Buildings as a thermal storage – a case study from Gothenbourg

Sønderborg 2017-10-04

Short-term Storage in Building

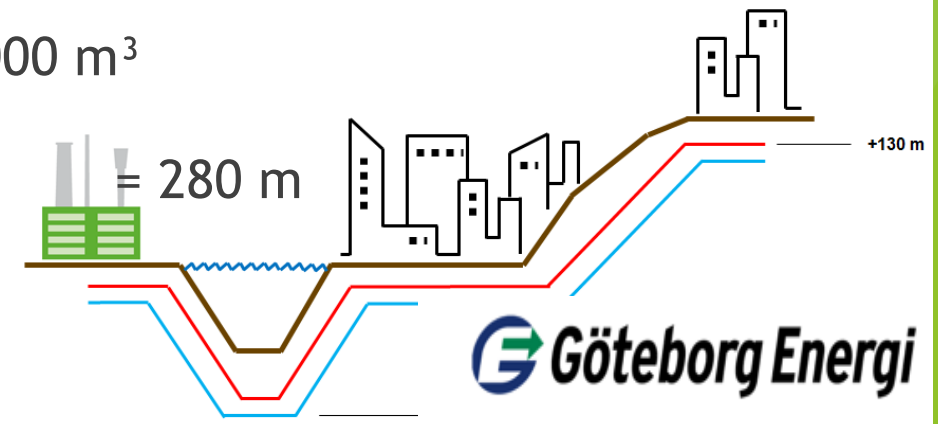
- History
- Test
- What we did
- Conclusion
- Big pilot test

Sønderborg 2017-10-04

Göteborg Energi

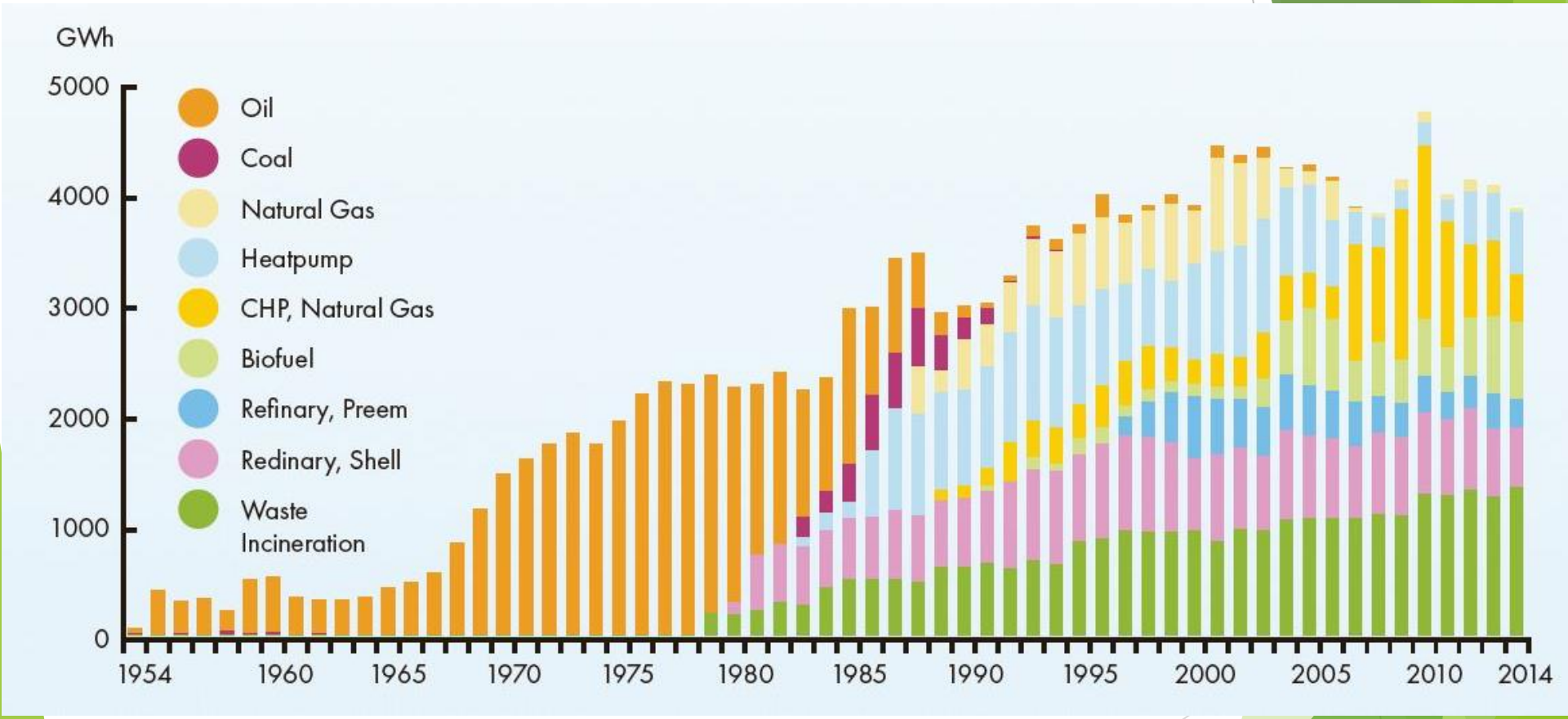
District Heating - Key Notes Göteborg Energi

