Evaluation of innovative heat pump concepts for multi-family houses

Monitoring data – A study of advantages



4DH
4th Generation District Heating Technologies and Systems

reINVEST

Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

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12.09.2017

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Eidgenössische Technische Hochschule Zürich
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Empa
Materials Science and Technology

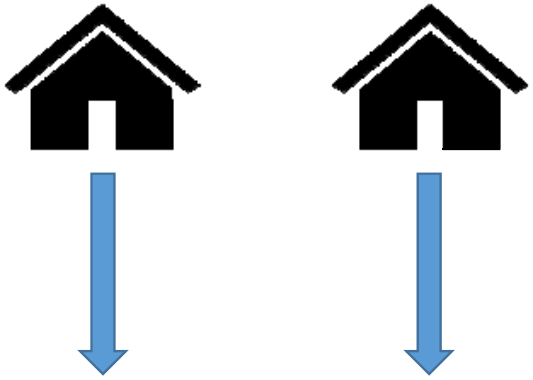
ROGENHOFER Lennart

Key Questions

Monitoring

Why?

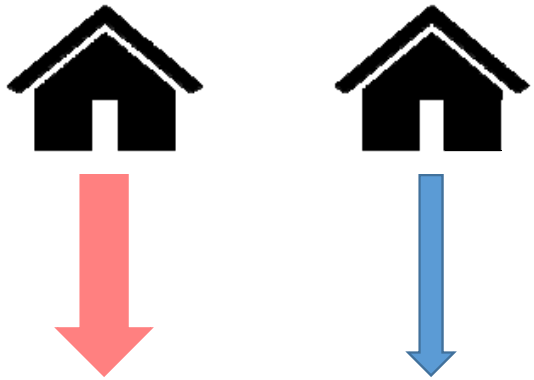
CO2



Reference

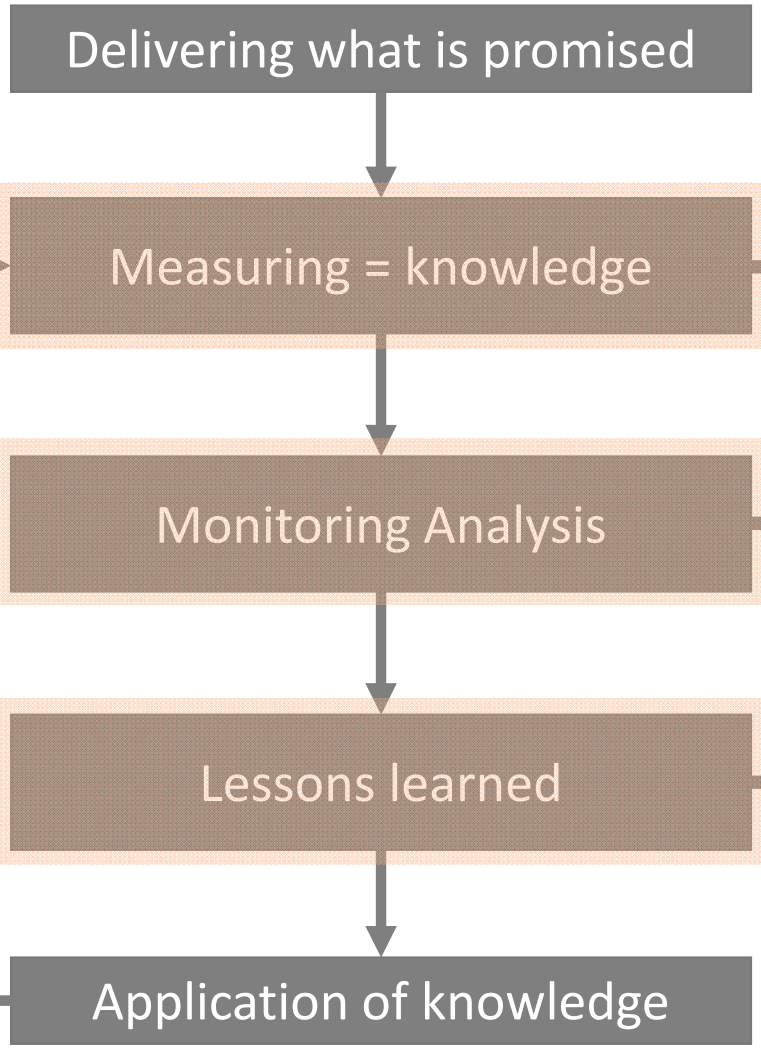
How?

PVT



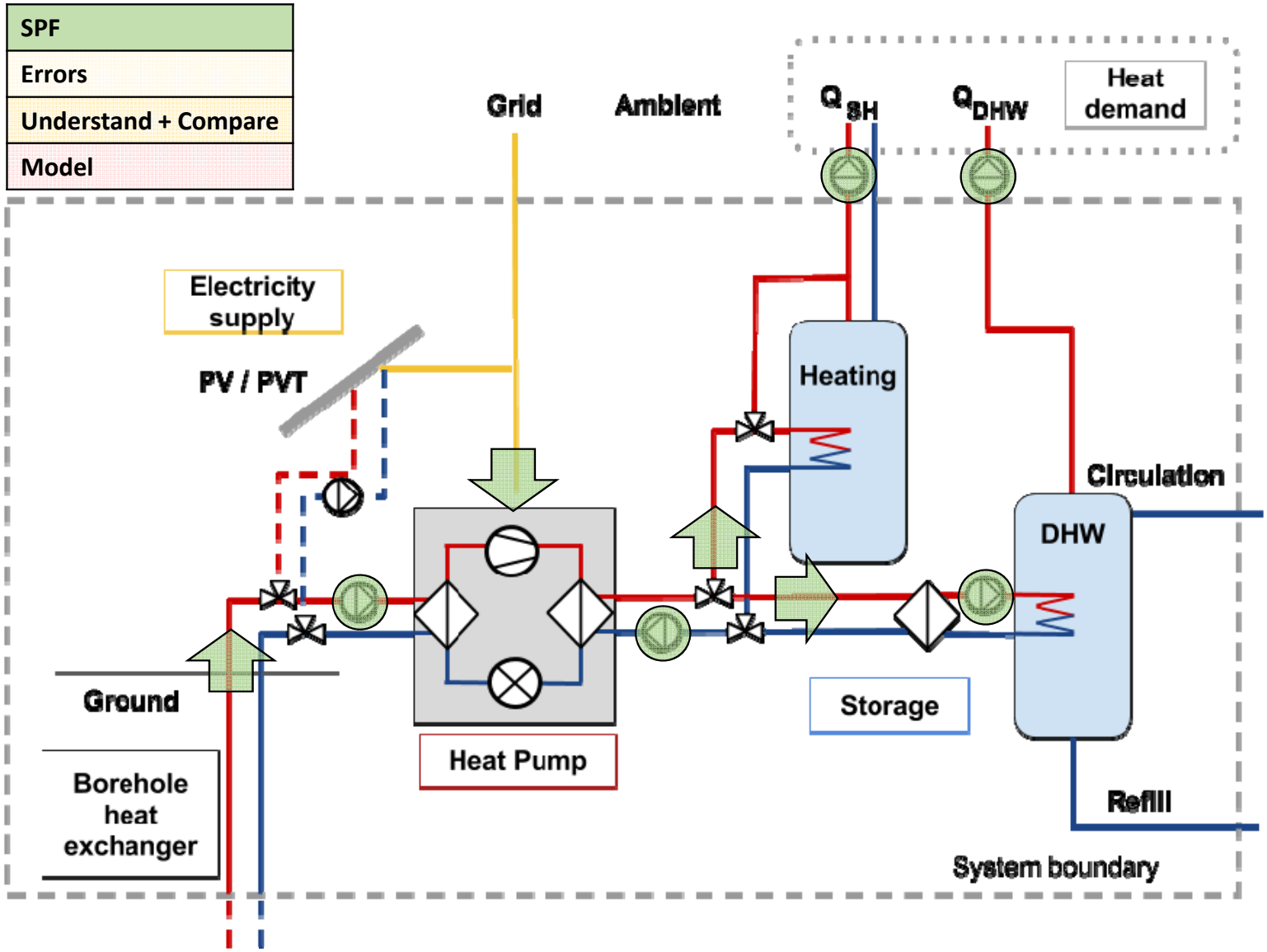
Weather Predictive

Why?



