Research Project aDSM

„Active DSM by forecasting“

Date set (1)

- „aDSM“ model settlement and grid topology

residential houses with a farm

8 x

9 households
31 people

1,1 hh / bldg
3,4 ppl / hh
3,9 ppl / bldg

Detached houses

45 x

52 households
137 people

1,2 hh / bldg
2,6 ppl / hh
3,0 ppl / bldg

residential houses with 3 to 10 households

5 x

27 households
57 people

5,4 hh / bldg
2,1 ppl / hh
11,4 ppl / bldg

residential houses with 11 and more households

2 x

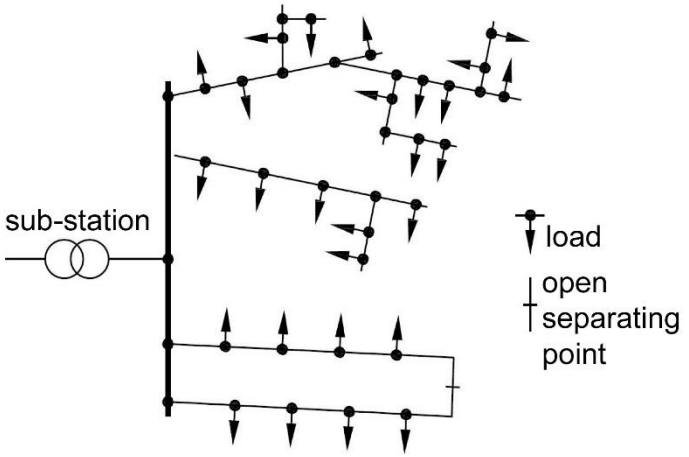
38 households
75 people

19,0 hh / bldg
2,0 ppl / hh
37,5 ppl / bldg

aDSM - settlement

60 buildings
126 households
300 people

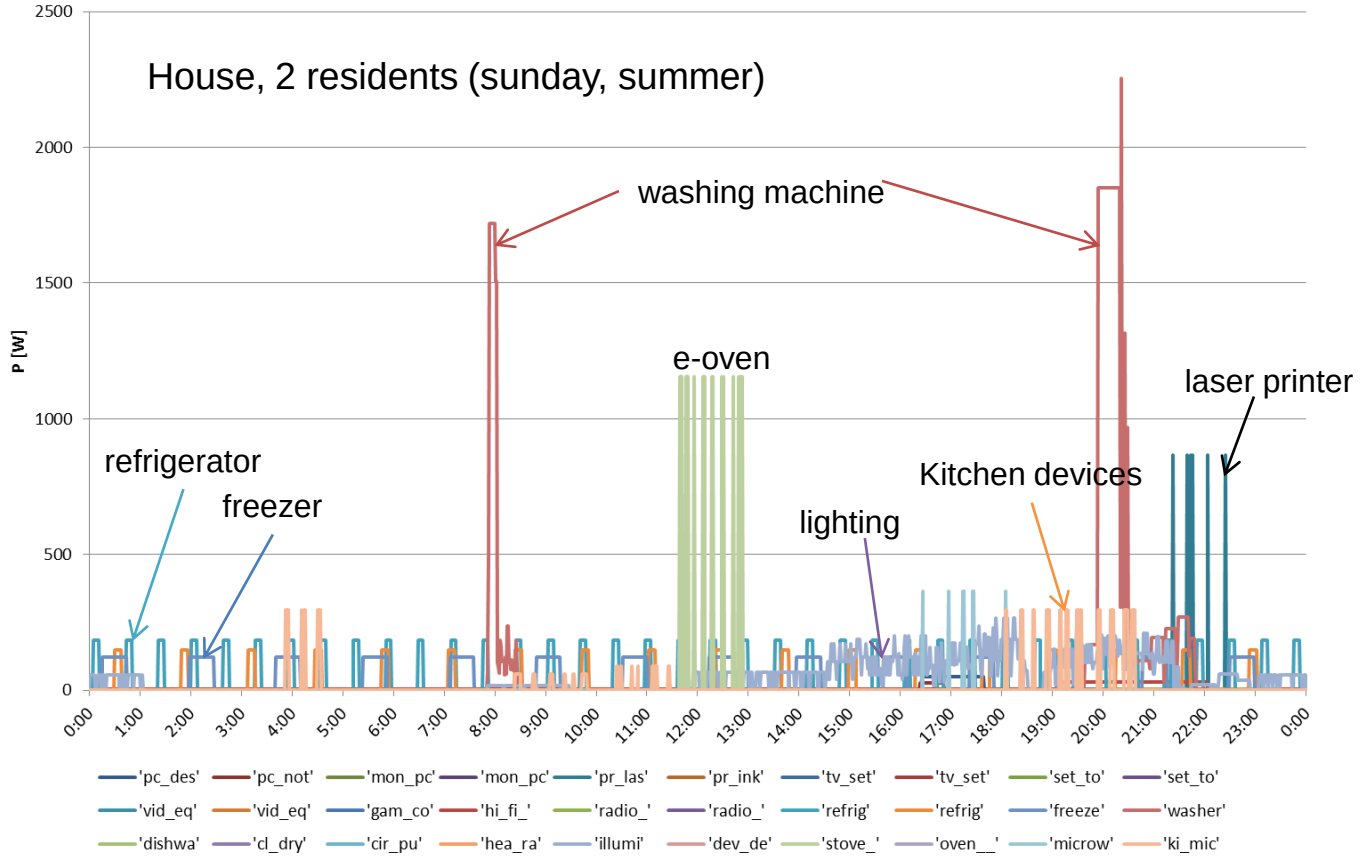
2,1 hh / bldg
2,4 ppl / hh
5,0 ppl / bldg



C. Groiß, et.al.:„**CIRED,** 22nd International Conference on Electricity Distribution, Stockholm, 10-13 June 2013

Data set (2)

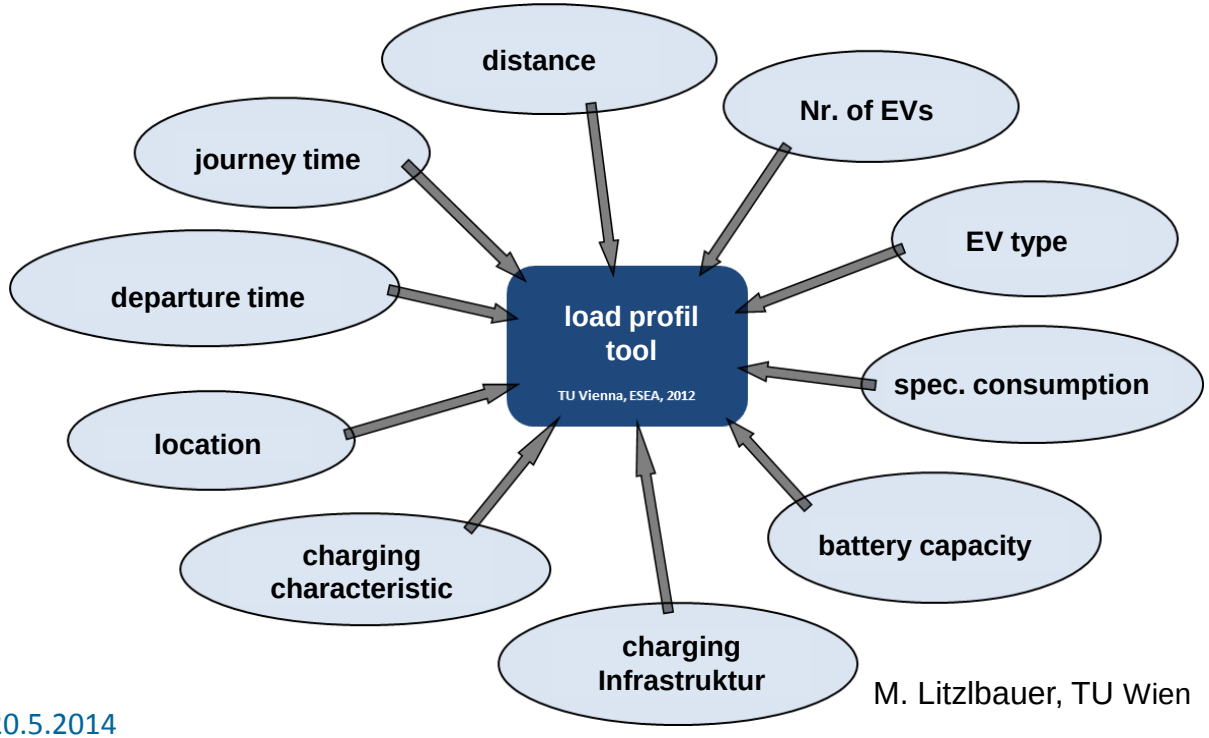
- Device equipment in households
  - Synthetic load profiles
  - 1min resolution