DH Production	= 3500 – 5000 GWh/year
Electricity Production	= 300 – 1200 GWh/year
Production Capacity	= 1 800 MW
Connected DH Substations	= ~20 000
System Length	= 1 400 km
Volume Water	= 80 000 m^3
Height Difference	= 280 m



Sønderborg 2017-10-04

History - Fuel mix of produced heat



Sønderborg 2017-10-04

Göteborg Energi

Build a large storage?

Sønderborg 2017-10-04

Göteborg Energi

Use the building instead of store the water in a big tank

Sønderborg 2017-10-04

Göteborg Energi

History

- 2005 Practice test, ”shut of heating” for a few hours
- 2007 Testing ”time constants” för different kind of houses
- 2008 Test of a black box ” measuring the flow on hot water”
- 2009 Test program for the test of “Short-term storage in buildings”
- 2010 Testing and measurement for 1 year in 10 houses

Göteborg Energi

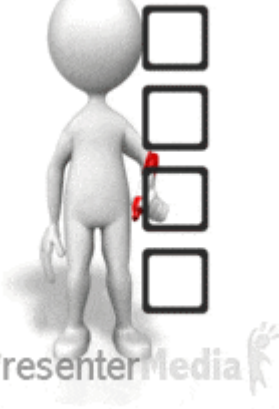
Assignment ”Buildings as thermal energy storage”

- How will the indoor climate be affected if we use a building as thermal energy storage?
- Continuous simulation of the outside temperature and measurements in building for 1 year
- 10 buildings
- Hisingen to central Gothenburg
- Lightweight to heavy buildings

