Design of a modulating heat pump system and the impact on the seasonal coefficient of performance

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Agenda

Introduction

Idea for customized control

Parametric runs for sizing

Impact of different measures on the system sizing

Conclusion and further work

Introduction

Background

- Testing control strategies for demand side management by using the ESBO plant layout of IDA ICE not always possible
- Sizing of heat pump systems, here capacity of the heat pump and electric back-up, based on design outdoor temperature (DOT) at the location

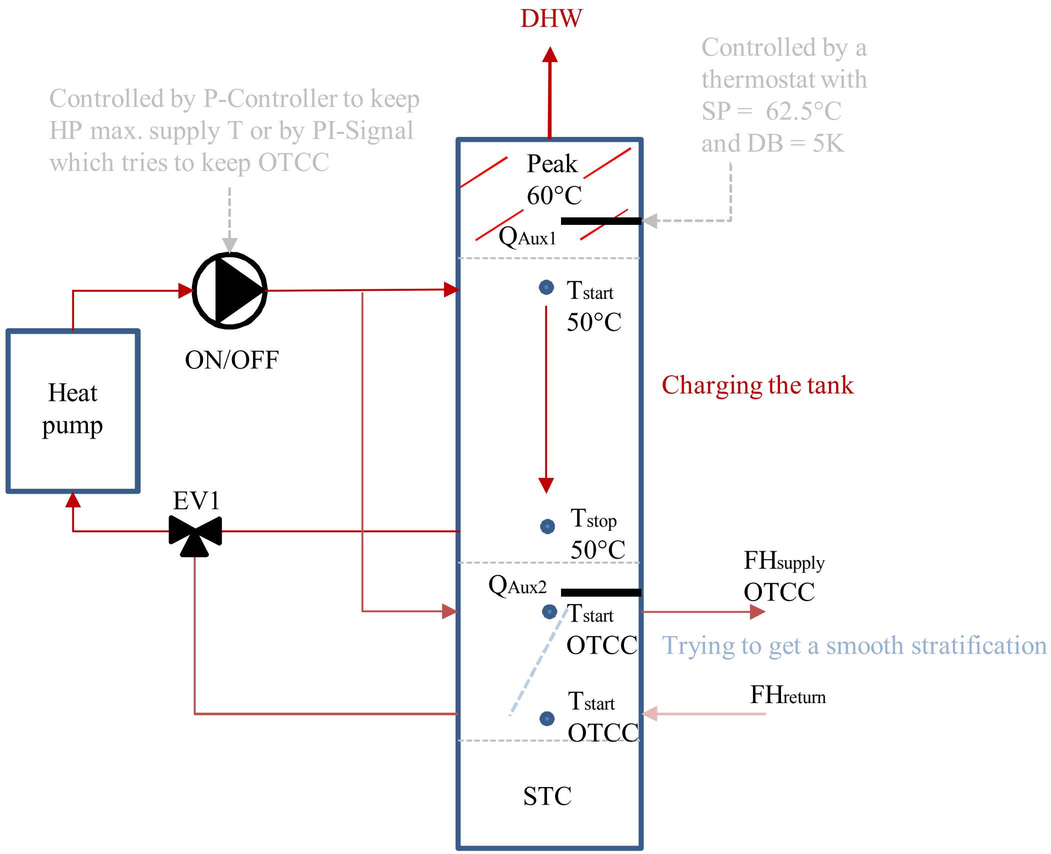
Motivation

- Setting up a customized control for the heat pump based on temperatures in the tank, rather than the state-of-charge (SOC)
- Finding an optimal system configuration which minimizes electricity use for heating

Heat pump control

Control idea

- Heat pump supplies heat for SH (at OTCC) and DHW (at 60-65°C)
- If required. DHW is heated by Q_{Aux1} with 3kW heating capacity (On/off)
- If requried. SH is heated by Q_{Aux2} with 9kW heating capacity (On/Off)
- Several temperature sensors are applied for the temperature control of the two parts of the tank



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Parametric analysis

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Parameter	Range	Step
HP capacity [kW]	[2.5 – 7.5]	0.5
Tank radius [m] Corr. Volume [l]	[0.26 – 0.34] [425 – 726]	0.02
El. back-up DHW Q_{Aux1} [W]	[0 – 4000]	1000
El. back-up SH Q_{Aux2} [W]	[4000 – 12000]	2000

GenOpt algorithm: Hybrid GPS/PSO algorithm

- PSO: Particle swarm algorithm
- GPS: Generalized pattern search

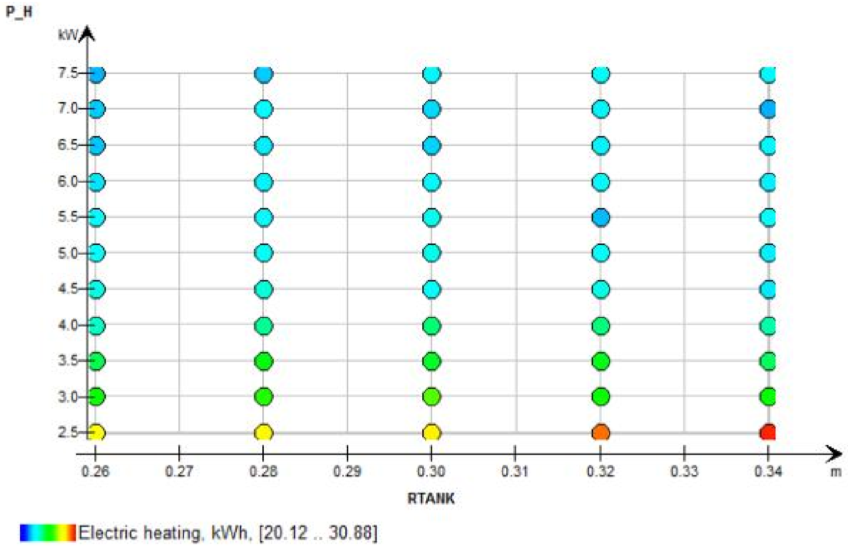
- First. the PSO performs a global search
- Afterwards, the GPS does a local search starting with the best solutions reached by the PSO to improve the exploration and achieve adequate accuracy