F. Zeilinger, „Detaillierte Modellierung des Haushaltsstromverbrauchs zur Untersuchung von Demand Side Management“, EnInnov14, Graz

Data set (3)

- Electric vehicles
  - Survey MiD08 (~50.000 HH)
  - Design of charging infrastructure
  - Modelling of driving behavior and power demand
  - Compilation of annual profiles for all EVs



M. Litzlbauer, TU Wien

DSM rules

household devices	Variant "Basic" / Variant "Full"									
Categories	electro-thermal				washing			illuminate		
Parameter	heating	hot water	fridge	freezer	washing machine	dryer	dishwasher	TV set	Computer	lighting
Switch off time [h]	18 h	11 h	2,5 h	6 h						
Ratio P_{med} / P_N	0,25	0,083	0,25	0,25						
Start delay [h]					5 h	5 h	5 h			
Power reduction [%]								- 20%	- 30%	- 9%
Standby reduction	no	no	no	no	no	no	no	yes	yes	no

electric vehicles	Categories	
Parameter	BEV / only electric	PHEV / Plug-In hybrid
Variation of charging power	variable (not continously)	variable (not continously)
Max. rate of change of charging power per min.	5% of max. charging power	5% of max. charging power
DSM allowed from a SOC higher than	50%	no limitations
"Vehicle to Grid"	no	no

M. Litzlbauer, TU Vienna

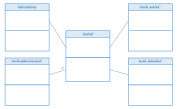
aDSM – operating behavior

tasks

- Efficient usage of available DSM potential
- Designing of a local DSM model and operation under uncertainty
- Weighted multiobjective optimization
  - Maximizing of own consumption
  - Minimizing of load peaks

implementation

Local model



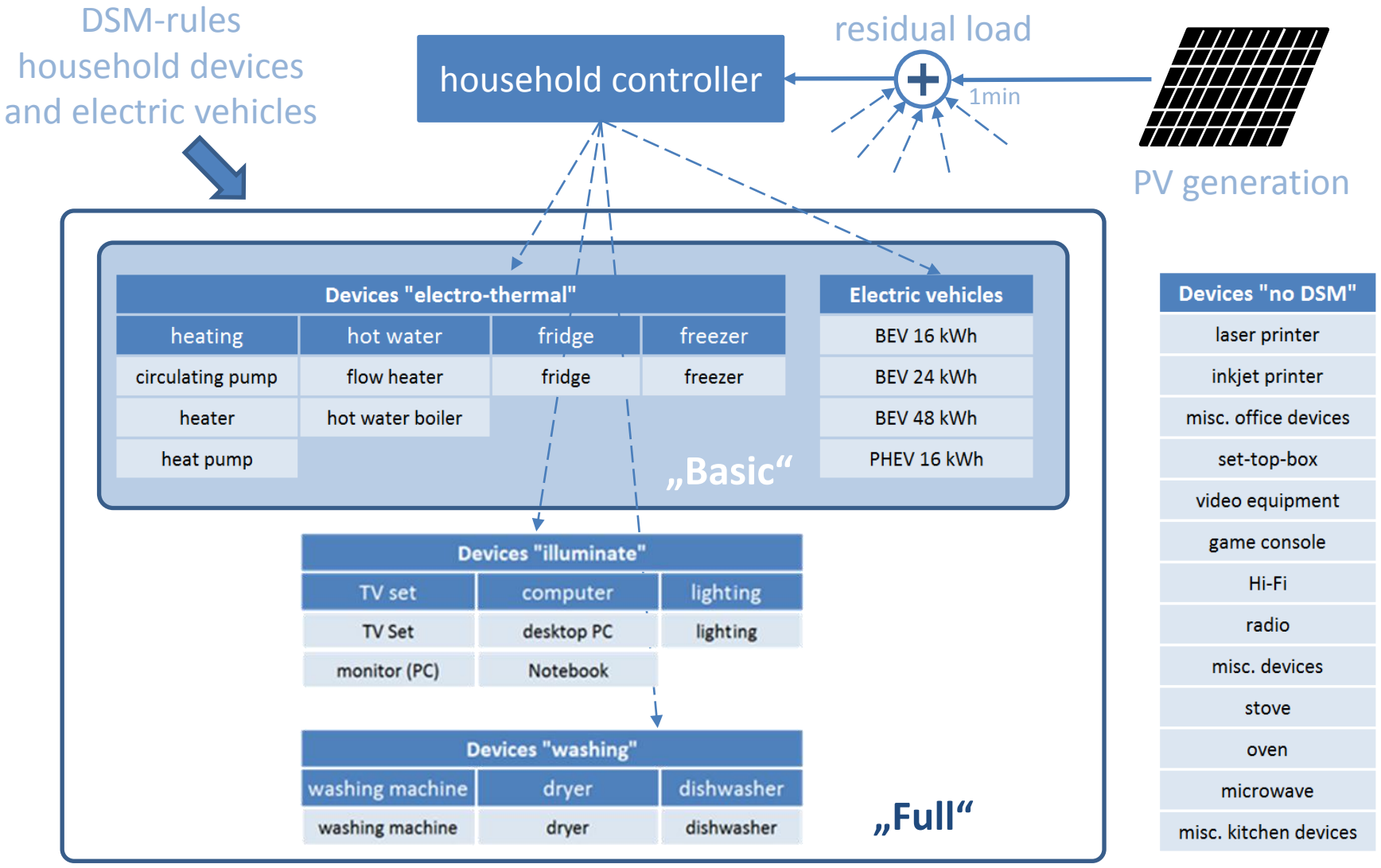
- Household level
- Controlling of hh-devices
- Controlling EV charging