Sønderborg 2017-10-04

Göteborg Energi

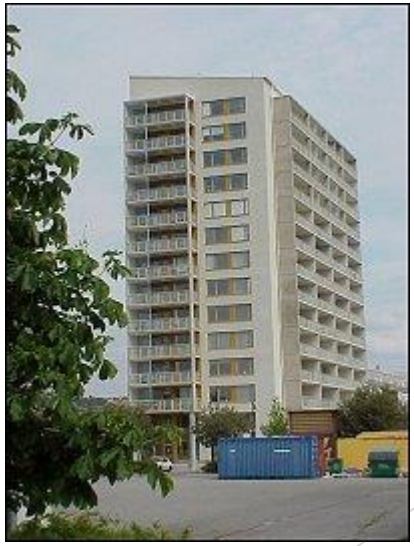
Testbuildings



Wood and stone buildings~100 h

Brick buildings ~350 h

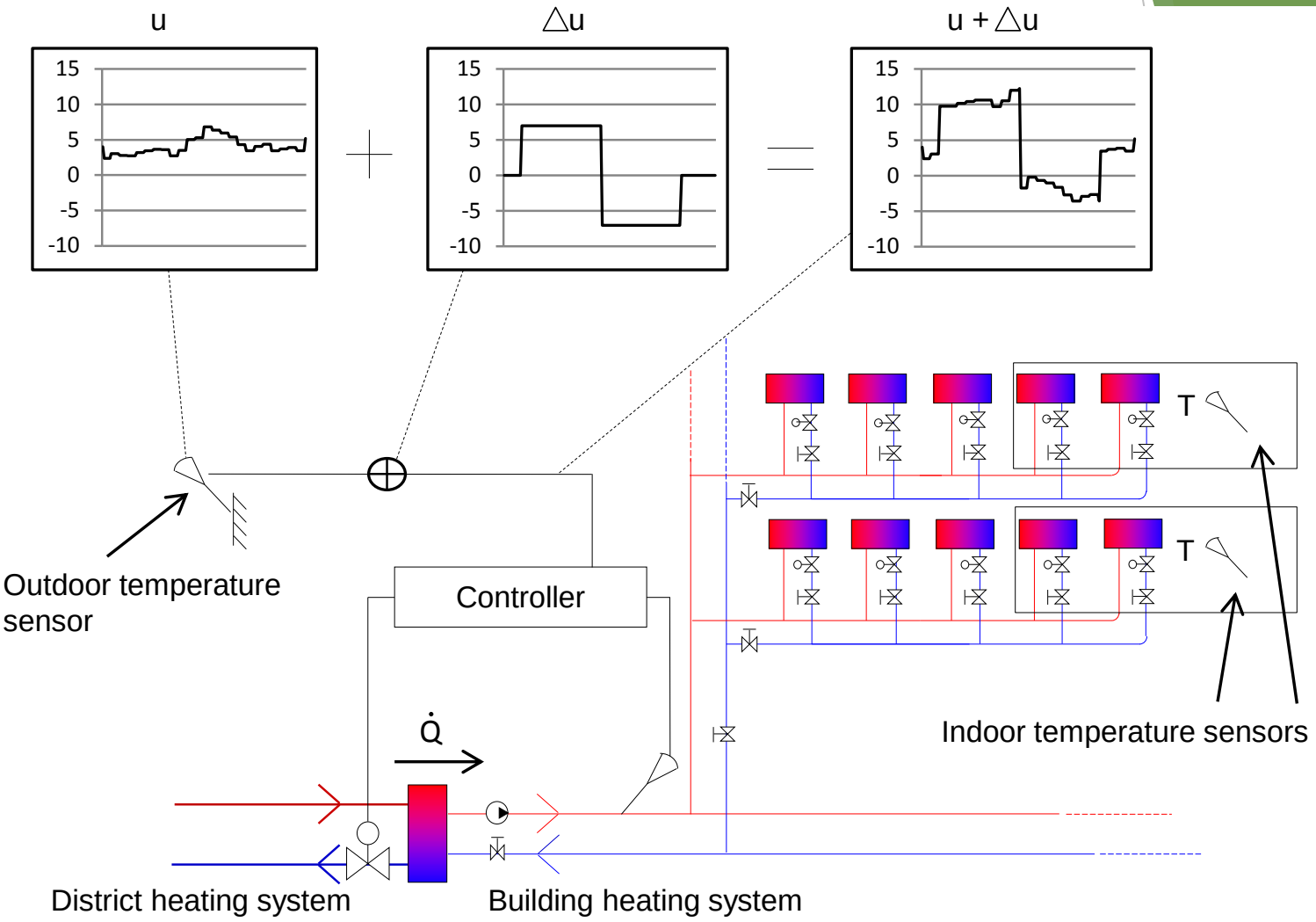
Stone house from year 1900 ~150 h



