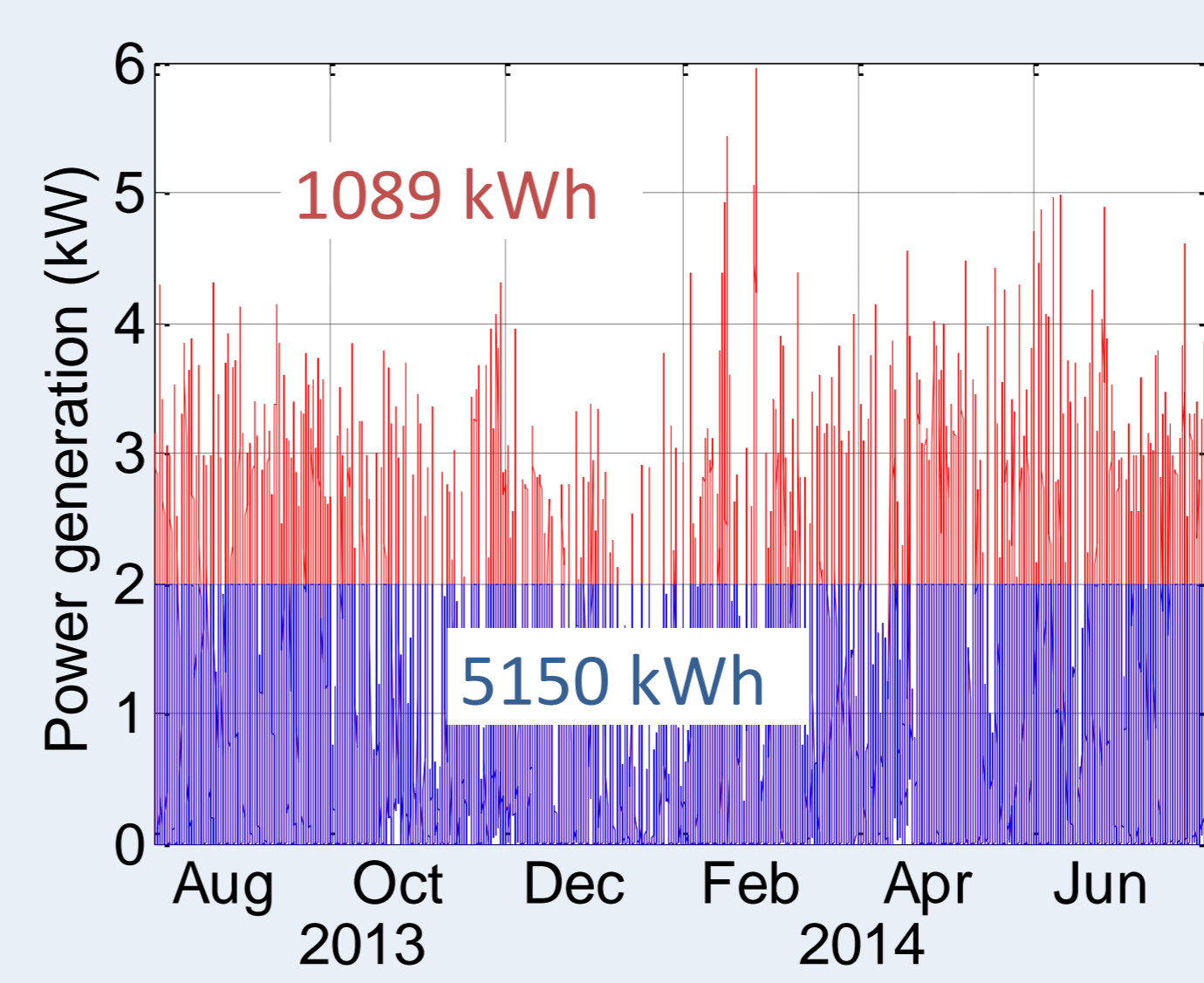
1. E_s as a function of $T_c = 1/f_c$