Optimization

$$\min_x c^T x$$

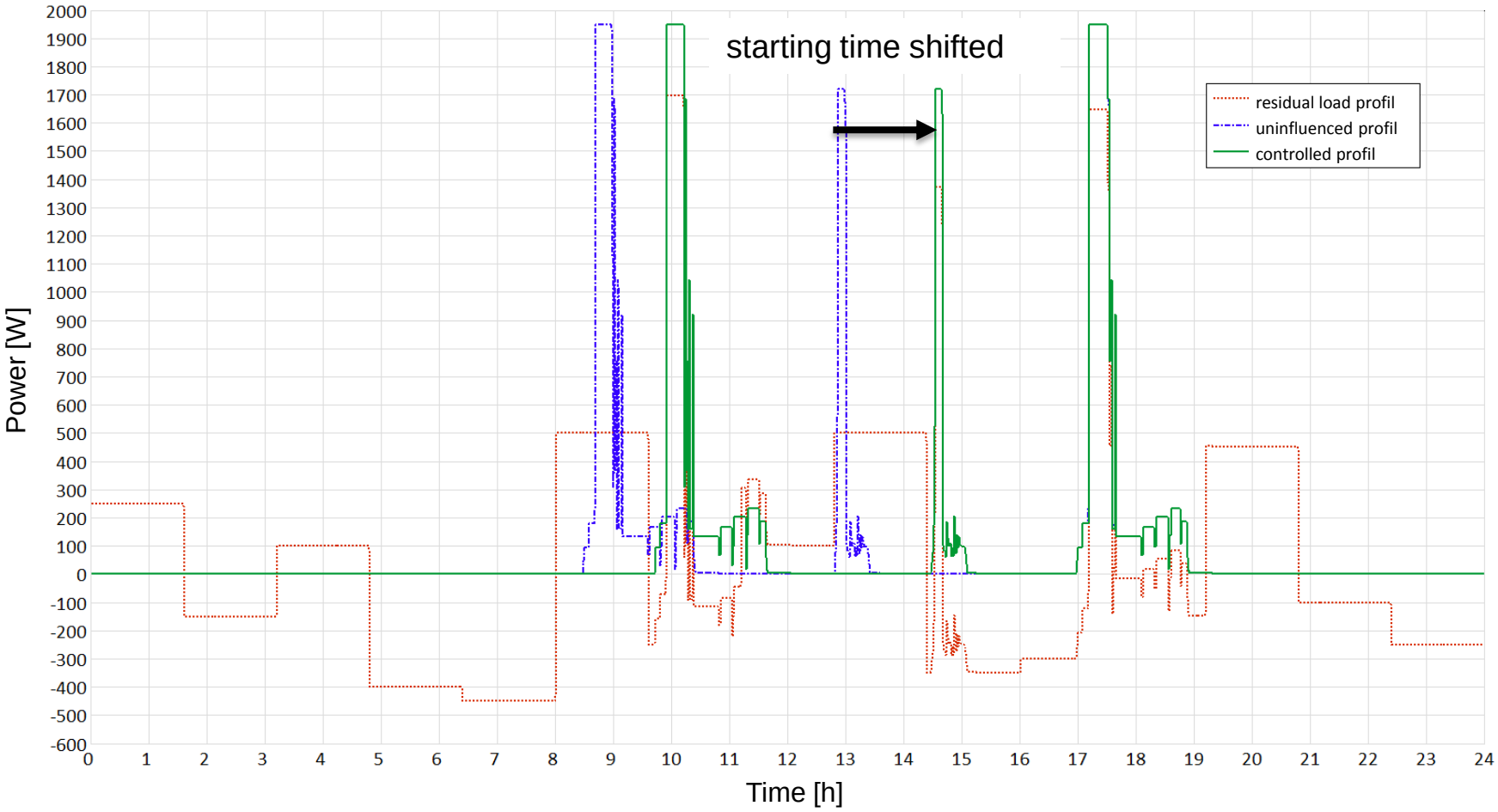
- Household level
- Perfect prediction of generation
- Perfect load prediction
- Fulfillment of all EV trips

aDSM model


DSM-rules
household devices
and electric vehicles
household controller
residual load
1min
PV generation
Devices "electro-thermal"
heating
hot water
fridge
freezer
circulating pump
flow heater
fridge
freezer
heater
hot water boiler
heat pump
„Basic“
Electric vehicles
BEV 16 kWh
BEV 24 kWh
BEV 48 kWh
PHEV 16 kWh
Devices "illuminate"
TV set
computer
lighting
TV Set
desktop PC
lighting
monitor (PC)
Notebook
Devices "washing"
washing machine
dryer
dishwasher
washing machine
dryer
dishwasher
„Full“
Devices "no DSM"
laser printer
inkjet printer
misc. office devices
set-top-box
video equipment
game console
Hi-Fi
radio
misc. devices
stove
oven
microwave
misc. kitchen devices