Energy-efficient buildings ~200 h

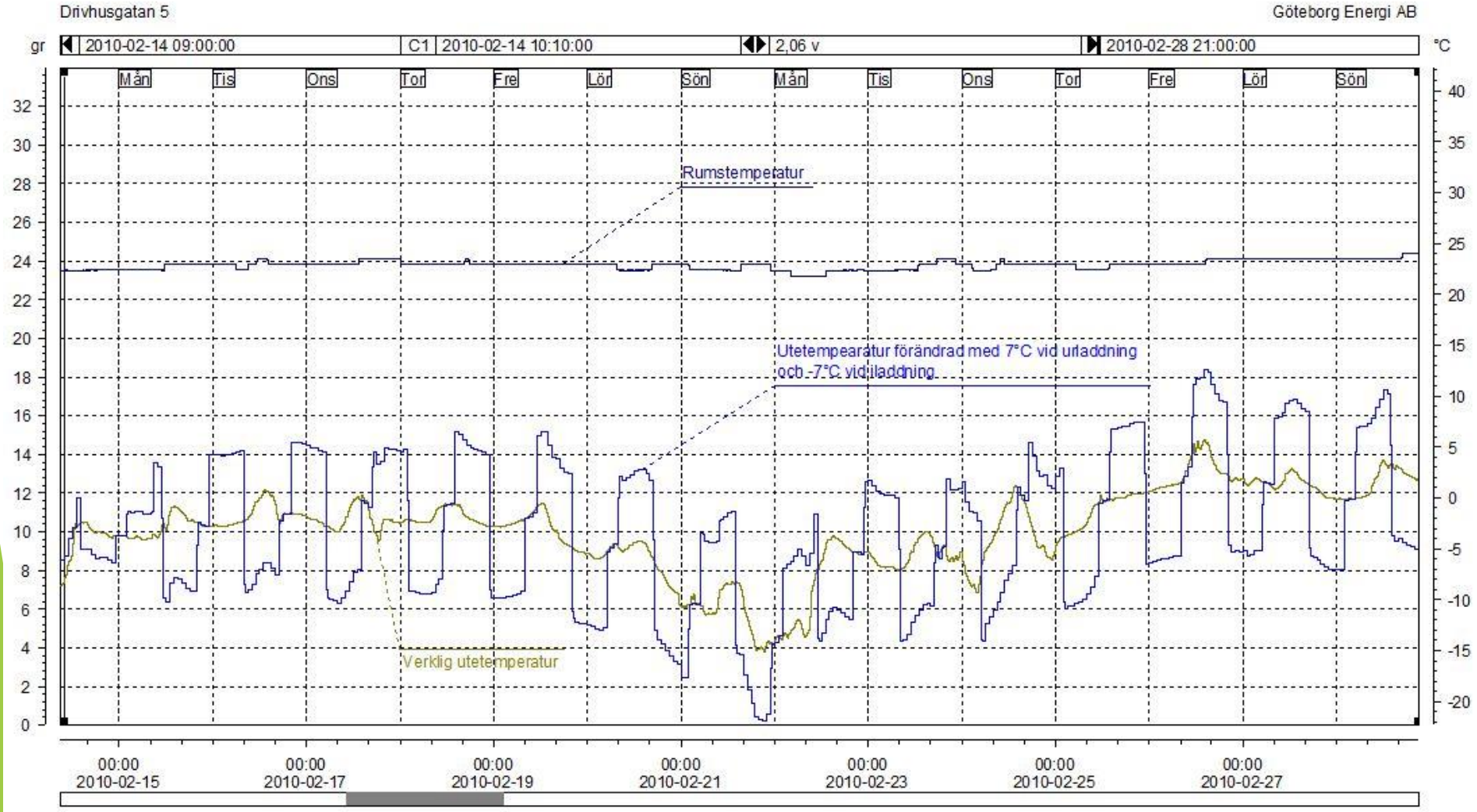
Göteborg Energi

Pilot test – Setup



Göteborg Energi

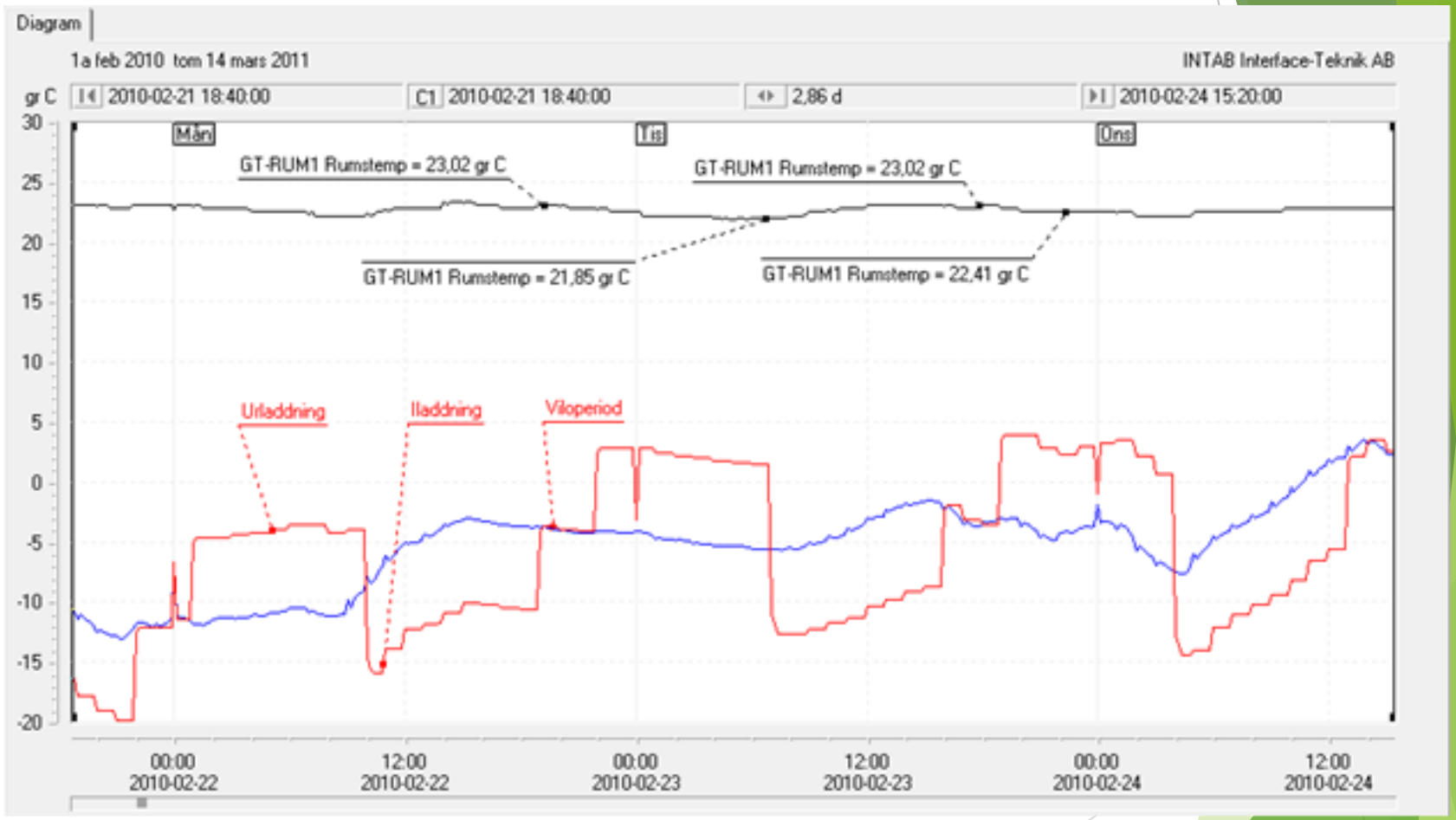
How do we simulate loading and discharge?