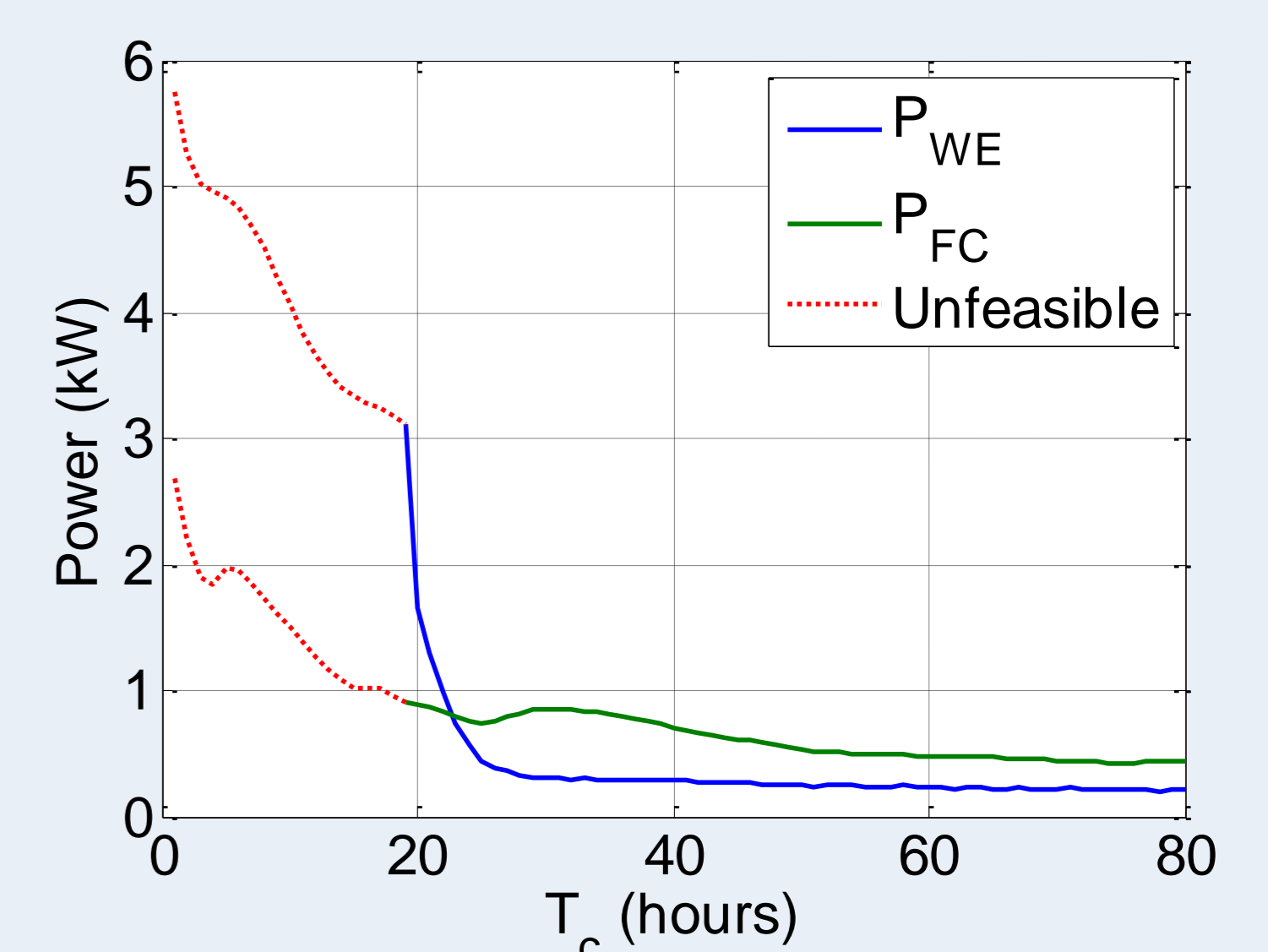
2. Battery and hydrogen capacities as functions of $T_c = 1/f_c$