Example

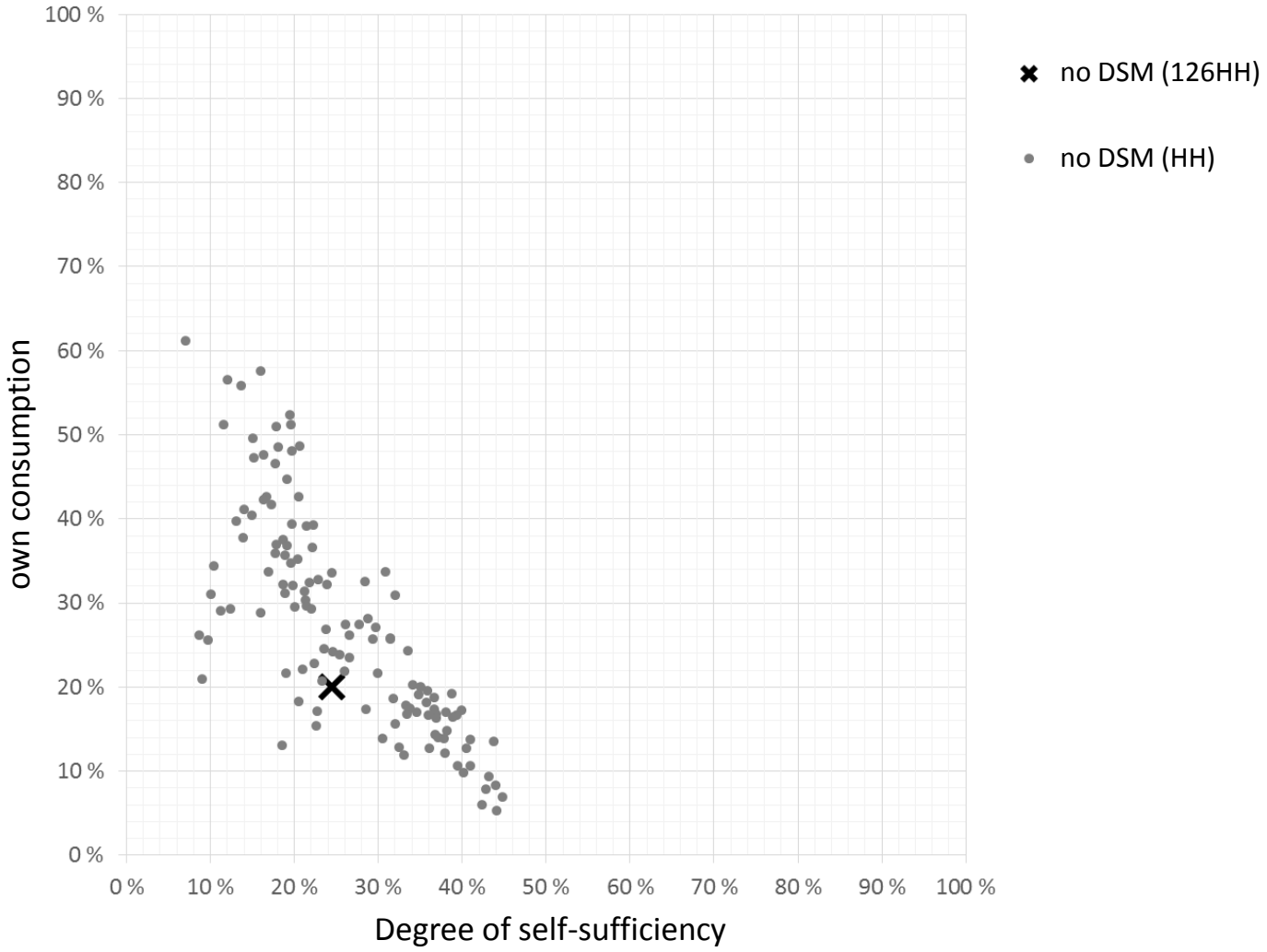
Washing machine



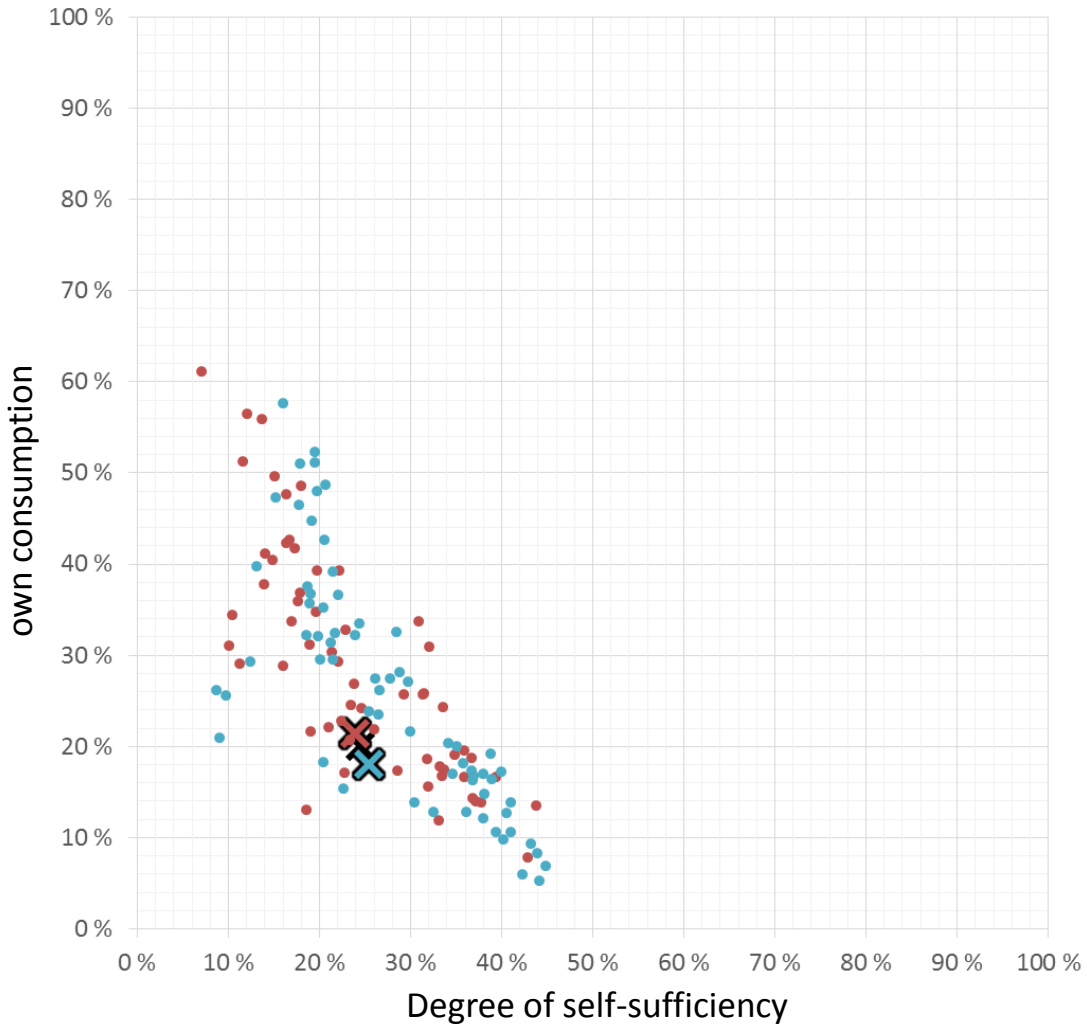
Baseline scenario

	Baseline scenario	Variations	
Electric Vehicles			
- Penetration	high (~41%)	low (~2%)	max. (~98%)
- Charging location	at home	at home + work	
- Controlled charging	yes	no	
DSM			
- Controlled loads	electro-thermal ("basic")	electro-thermal + washing + illuminate ("full")	no DSM
Devices/PV			
- Efficiency	current	increase in efficiency	
- Device equipment	current	more heat pumps	
- PV prediction	no	yes	

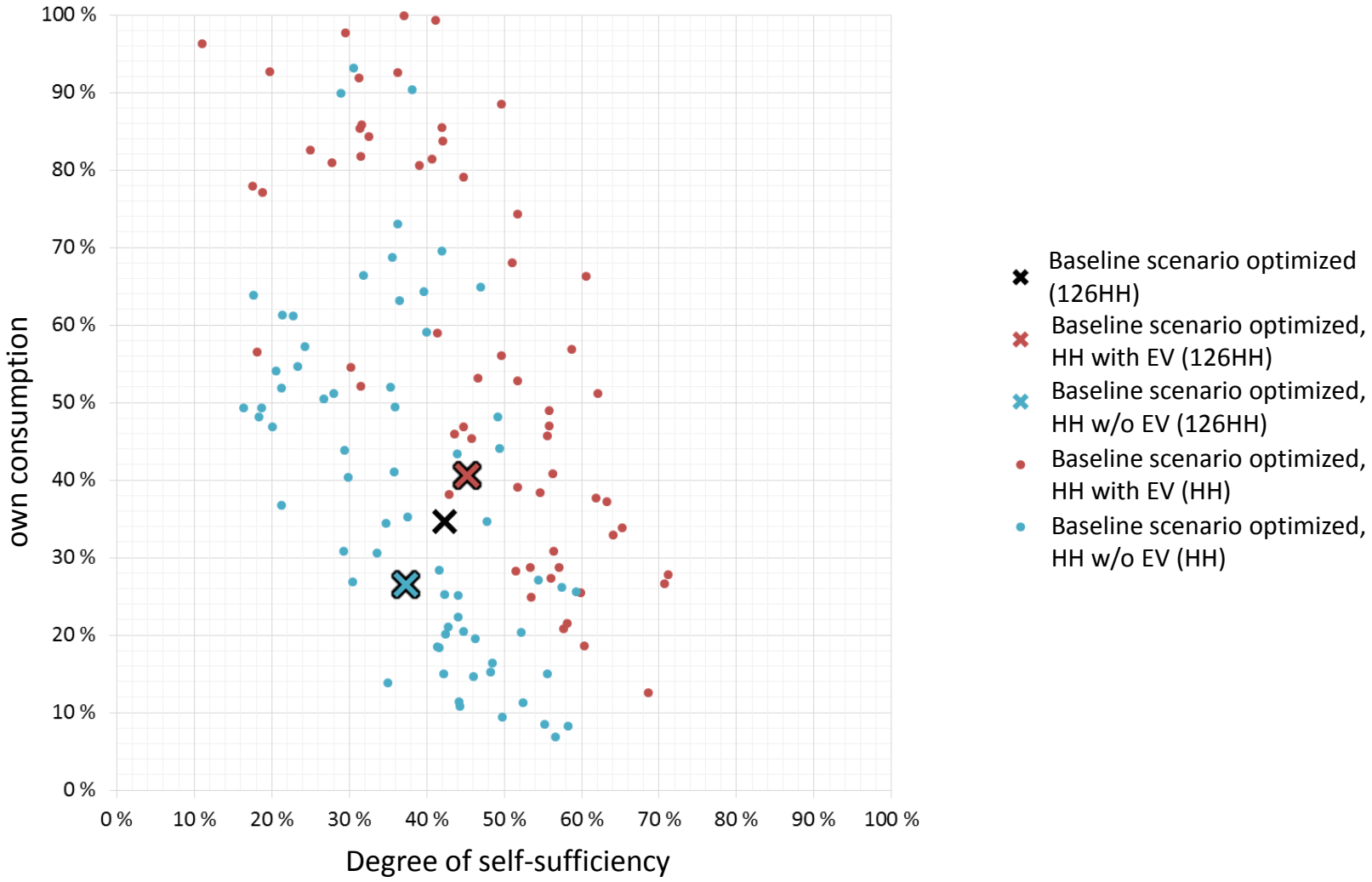
Results – no DSM (1)