Sønderborg 2017-10-04

Göteborg Energi

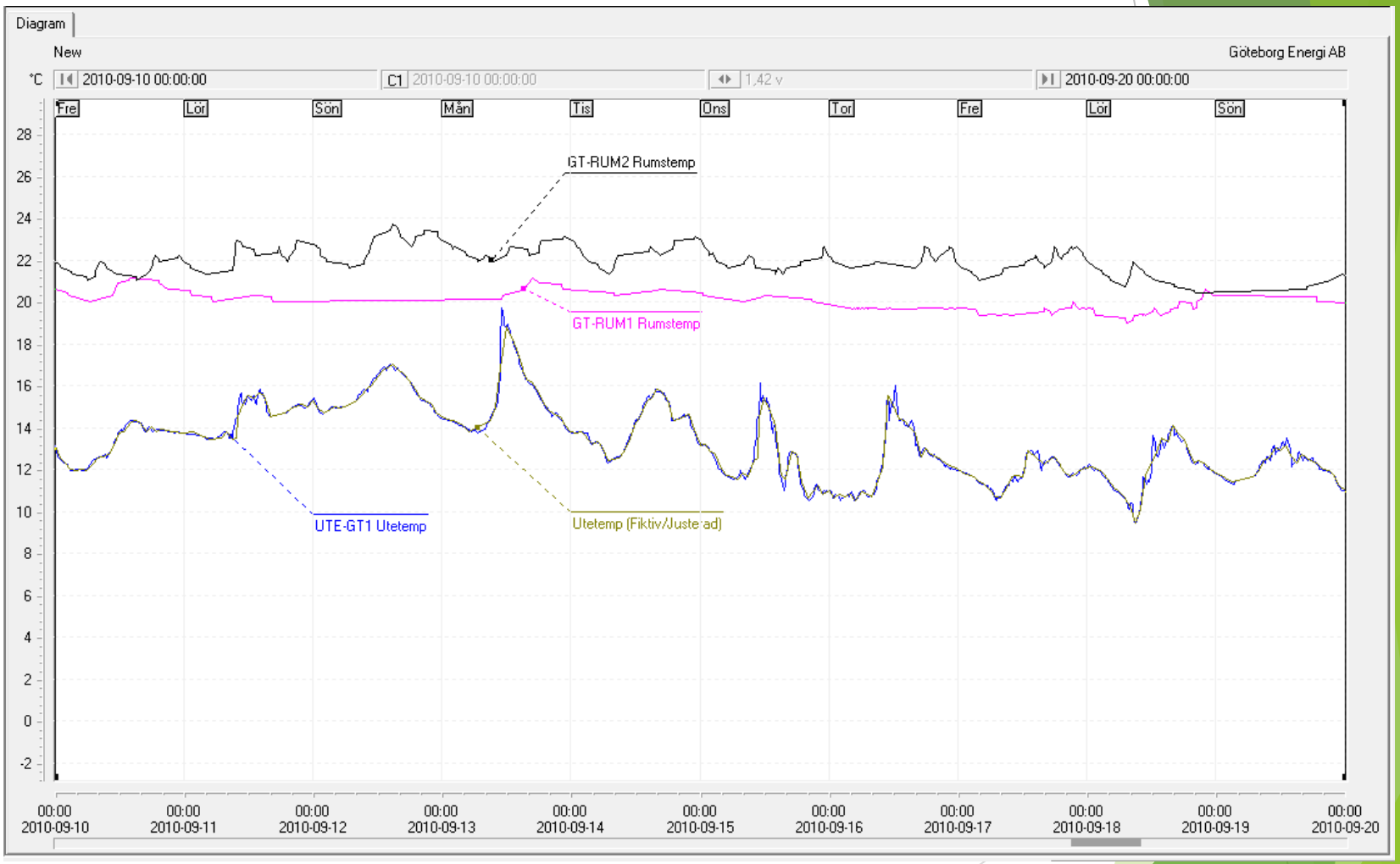
How much does the room temperature change when loading and discharging?