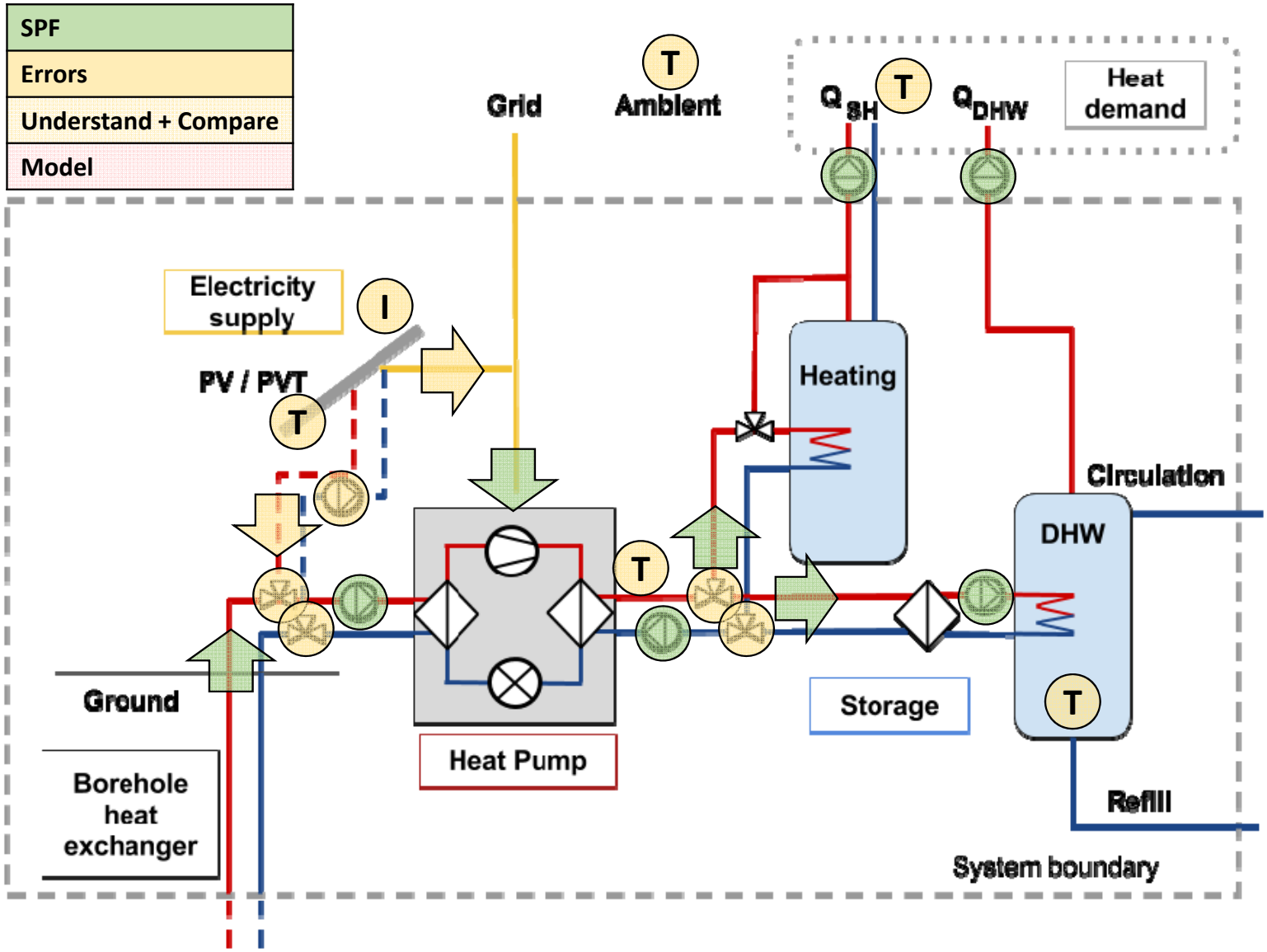
Kleefkens O, Riviere P, Nowak T, Zottl A, Lehmann A, Polyzou O, et al. SEasonal PErformance factor and MOnitoring for heat pump systems in the building sector SEPEMO-Build Final Report 2012.
Miara M (Frauenhofer). Analysis and Evaluation of Heat Pump Efficiency in Real-life Conditions Authors : 2010.
Dr Hughes D (Graham EM. Monitoring of Non-Domestic Renewable Heat Incentive Ground-Source and Water-Source Heat Pumps. 2016.

Full Monitoring Setup



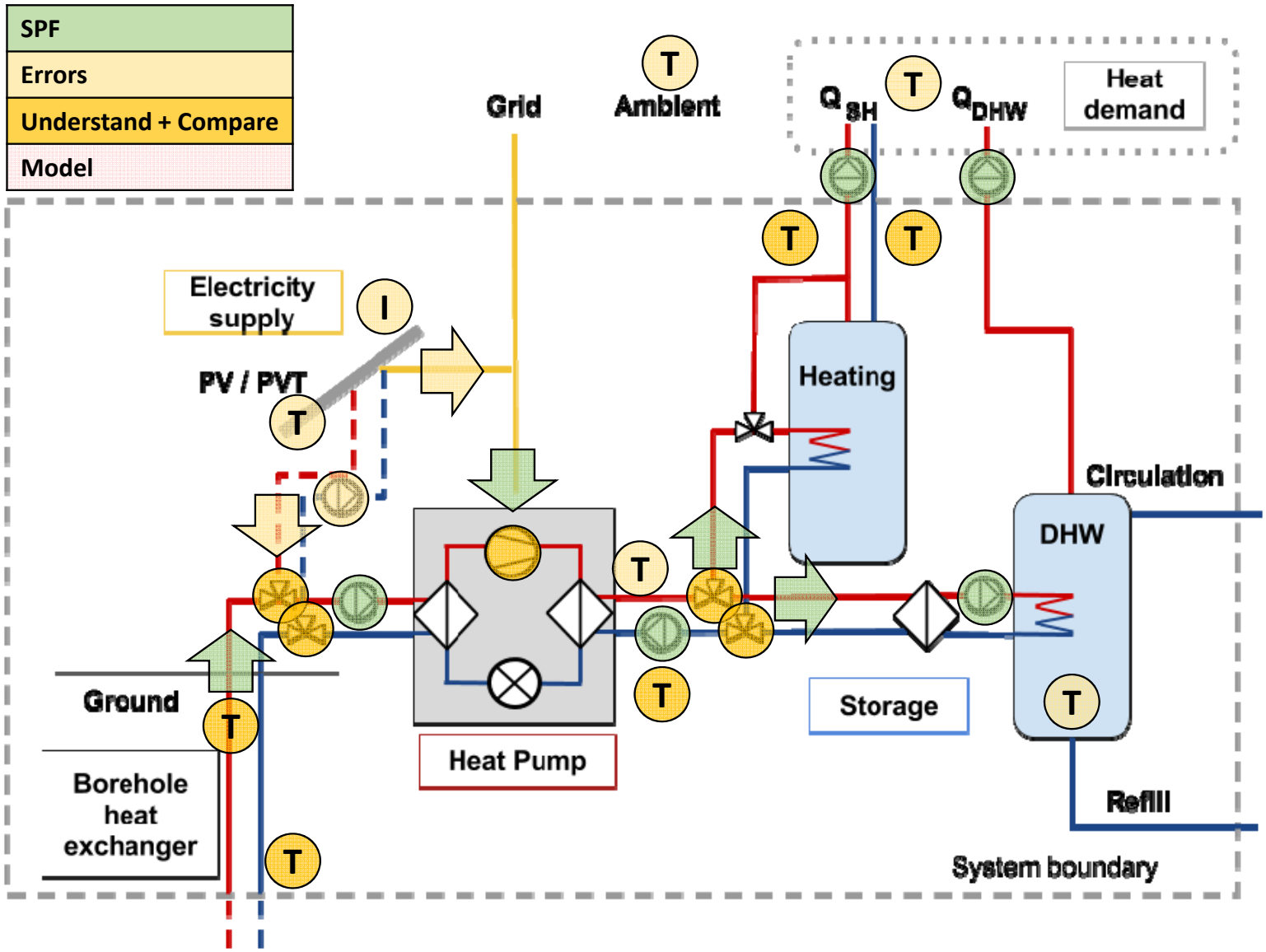
Nordman R, Nowak T. SEasonal PErformance factor and MOnitoring for heat pump systems in the building sector SEPEMO-Build - Position paper on heat pump SPF 2012.