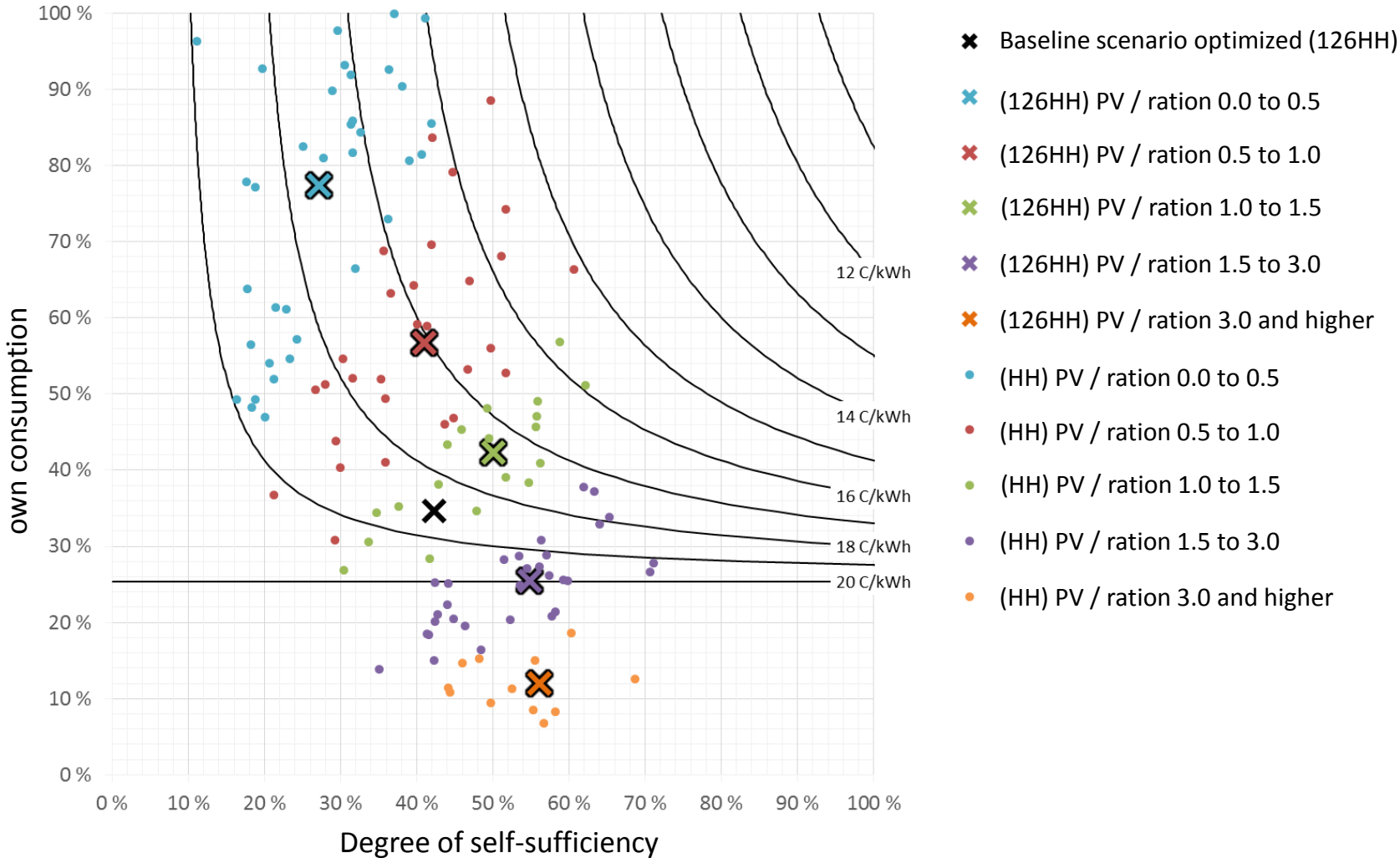
Results – no DSM (2)



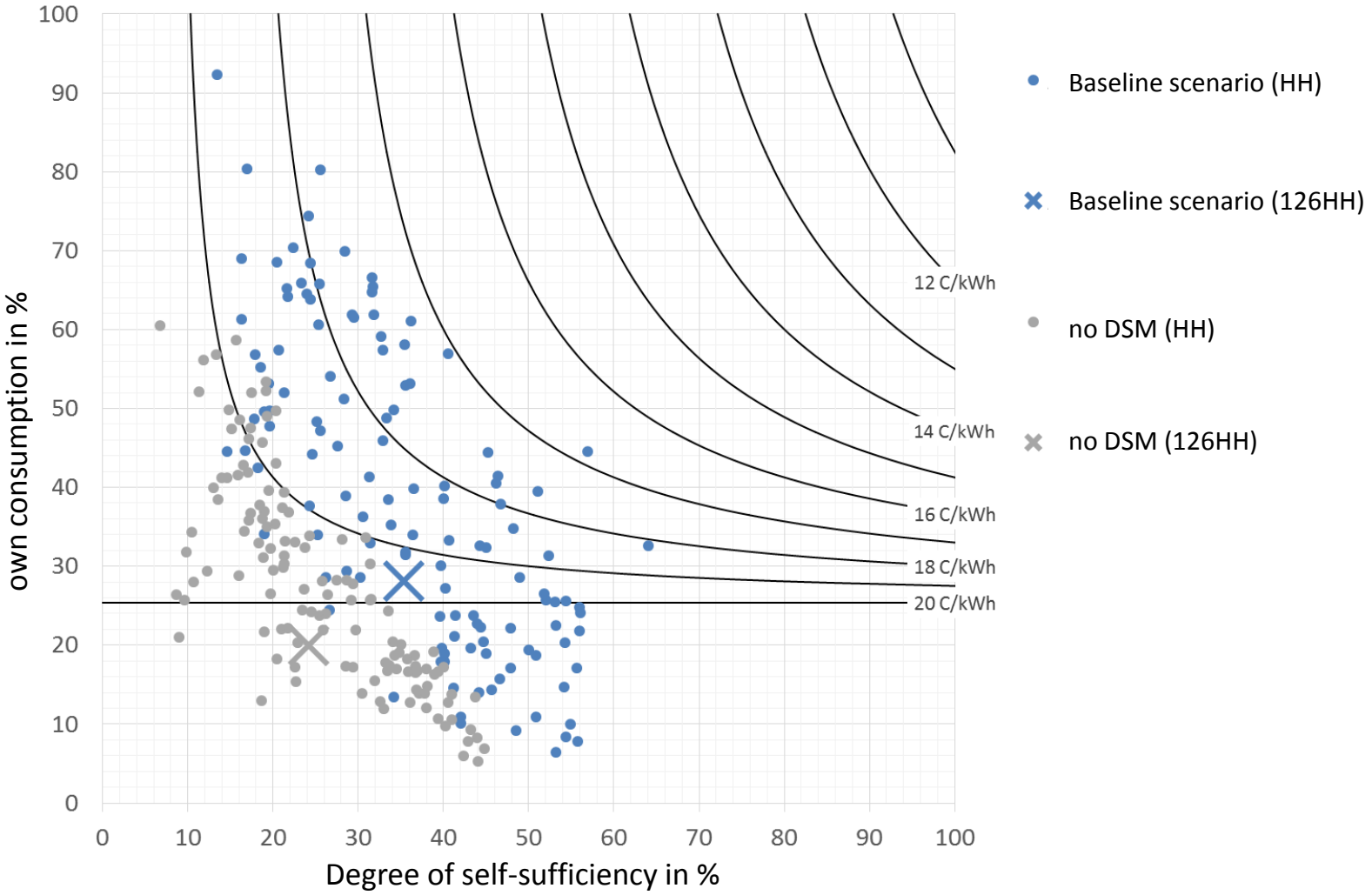
Results – baseline scenario optimized (1)