Sønderborg 2017-10-04

Göteborg Energi

Variety of room temperature when energy storage has not been activated



Sønderborg 2017-10-04

Göteborg Energi

Preconditions to use ”Buildings as thermal energy storage”

No air heating systems.

Separate heatexchangers / shunts for radiator and heating system for ventilation.

No big areas of windows

Sønderborg 2017-10-04

Göteborg Energi

Summary
Short-term storage in buildings”

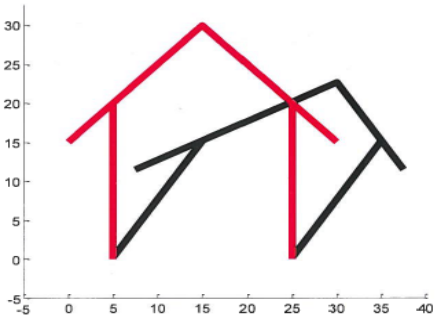
When the temperature changes of outdoor temperature (7°C or lower, for 9 hours), no major changes in the room temperature could be detected.

Sønderborg 2017-10-04

Göteborg Energi

Confirmation of the temperature deviations

CHALMERS



Evaluation of buildings' suitability as thermal energy storage in a district heating system

Master of Science Thesis in the Master's Programme Sustainable Energy Systems

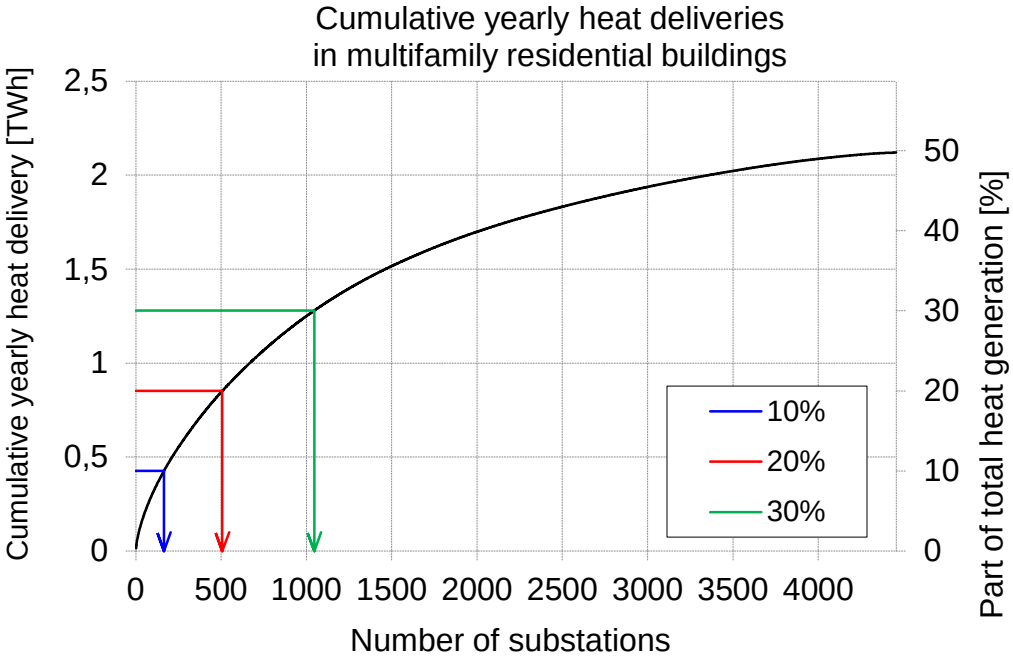
JOI ELEBO
DAVID PETERSSON

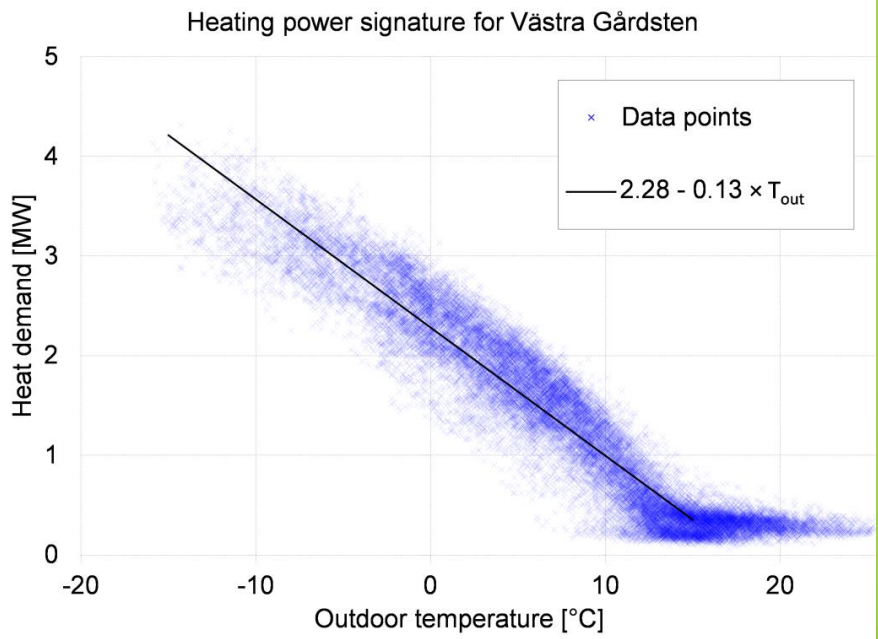
Department of Energy and Environment
Division of Building Services Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2013
Master's Thesis E2013:02

Sønderborg 2017-10-04

Göteborg Energi

Large-Scale Implementation

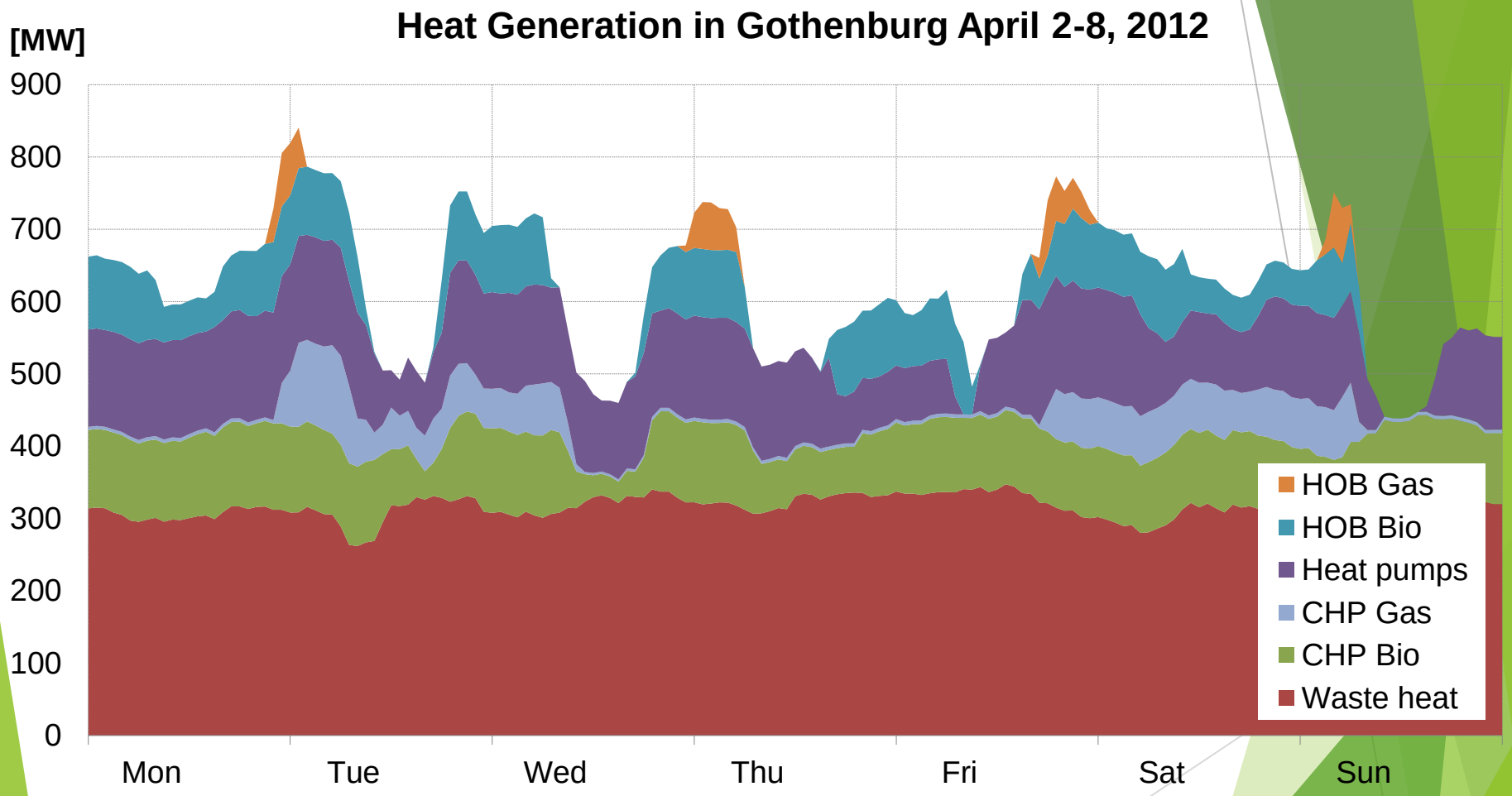




Case	Yearly heat delivery to utilized substations [GWh]	Number of utilized substations	Power limitation [MW]	Storage capacity limitation [MWh]
0% (ref)	0	0	0	0
10%	426	165	32	285
20%	852	507	63	571
30%	1,279	1,046	95	856