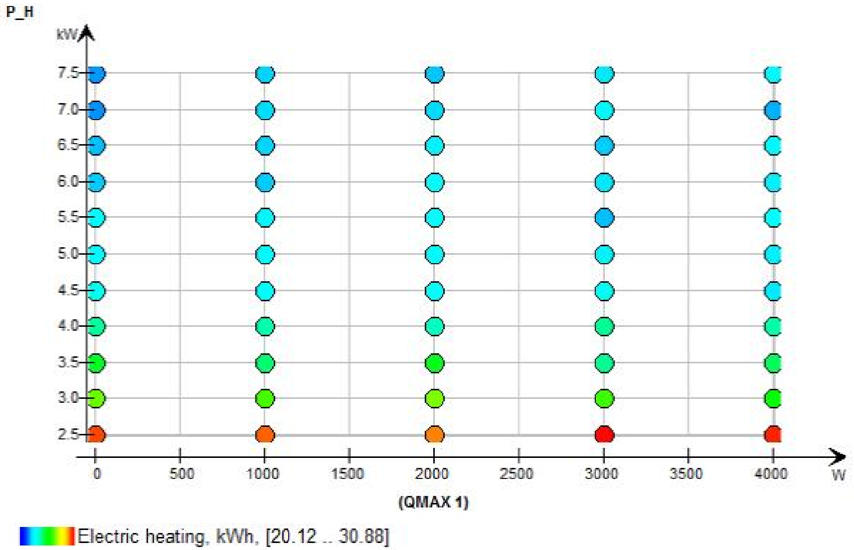
Parametric analysis - Results

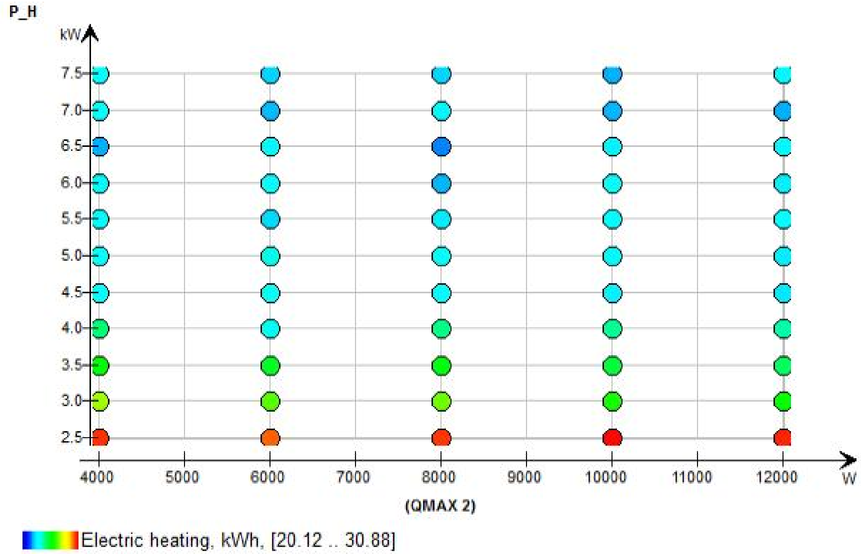
Optimal configuration with regards to minimizing electrical heating

Heating calculation DOT=-19°C

HP capacity [kW]	WT radius [m]	QMax1 [W]	QMax2 [W]	Electric heating [kWh]
7.5	0.26	0	10000	20.12
7.5	0.26	0	6000	20.15
4.5	0.28	0	12000	21.26
7.5	0.26	3000	10000	21.63
6.5	0.3	3000	6000	22.67
3.5	0.28	3000	8000	24.97
3.5	0.3	4000	10000	25.08
2.5	0.34	3000	10000	30.88







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Results for system sizing

	Annual calculation for 2015						
	HP capacity [kW]	WT radius [m]	QMax1 [W]	QMax2 [W]	Electric heating [kWh]	SCOP [-]	Nr. of HP cycles [-]
Case 1	7.5	0.26	0	10000	1744	3.17	6405
Case 2	7.5	0.26	0	6000	1743	3.20	6401
Case 3	4.5	0.28	0	12000	1625	3.94	4476
Case 4	7.5	0.26	3000	10000	2181	3.08	6419
Case 5	6.5	0.30	3000	6000	2294	3.84	3081
Case 6	3.5	0.28	3000	8000	2191	4.25	3541
Case 7	3.5	0.30	4000	10000	2268	4.36	3184
Case 8	2.5	0.34	3000	10000	2321	4.30	1817
Case 9	3.2	0.29	3000	9000	2252	4.33	3105

Conclusion and further work

Conclusion

- Presentation of preliminary results
- The use of electric back-up heaters decreases the COP slightly (cases 1, 2, 4)
- Combination of smallest heat pump capacity and biggest storage tank leads to highest electricity use for heating. but also to lowest number of cycles of the heat pump per year
- The optimal configuration from heating simulations at DOT does not give the lowest electricity use for heating over an annual period

Further work

- Improving the heat pump control in the model
    - Temperature set-points for the hysteresis
    - Include minimum cycling time and minimum pause times for the heat pump
- Implement a control for charging the thermal mass of a building

Thanks for your attention! ☺

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