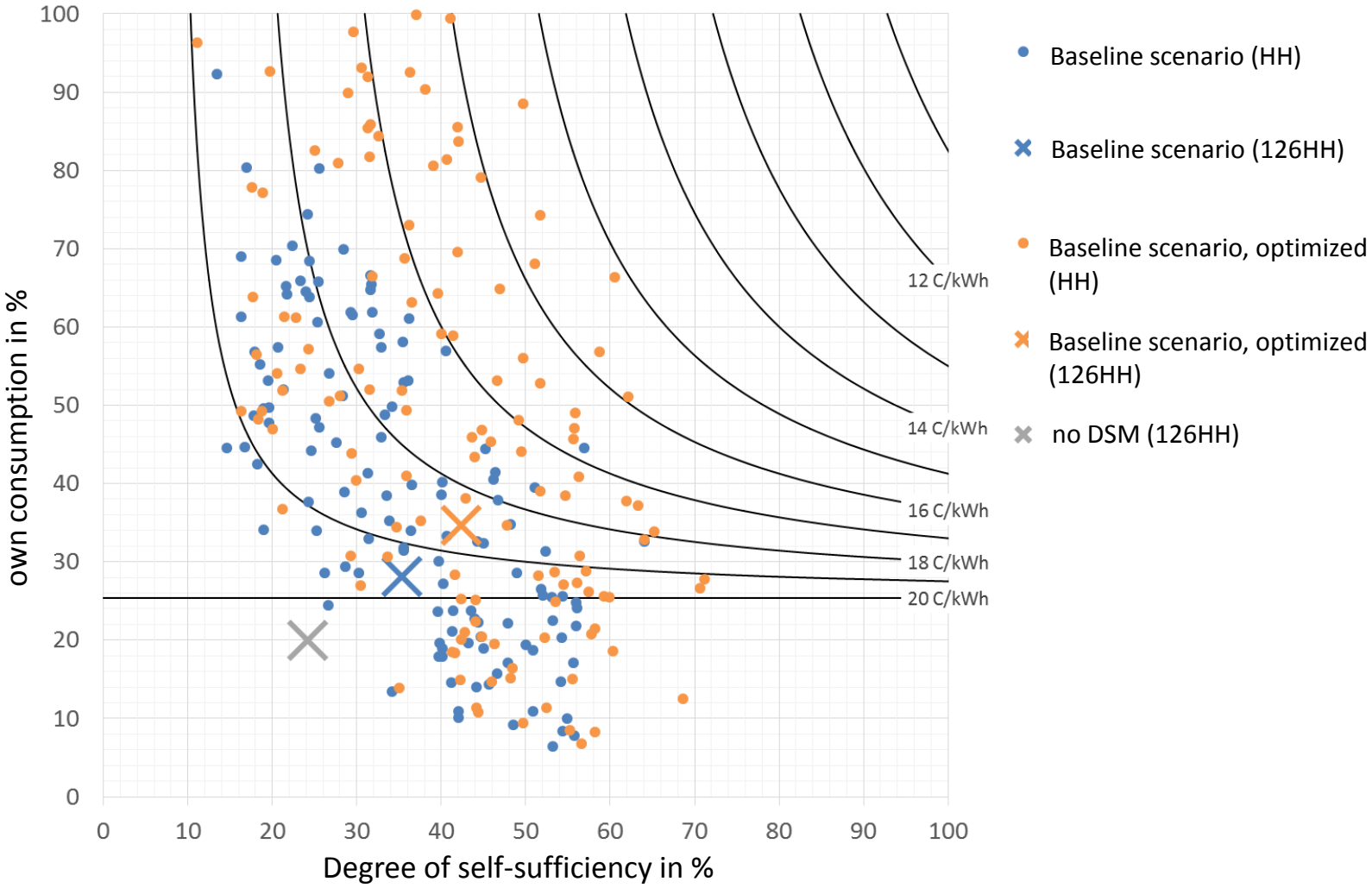
Results – baseline scenario optimized (2)



Results – local DSM model (1)



Results – local DSM model (2)



Results – Overview (1)

	own consumption	self-sufficiency	(simplyfied) effective household electricity price
	%	%	€/kWh
baseline scenario	28%	35%	0,195
no DSM	20%	24%	0,209
"Full"	28%	36%	0,195
"Full + PV prediction"	28%	36%	0,195
max. EV penetration	36%	31%	0,188
low EV penetration	24%	37%	0,204
only EV controlled	25%	31%	0,201
only "electro-thermal" controlled	26%	32%	0,199
increase in efficiency	25%	37%	0,201
modified device equipment	44%	18%	0,190
EV charging at home and work	28%	36%	0,196
baseline scenario optimized	35%	42%	0,185

Results – Overview (2)

	own consumption	self-sufficiency	(simplyfied) effective household electricity price
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Results – Overview (3)

	own consumption	self-sufficiency	(simplyfied) effective household electricity price
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modified device equipment	44%	18%	0,190
EV charging at home and work	28%	36%	0,196
baseline scenario optimized	35%	42%	0,185

Results – Overview (4)

	own consumption	self-sufficiency	(simplyfied) effective household electricity price
	%	%	€/kWh
baseline scenario	28%	35%	0,195
no DSM	20%	24%	0,209
"Full"	28%	36%	0,195
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EV charging at home and work	28%	36%	0,196
baseline scenario optimized	35%	42%	0,185

Results – Overview (5)