Full Monitoring Setup

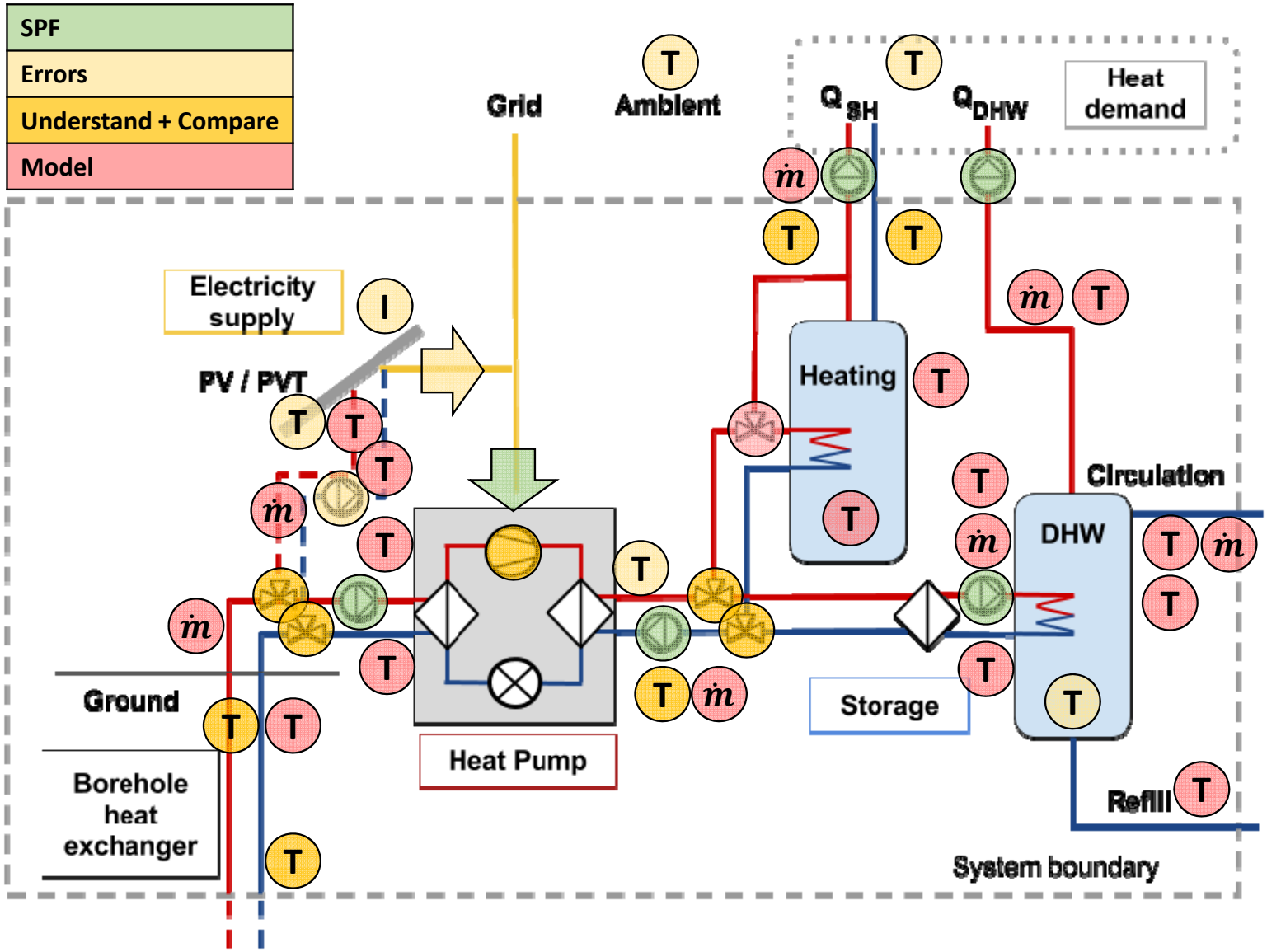


Zakula T, Gayeski NT, Armstrong PR, Norford LK, Program BT, Dhabi A. Variable-speed heat pump model for a wide range of cooling conditions and loads. HVAC&R Res 2011;17:5:670–91. doi:10.1080/10789669.2011.607745.

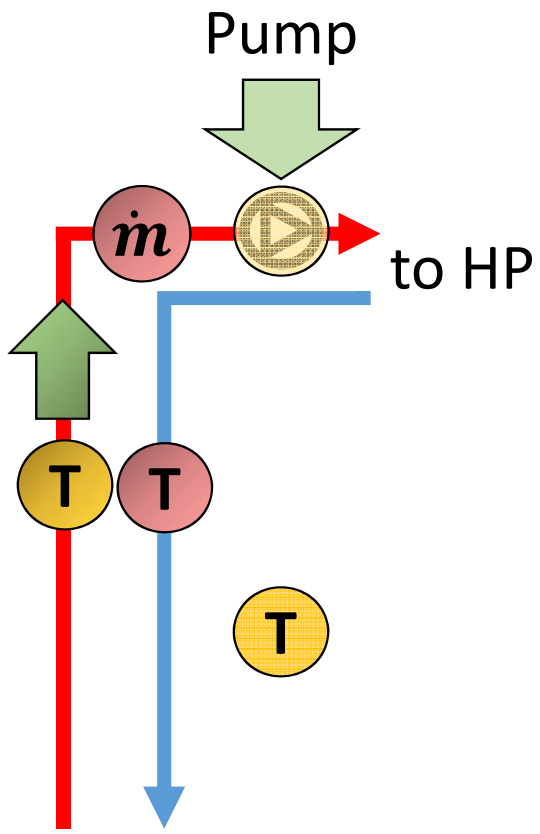
Full Monitoring Setup



Full Monitoring Setup



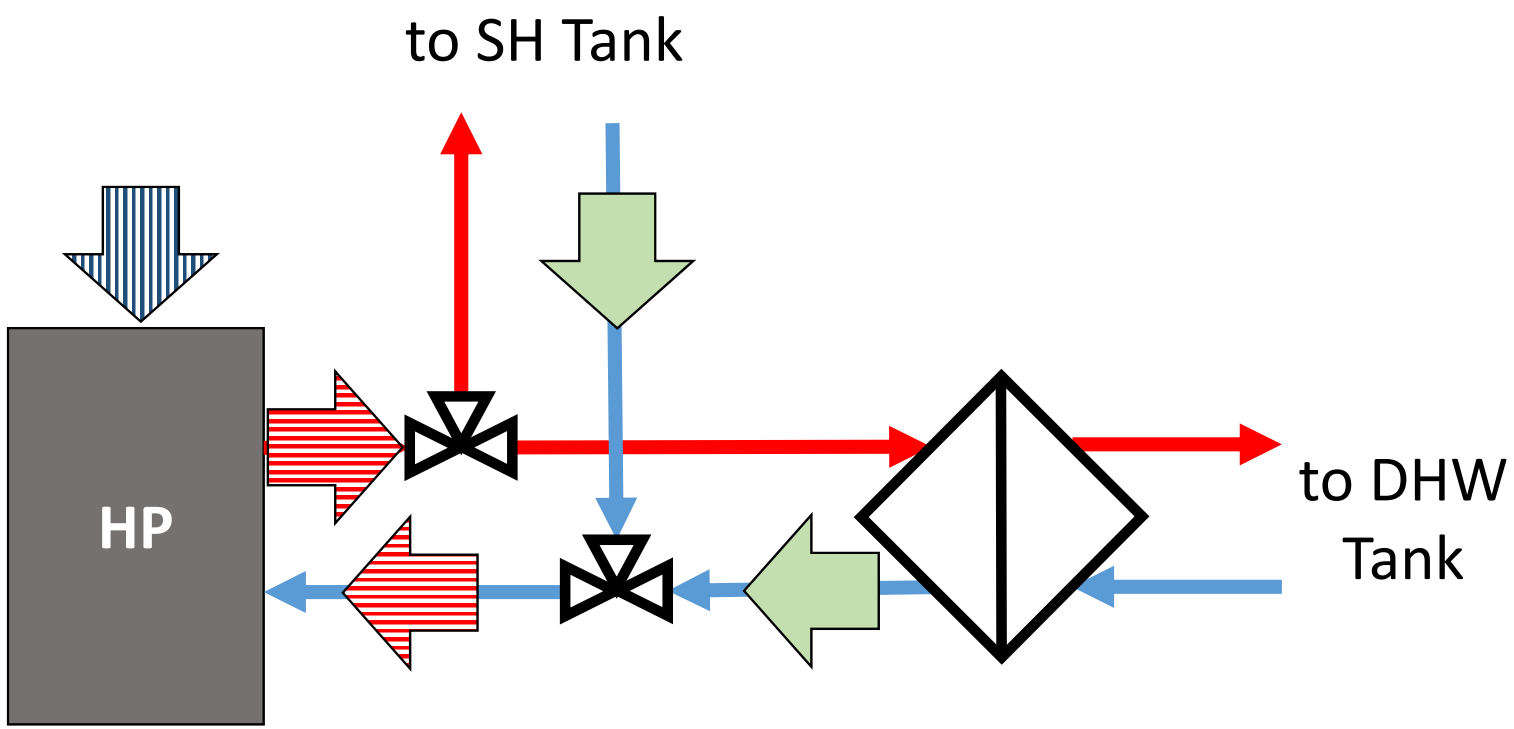
Borehole

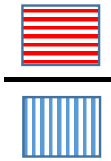


Goals

- SPF Measurements ☑
- Borehole Temperature development ☑
- Comparison to CO2 Borehole ☐
- Modelling ☐