3. High-power peaks wasting

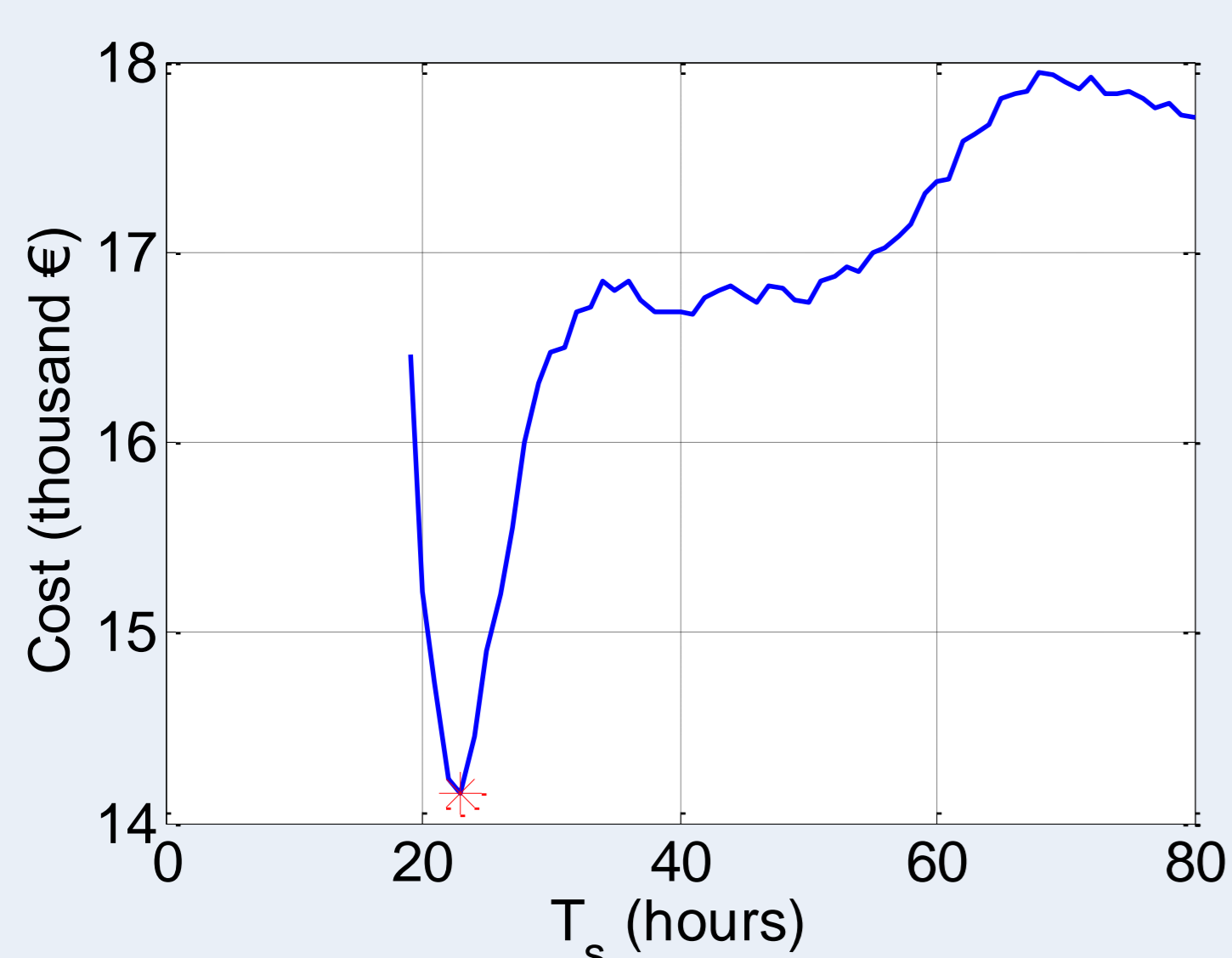


4. Power of WE and FC calculation



RESULTS

Total cost of the ESS



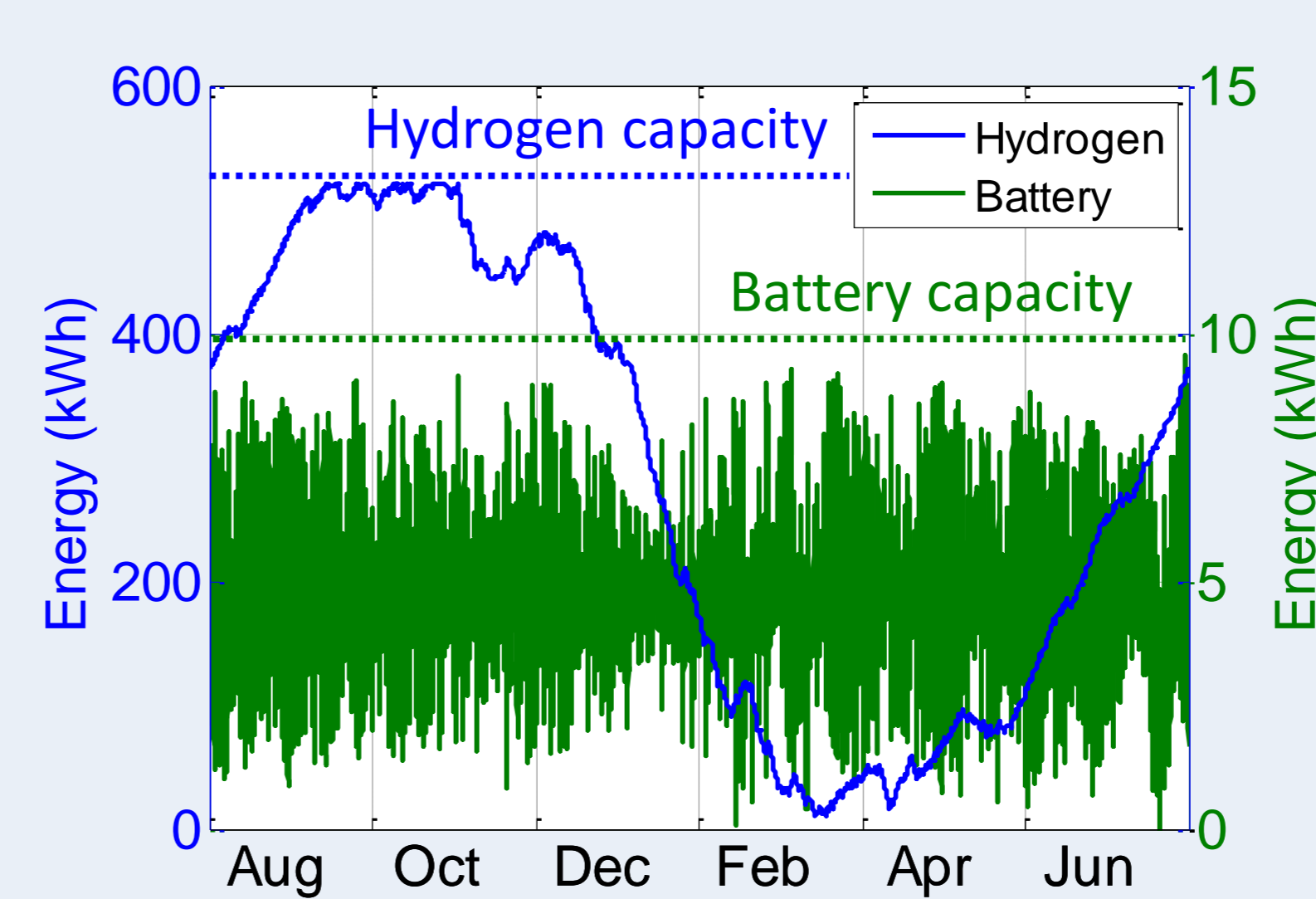
Optimal ESS:

- $T_c = 23$ hours
- $C_{H_2} = 520$ kWh, $C_{Li} = 10$ kWh
- $P_{WE} = 800$ W, $P_{FC} = 800$ W

Unit	Cost
WE (800 W)	\$ 752
FC (800 W)	\$ 880
Battery (10 kWh)	\$ 5000
H ₂ tank (5.8 m ³)	\$ 7800
Total	\$ 14432

SUMMARY

Performance during a year



Hydrogen for annual energy balance

- ✓ Large capacity
- ✓ Independent power and energy capacity

Lithium battery for daily energy storage

- ✓ High power
- ✓ High efficiency