	own consumption	self-sufficiency	(simplyfied) effective household electricity price
	%	%	€/kWh
baseline scenario	28%	35%	0,195
no DSM	20%	24%	0,209
"Full"	28%	36%	0,195
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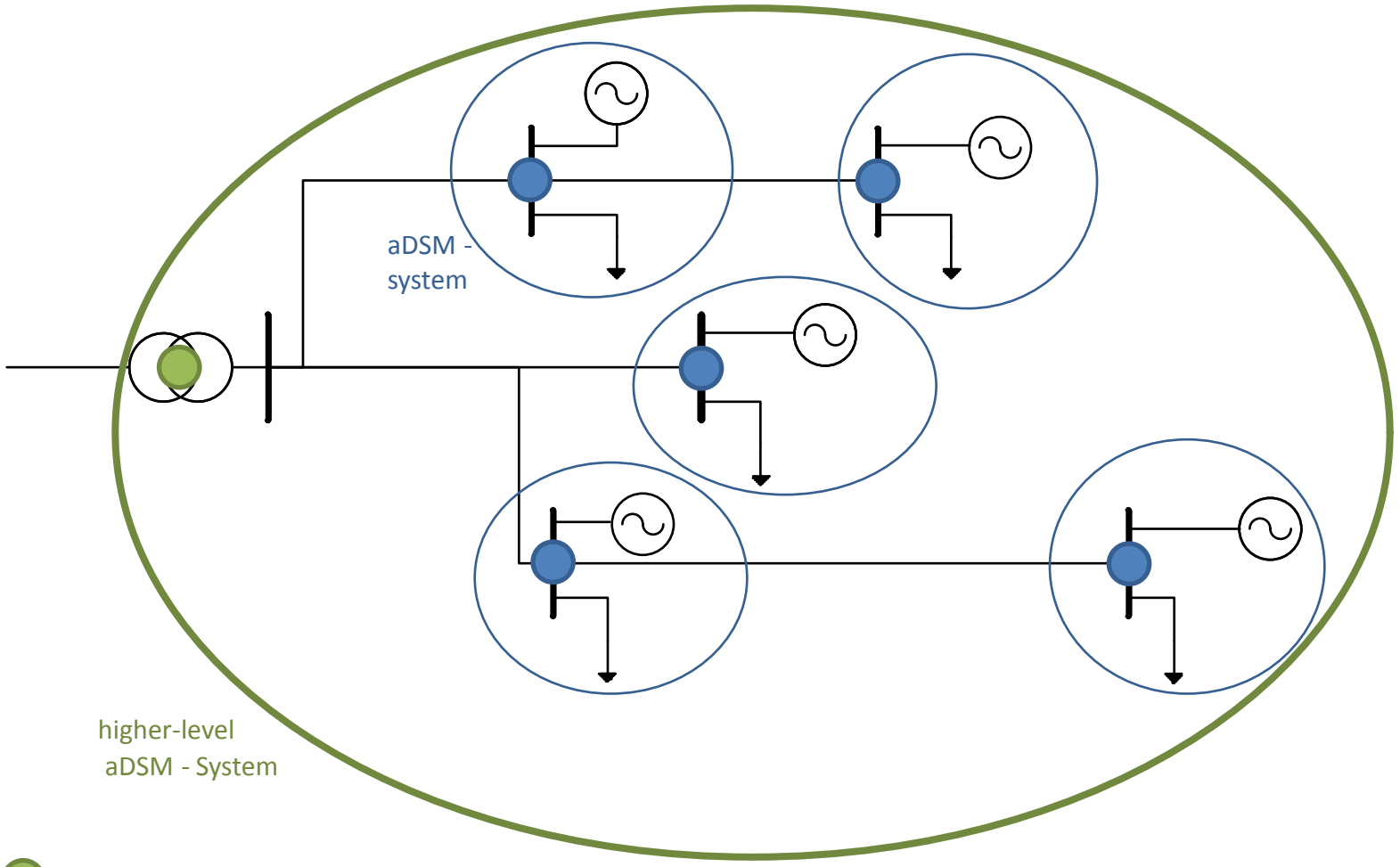
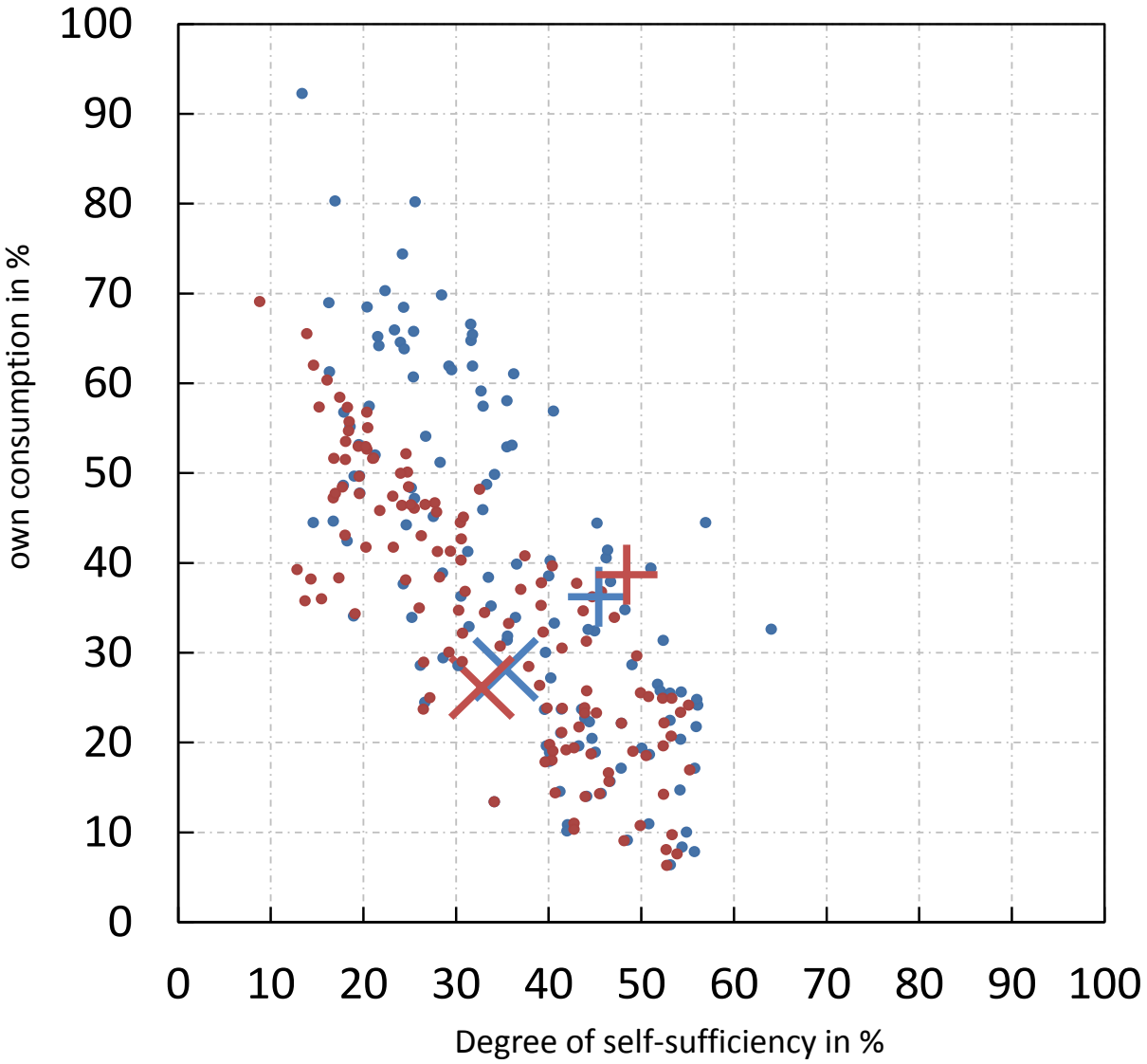
EV charging at home and work	28%	36%	0,196
baseline scenario optimized	35%	42%	0,185