Sensor placement

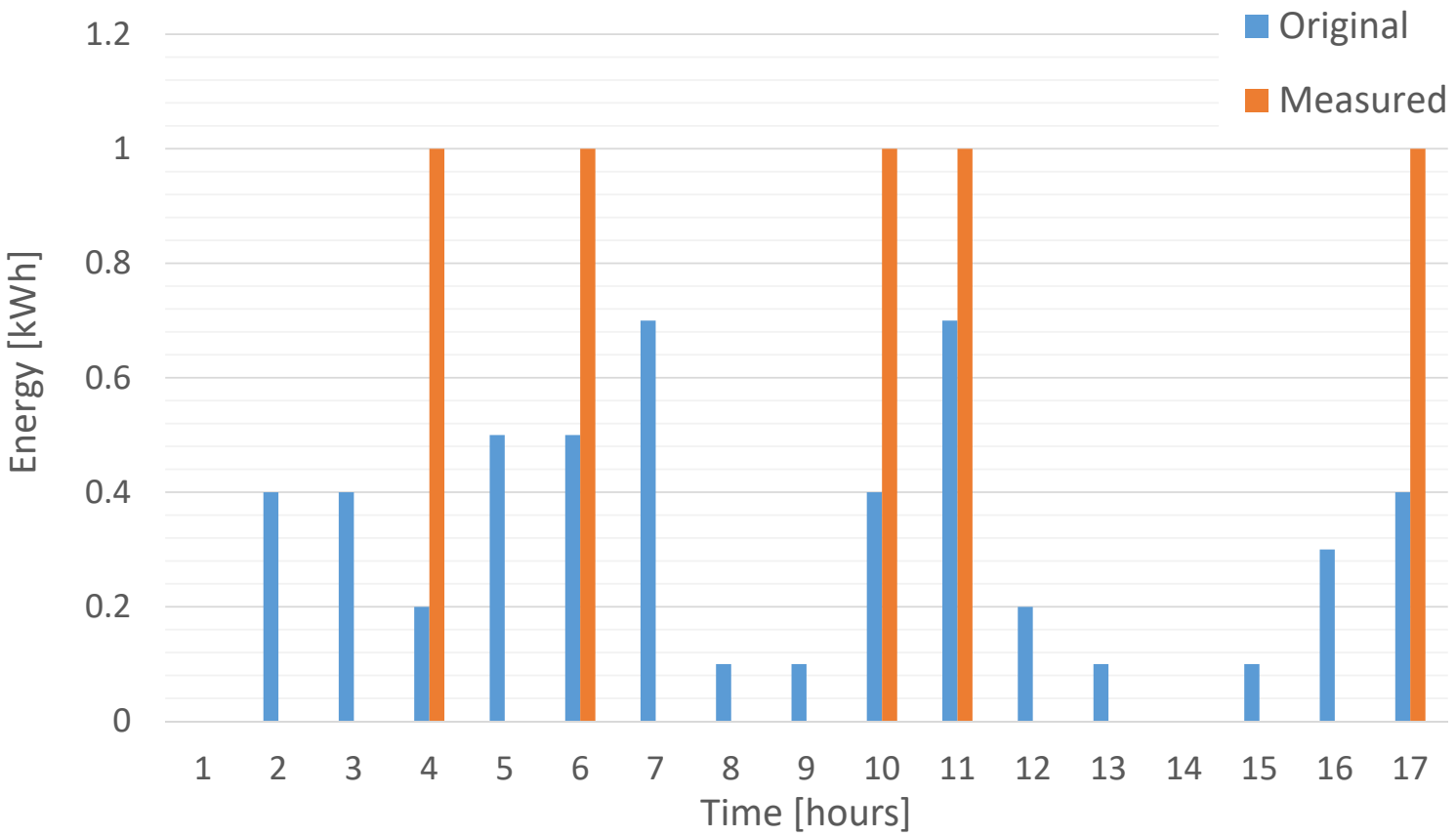


$$COP = \frac{Q_{prod,HP}}{P_{el,HP}} =$$ 

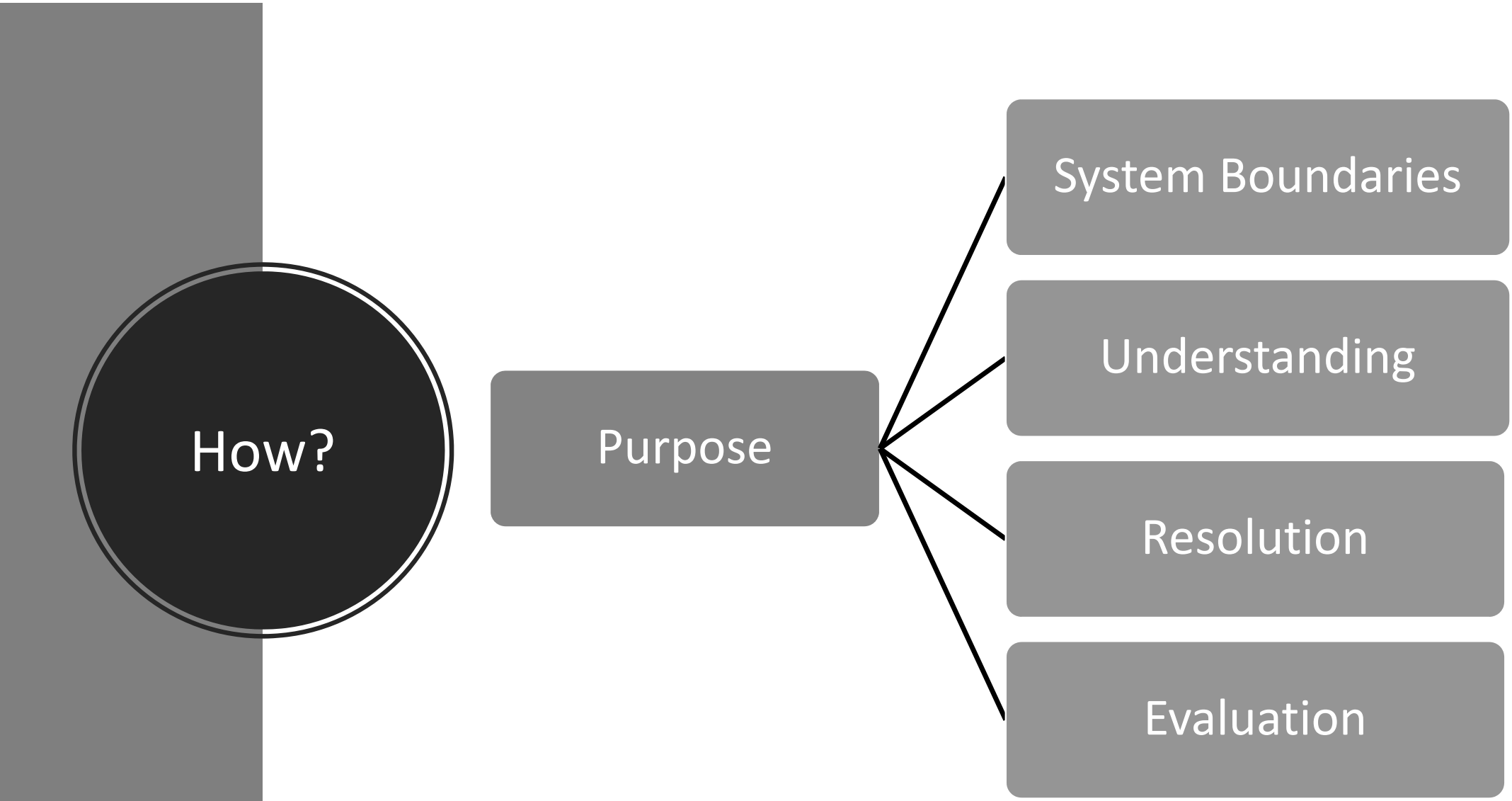
Peaks
- Time shift
- Valve switch

Incentive DRH. Domestic Renewable Heat Information for applicants and installers about metering for payment. 2014.

Timestep & granularity



-> high errors at low timescales! Mismatch!


How?
Purpose
System Boundaries
Understanding
Resolution
Evaluation

Conclusion

Monitoring

Why?

- SEPEMO, GRAHAM, Frauenhofer, RHI
- Data
  - Limited availability
  - Retrofitting problems
- Identify errors
- Understand system

How?

- Setup dependant on purpose
- Thorough planning necessary

Bourgarel S, Prof. Maréchal F, Dorer V, Prasanna A, Weber R. Iterative simulation and optimization approach for energy performance evaluation of ground source heat pump systems Author : 2017.

Conclusion

Monitoring

Why?

Planning monitoring setup

How?

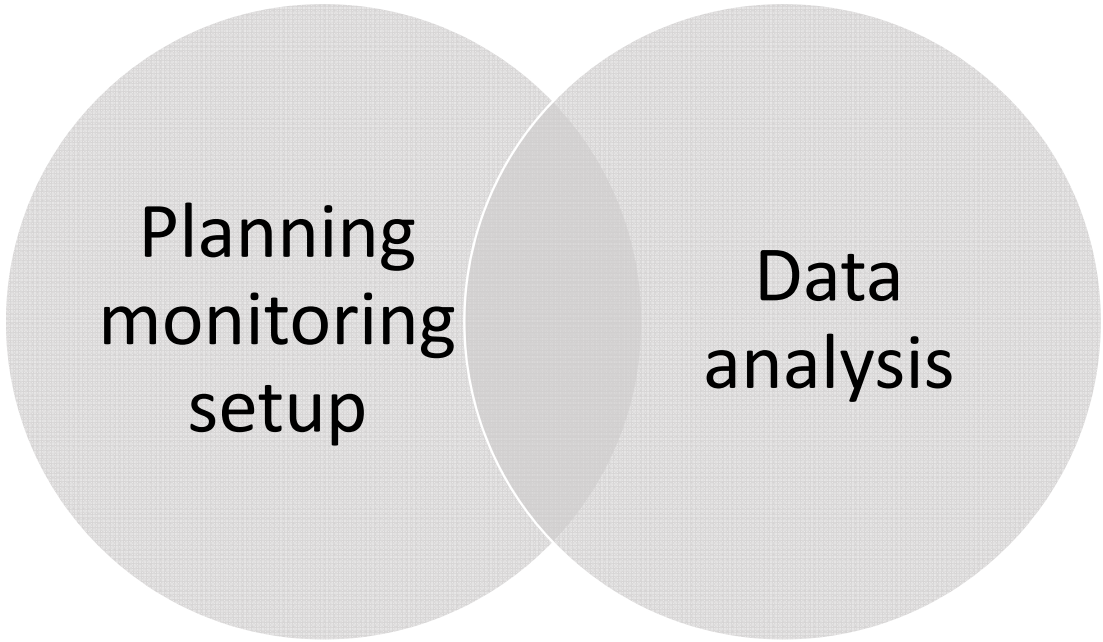
Data analysis

Conclusion

Monitoring

Why?

How?



Conclusion

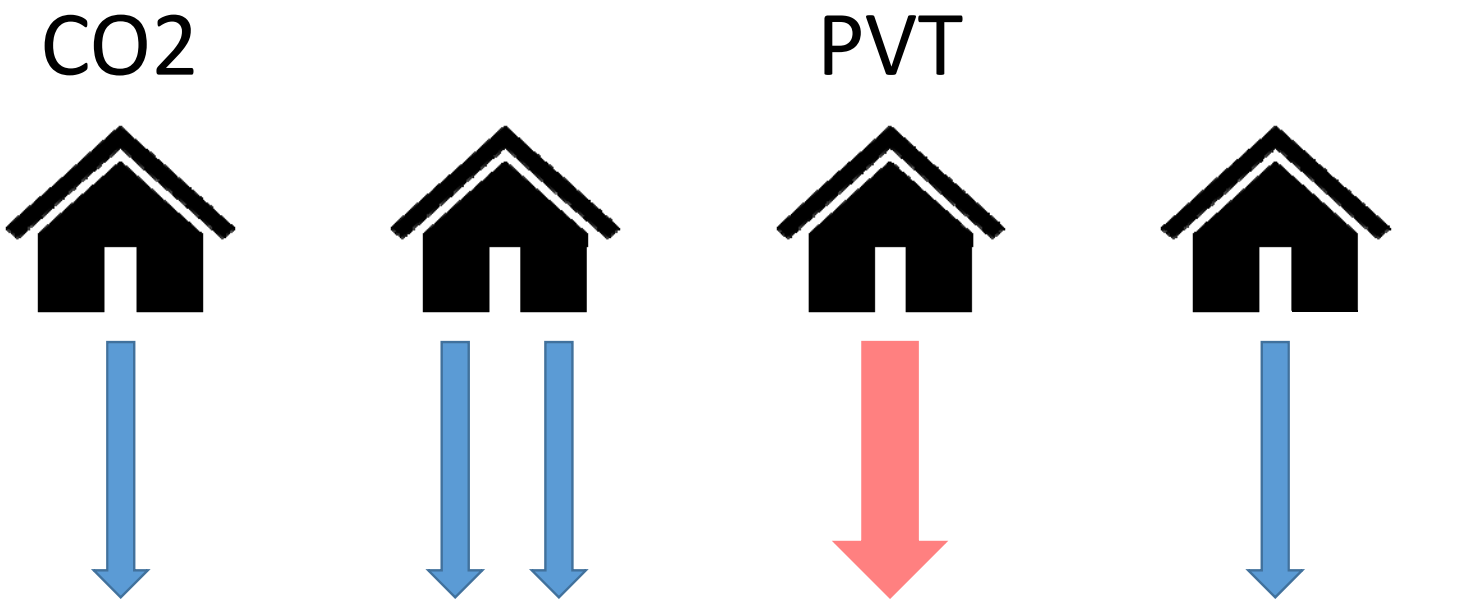
Monitoring:
identify errors/understand system/Model

Limited availability of monitoring data:
Retrofitting problematic
Setup dependant on purpose
-> good / thorough planning necessary

Future work:
-generalized methods for incomplete data handling
-expand guidelines to other heat pump systems
-Tièchestrasse design optimization

Bourgarel S, Prof. Maréchal F, Dorer V, Prasanna A, Weber R. Iterative simulation and optimization approach for energy performance evaluation of ground source heat pump systems Author : 2017.

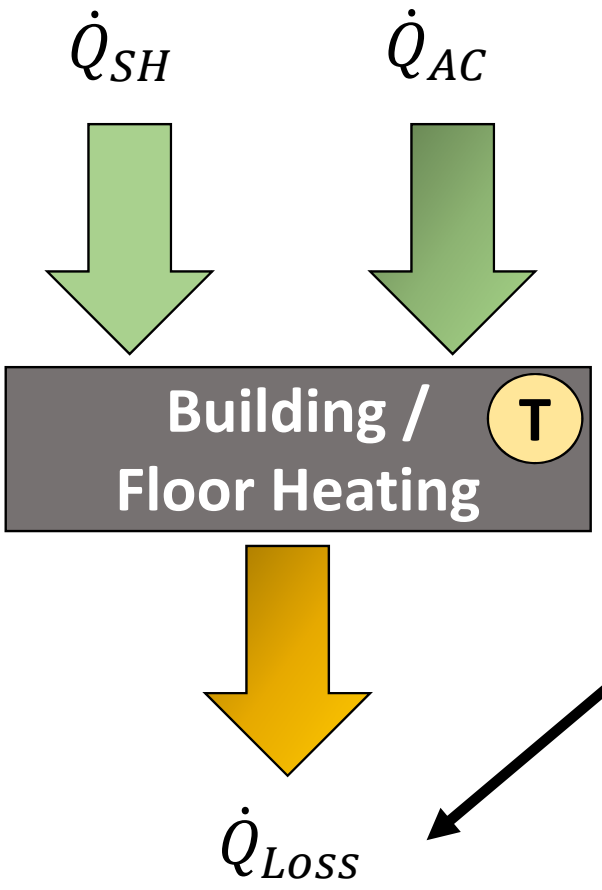
Tièchestrasse



Definitions

Purpose	Level of detail required	Colour
Calculate SPF	Low	Green
Operational improvements & Installation errors	Medium	Yellow (light)
Understand & compare	Medium	Yellow (dark)
Model	High	Red

Heat balance

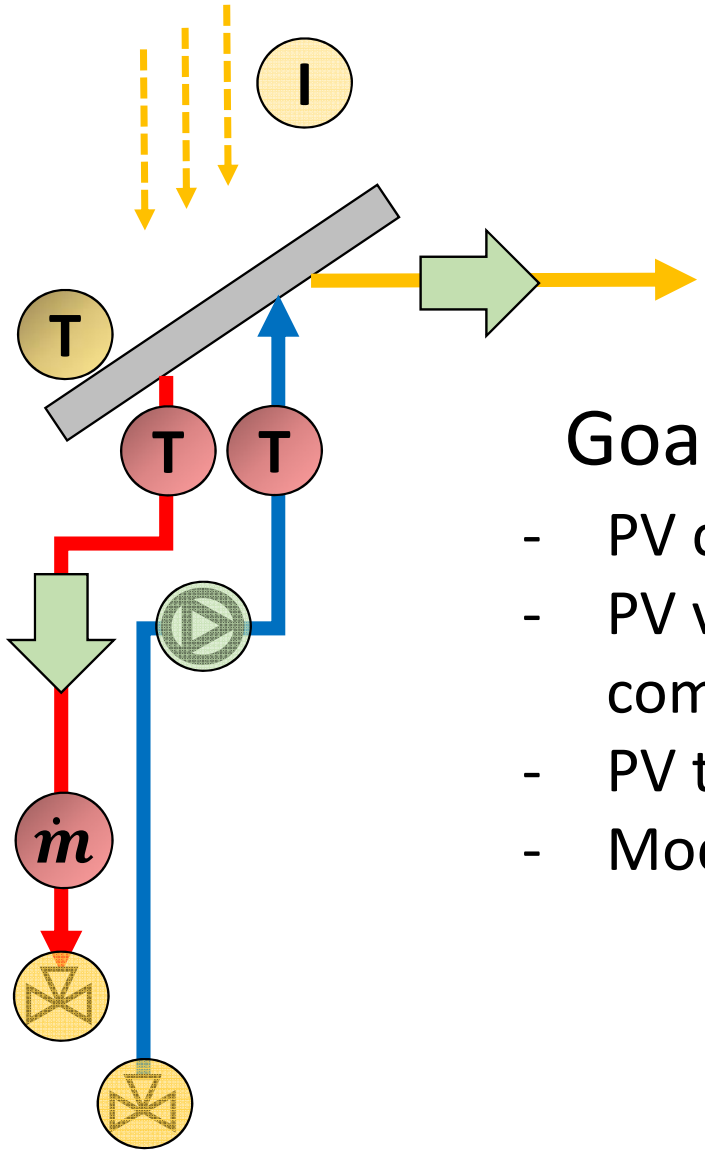


Hard to Measure but important for:

- Comparison
- Understanding
- Modelling

$$m * c_p * \frac{dT_{Room}}{dt} = \dot{Q}_{SH} + \dot{Q}_{AC} - \dot{Q}_{Loss}$$