aDSM system overview



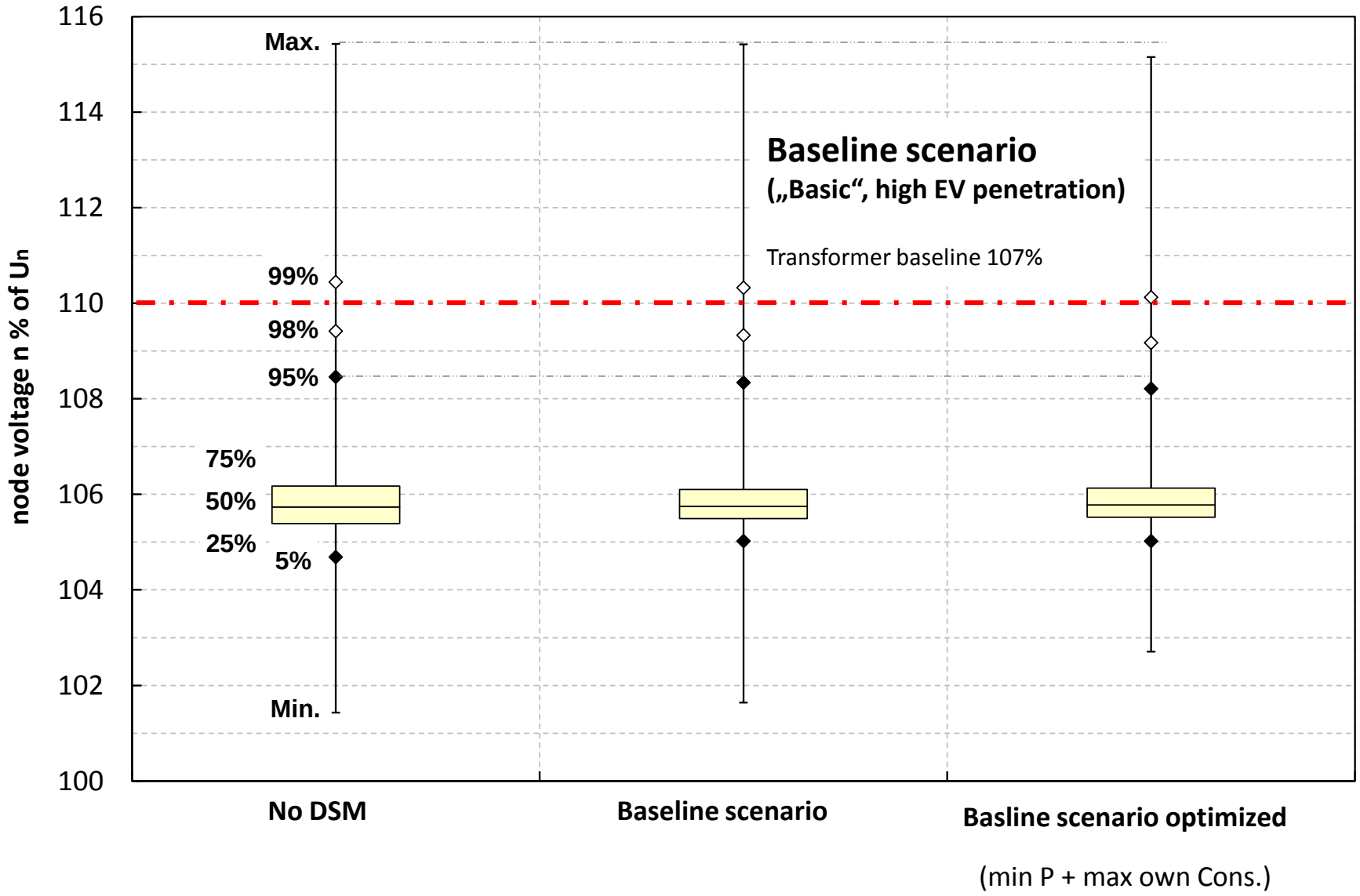
Results - Settlement



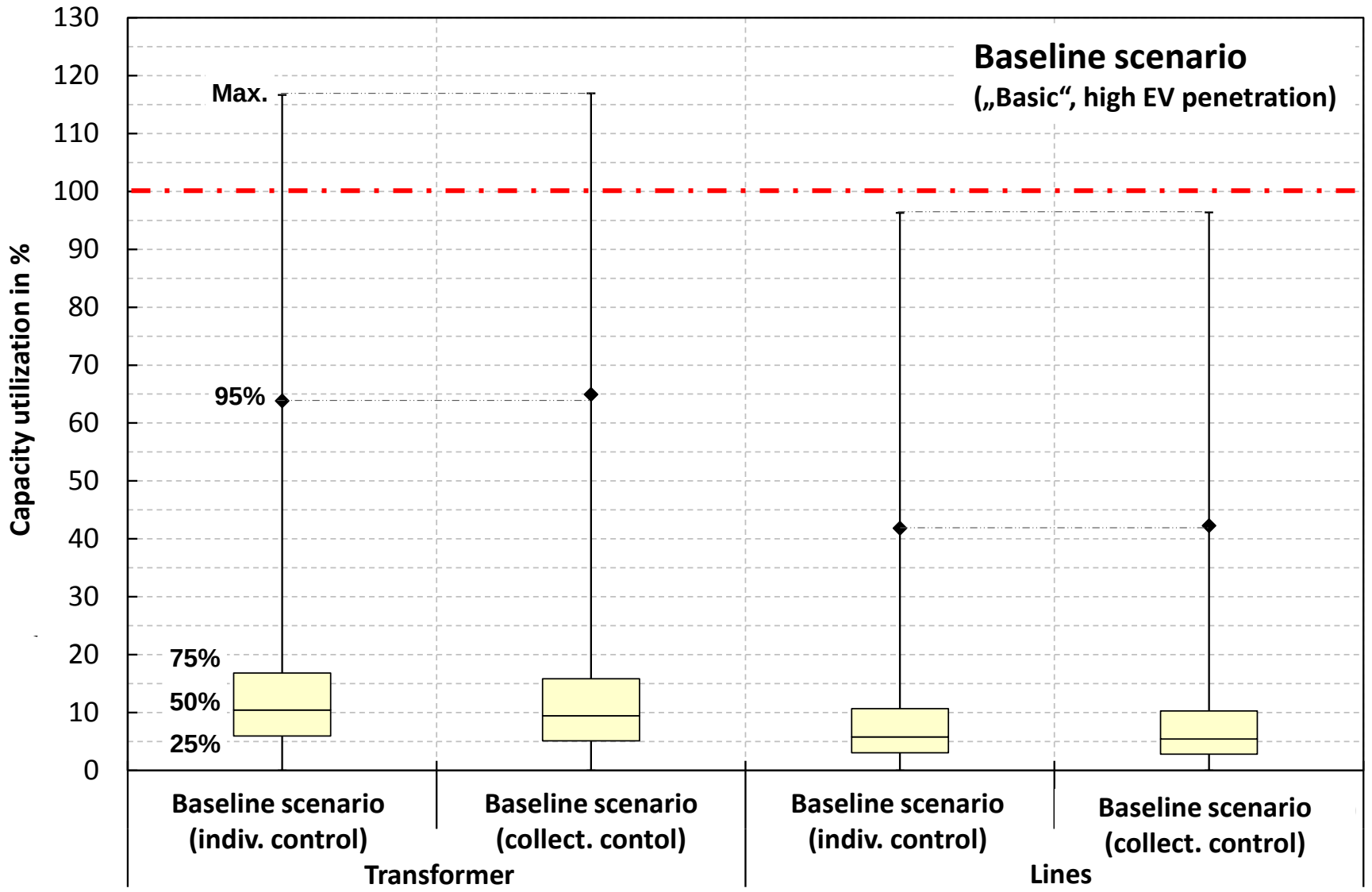
Baseline scenario
(„Basic“, high EV penetration)

- 126HH (individual control)
- 126HH (collective control)
- HH (individual control)
- HH (collective control)
- Settlement (individual control)
- Settlement (collective control)

Results – Voltages



Results – Capacity utilization



Summary

1) DSM increases the own consumption of PV systems and the degree of self-sufficiency of households significantly.

2) Cooling and heating devices as well as electric vehicles have the highest DSM potential.

3) Lighting and non electro-thermal devices in households (washing machines and dishwasher too) have low DSM potential.

4) DSM has no signifiant effect on capacity utilization of LV components.

Ongoing demonstration in Vorarlberg

- PV system and company car pool
- Controlled charging of electric vehicles

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