Parameter definition & mass flows

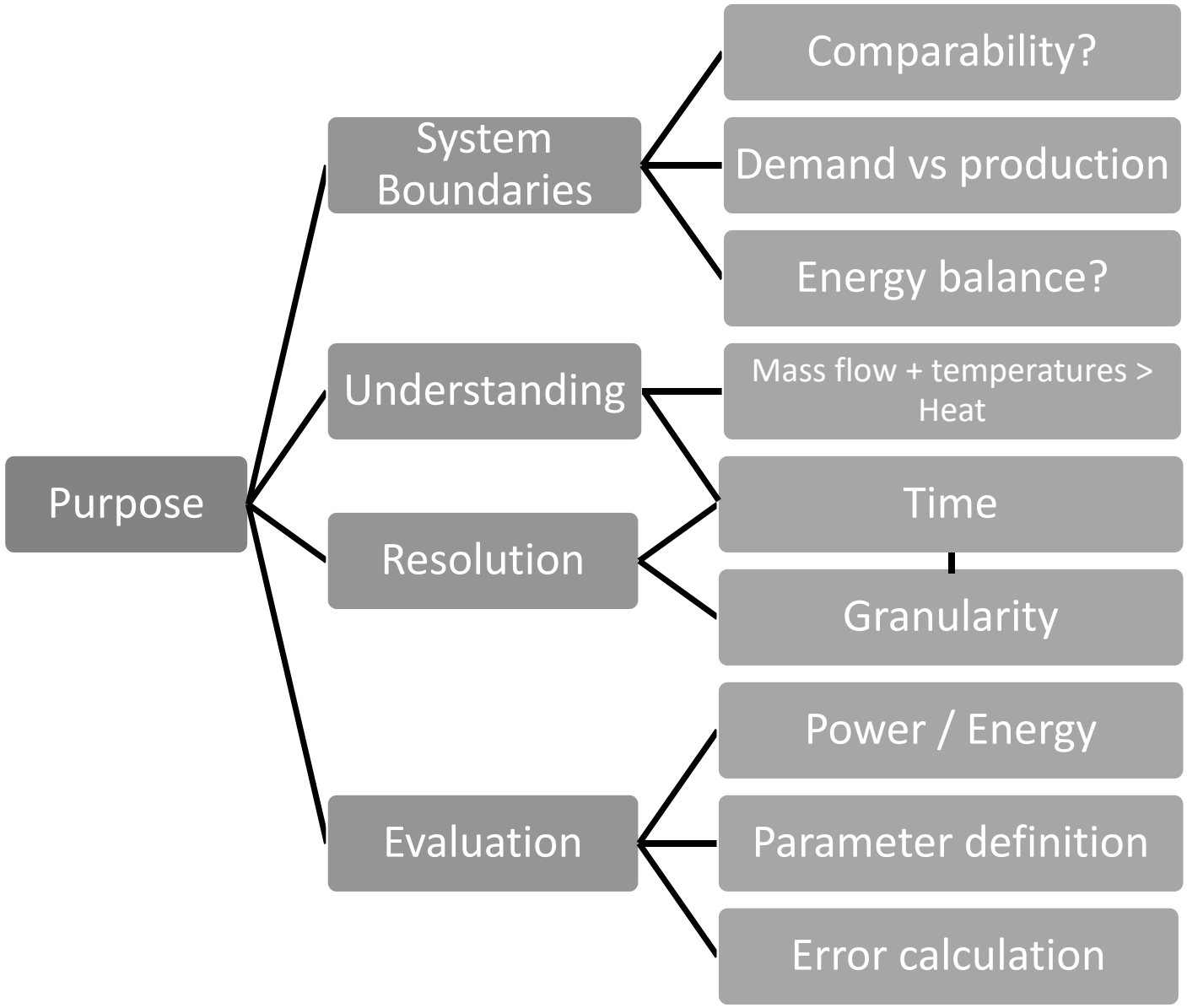


Goals?

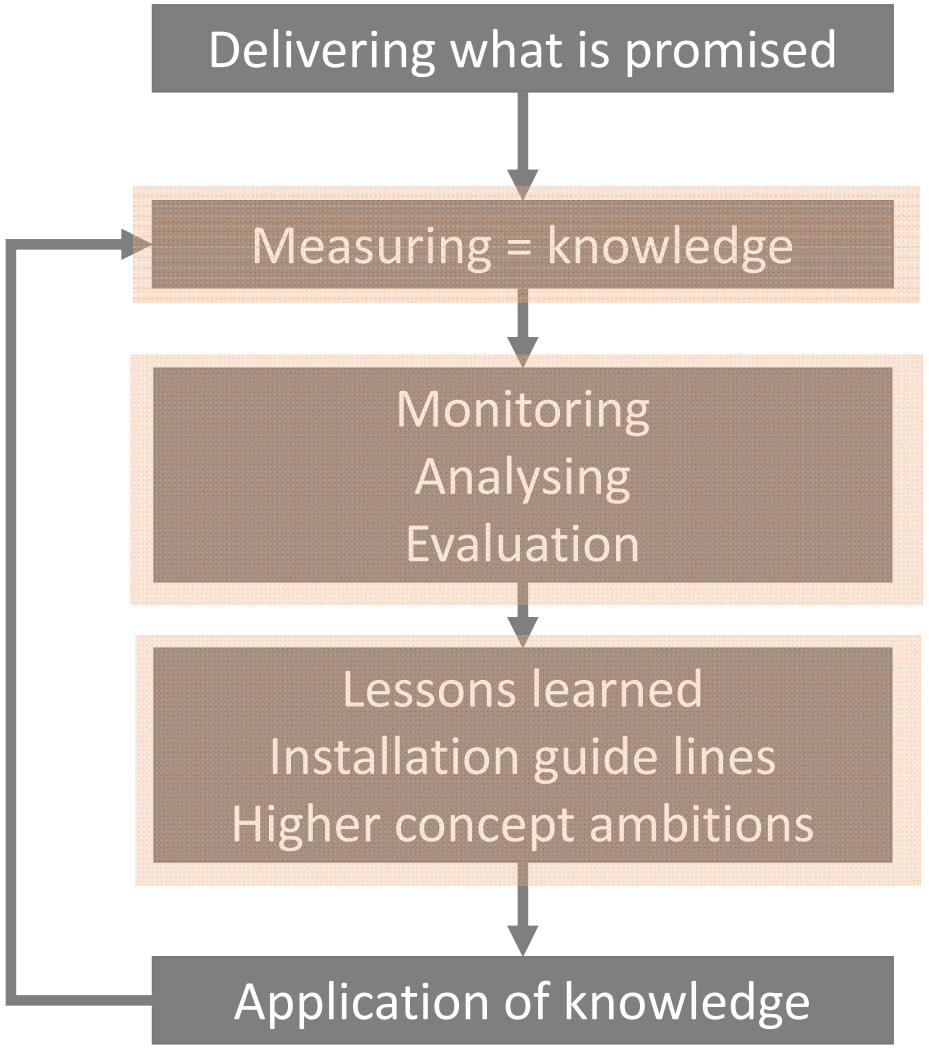
- PV cover factors ☑
- PV vs PVT comparison ☐
- PV total produced ☑
- Modelling ☐

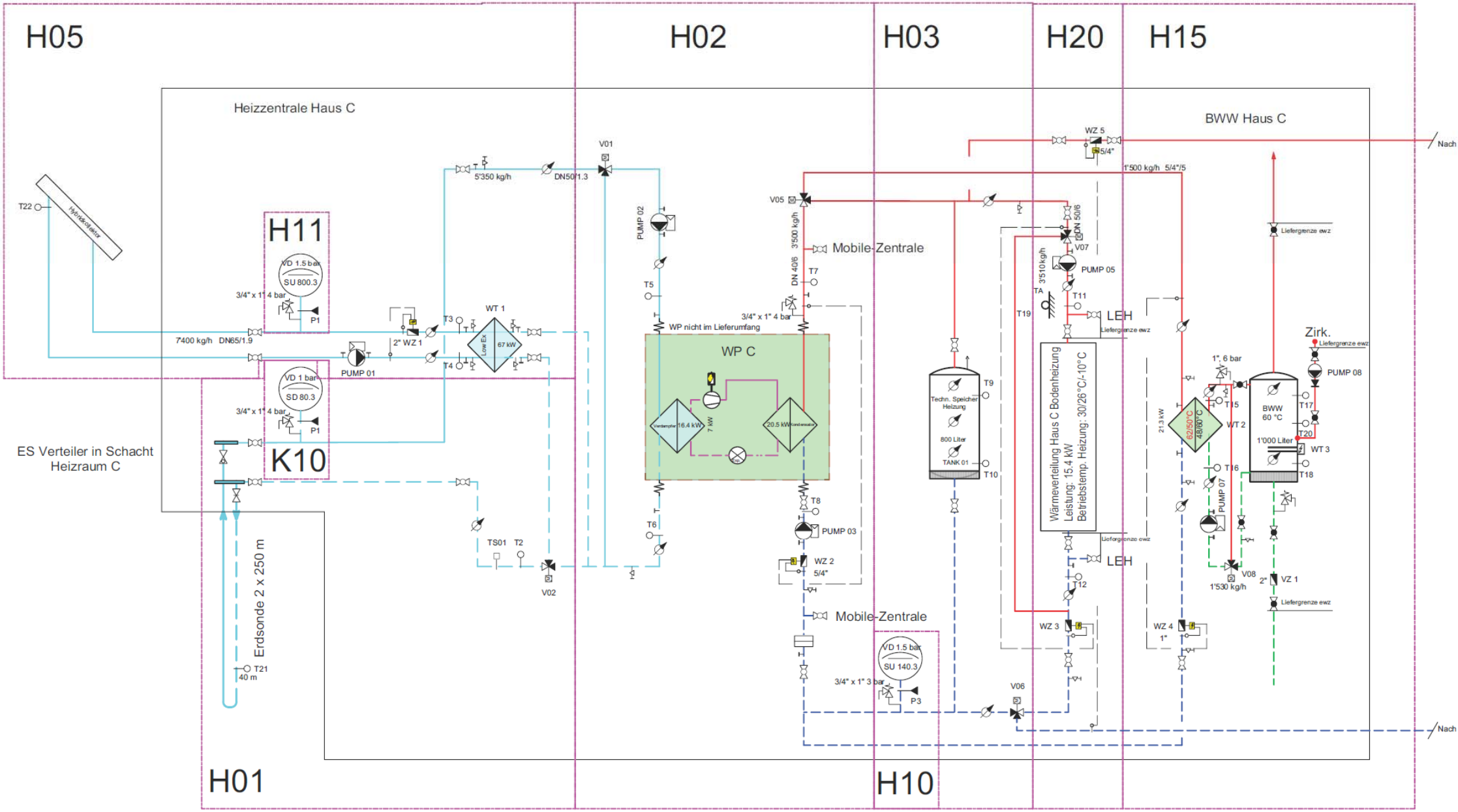
Prasanna A, Dorer V, Vetterli N. Optimisation of a district energy system with a low temperature network. Energy 2016:1–17. doi:10.1016/j.energy.2017.03.137.

How?

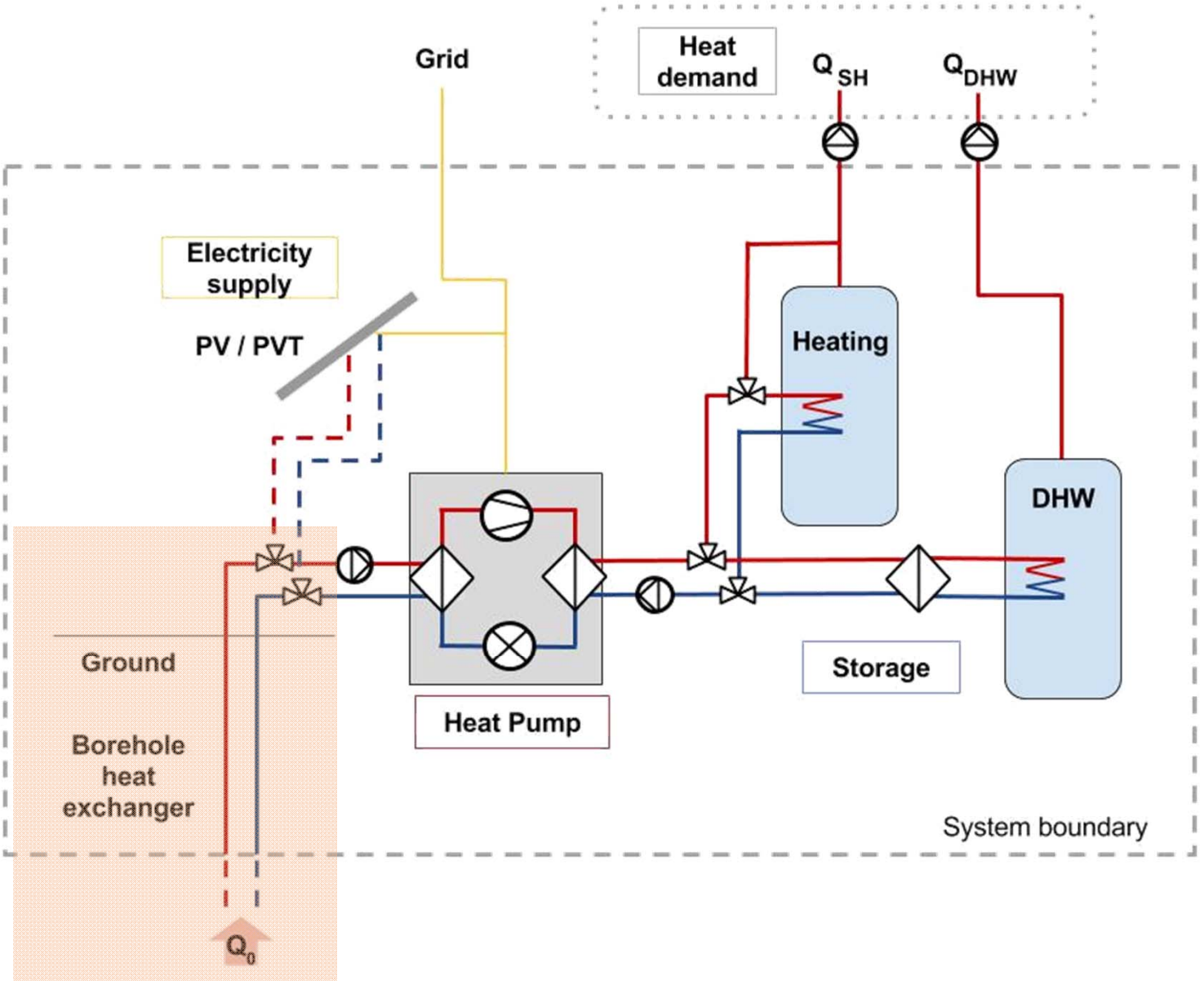

Purpose
System Boundaries
Comparability?
Demand vs production
Energy balance?
Understanding
Mass flow + temperatures > Heat
Resolution
Time
Granularity
Evaluation
Power / Energy
Parameter definition
Error calculation

Overview


Delivering what is promised
Measuring = knowledge
Monitoring
Analysing
Evaluation
Lessons learned
Installation guide lines
Higher concept ambitions
Application of knowledge

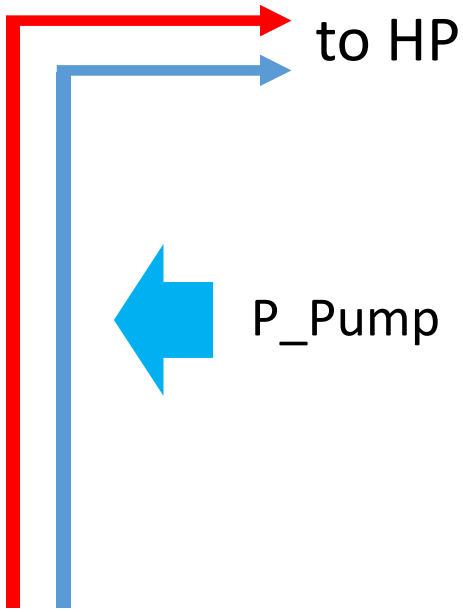

H05
H02
H03
H20
H15
Heizzentrale Haus C
BWW Haus C
T22
Hybridkollektor
H11
VD 1.5 bar
SU 800.3
3/4" x 1" 4 bar
P1
7'400 kg/h DN65/1.9
PUMP 01
2" WZ 1
T3
WT 1
Low Ex
67 kW
T4
VD 1 bar
SD 80.3
3/4" x 1" 4 bar
P1
K10
ES Verteiler in Schacht
Heizraum C
Erdsonde 2 x 250 m
T21
40 m
TS01
T2
V02
5'350 kg/h
DN50/1.3
V01
PUMP 02
T5
T6
WP nicht im Lieferumfang
WP C
Verdampfer 16.4 kW
7 kW
20.5 kW Kondensator
V05
3'500 kg/h
DN 40/6
Mobile-Zentrale
T7
3/4" x 1" 4 bar
T8
PUMP 03
WZ 2
5/4"
Mobile-Zentrale
VD 1.5 bar
SU 140.3
3/4" x 1" 3 bar
P3
V06
T9
Techn. Speicher Heizung
800 Liter
TANK 01
T10
WZ 5
5/4"
1'500 kg/h 5/4"/5
DN 50/6
V07
PUMP 05
3'510 kg/h
TA
T11
T19
LEH
Liefergrenze ewz
Wärmeverteilung Haus C Bodenheizung
Leistung: 15.4 kW
Betriebstemp. Heizung: 30/26°C/-10° C
LEH
Liefergrenze ewz
T12
WZ 3
WZ 4
1"
1", 6 bar
21.3 kW
62/50°C
48/60°C
T15
WT 2
T16
PUMP 07
V08
1'530 kg/h
2"
VZ 1
Liefergrenze ewz
BWW
60 °C
1'000 Liter
T17
T20
WT 3
T18
Zirk.
Liefergrenze ewz
PUMP 08
Liefergrenze ewz
Nach
Nach
H01
H10

Borehole


Grid
Heat demand
Q_{SH}
Q_{DHW}
Electricity supply
PV / PVT
Heating
DHW
Ground
Borehole heat exchanger
Heat Pump
Storage
Q_0
System boundary

Borehole

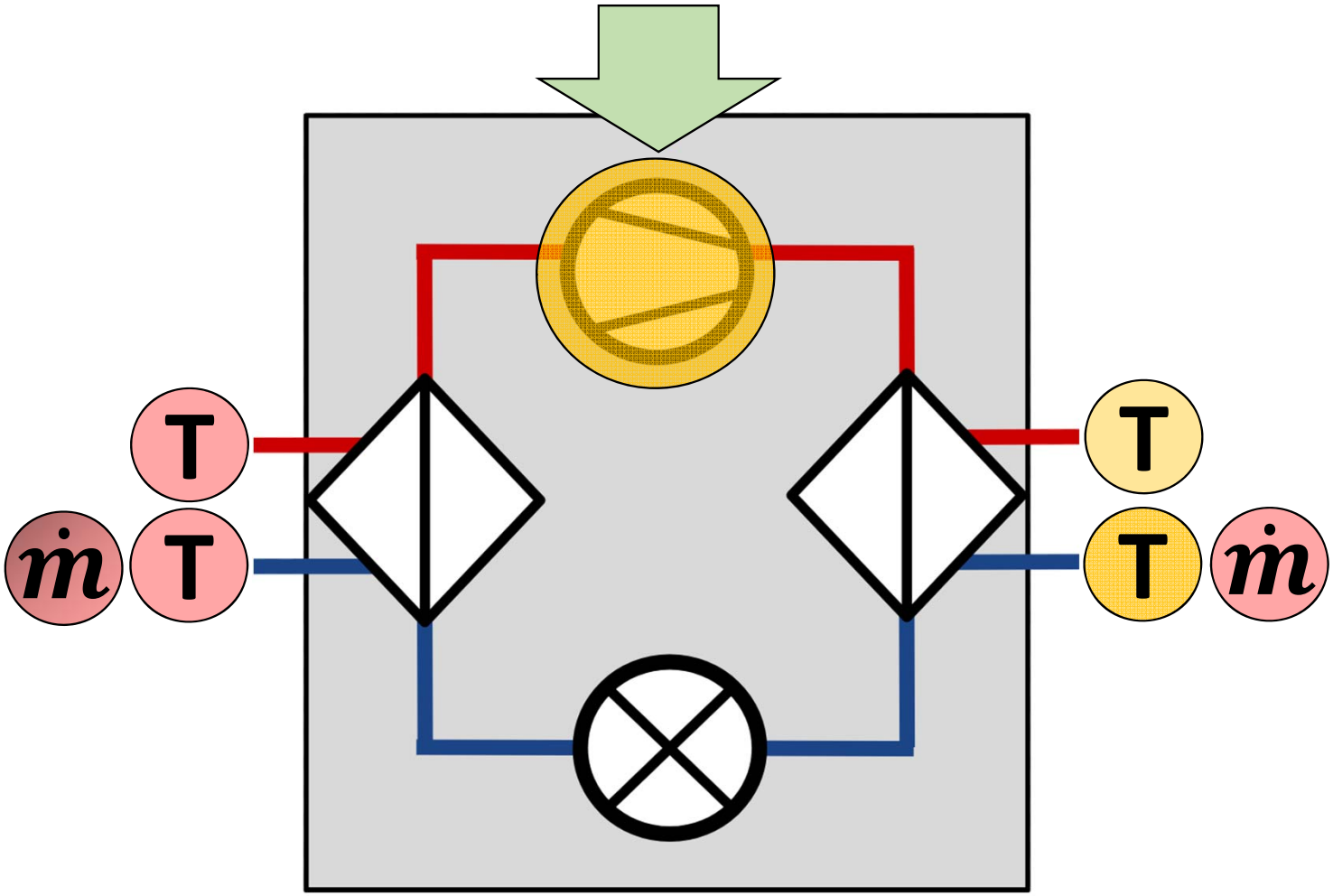
What?



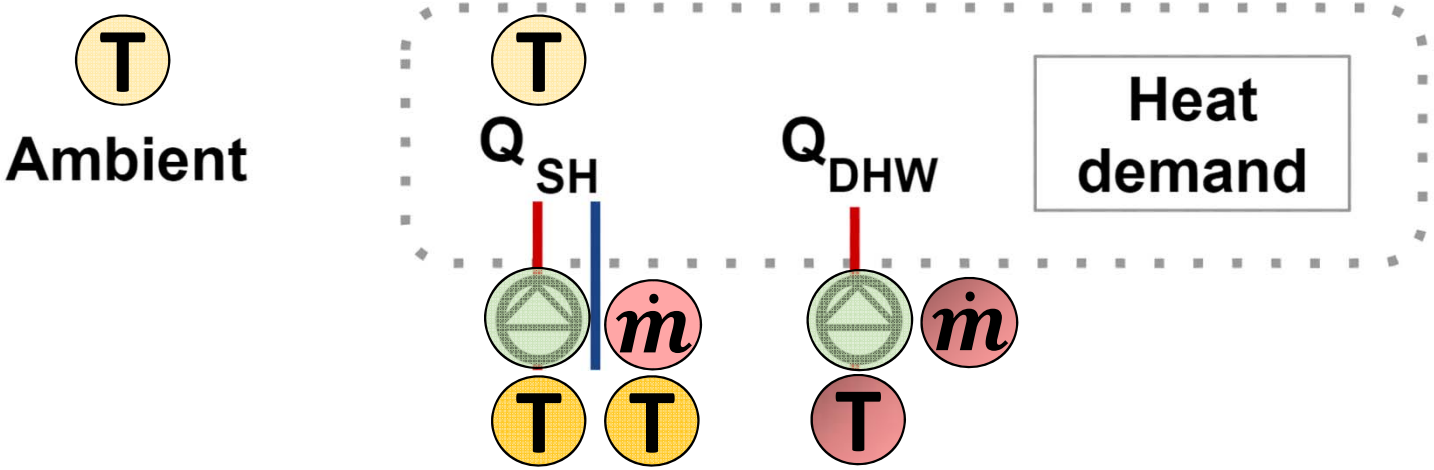
Why?

SEPEMO
SPF H2-H4

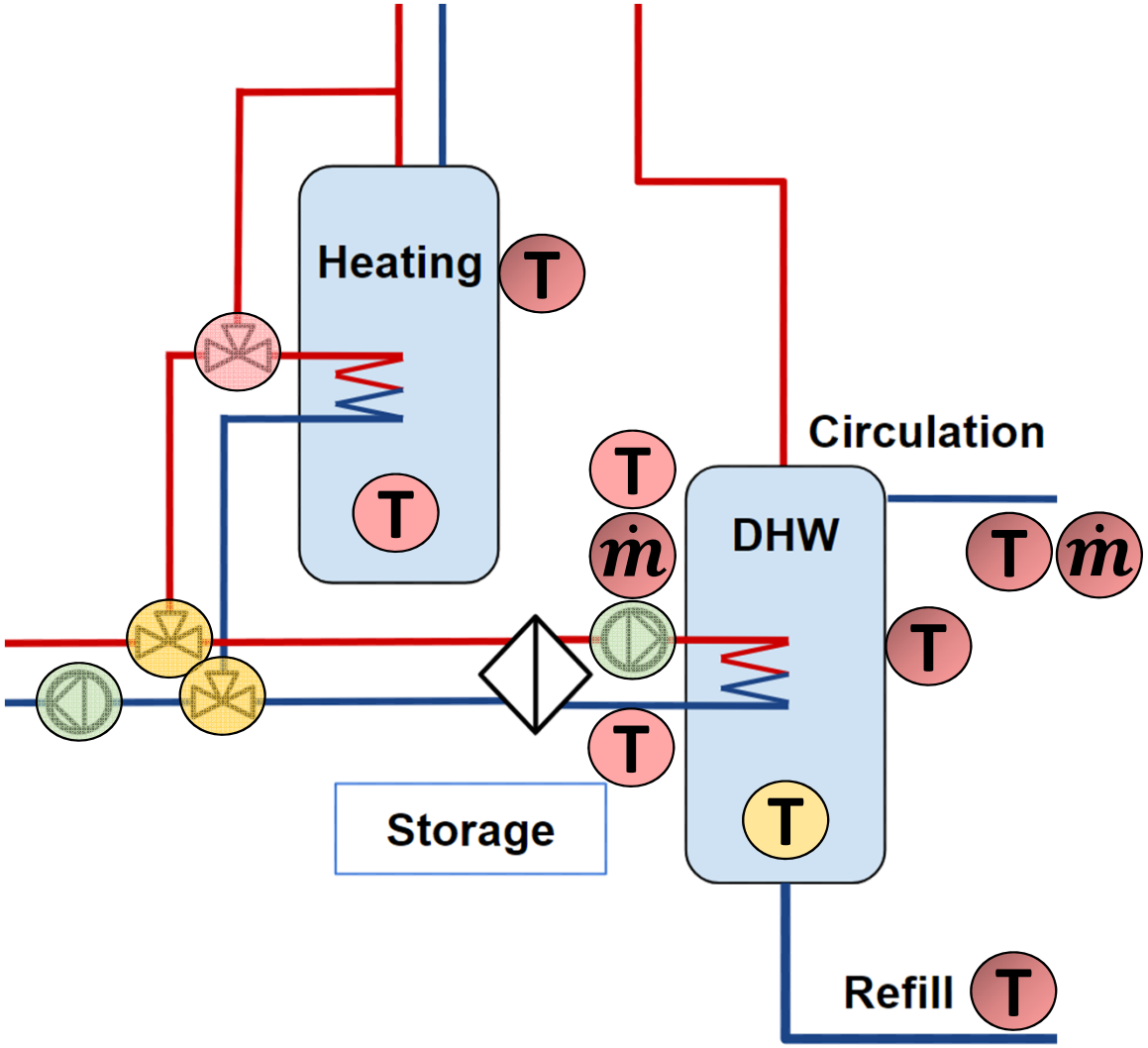
HP



Demand



Storage


Heating
T
T
Circulation
T
$\dot{m}$
DHW
T
$\dot{m}$
T
T
T
Storage
T
Refill
T