Göteborg Energi

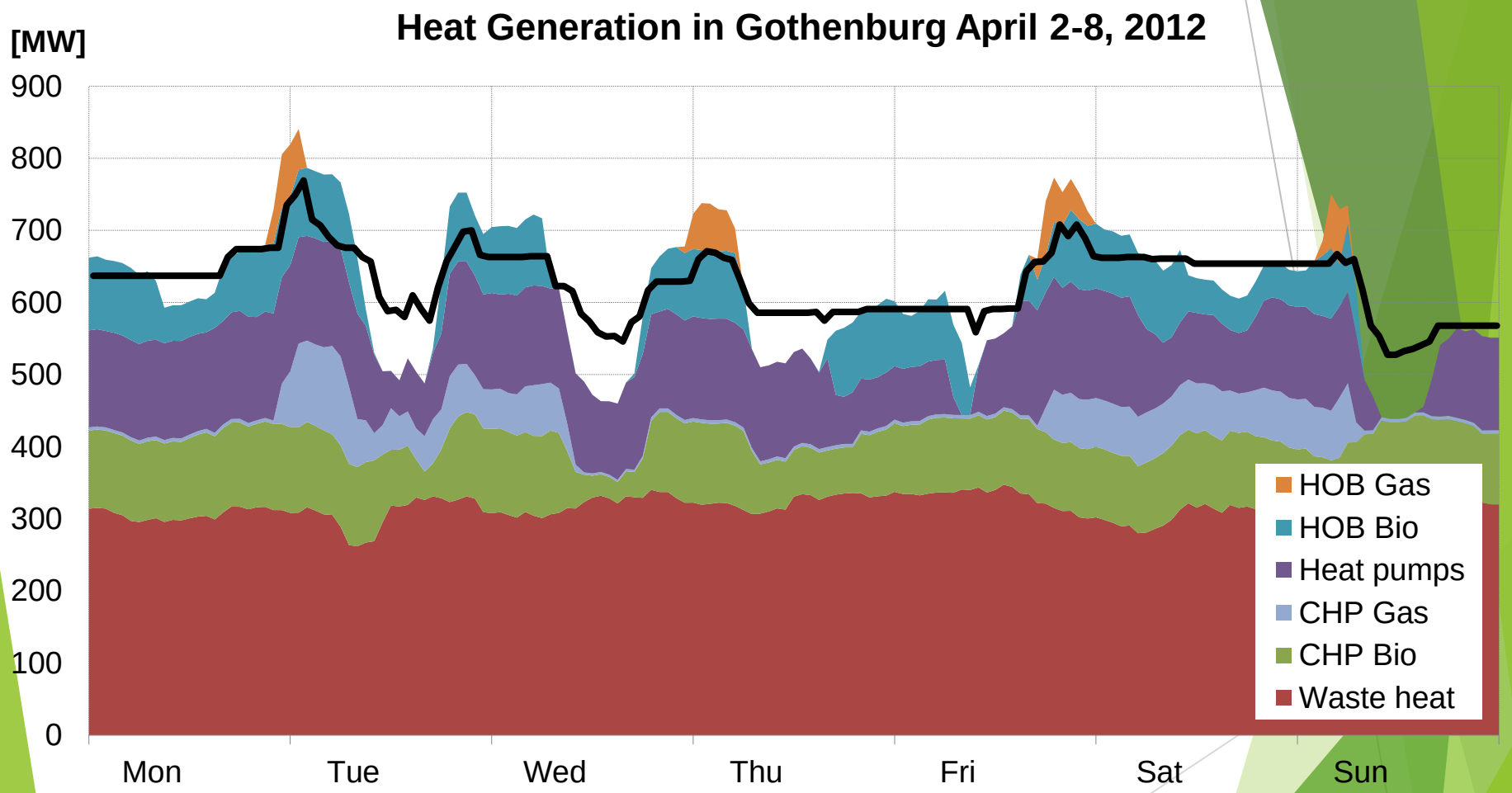
Large-Scale Implementation - Simulation



Sønderborg 2017-10-04

Göteborg Energi

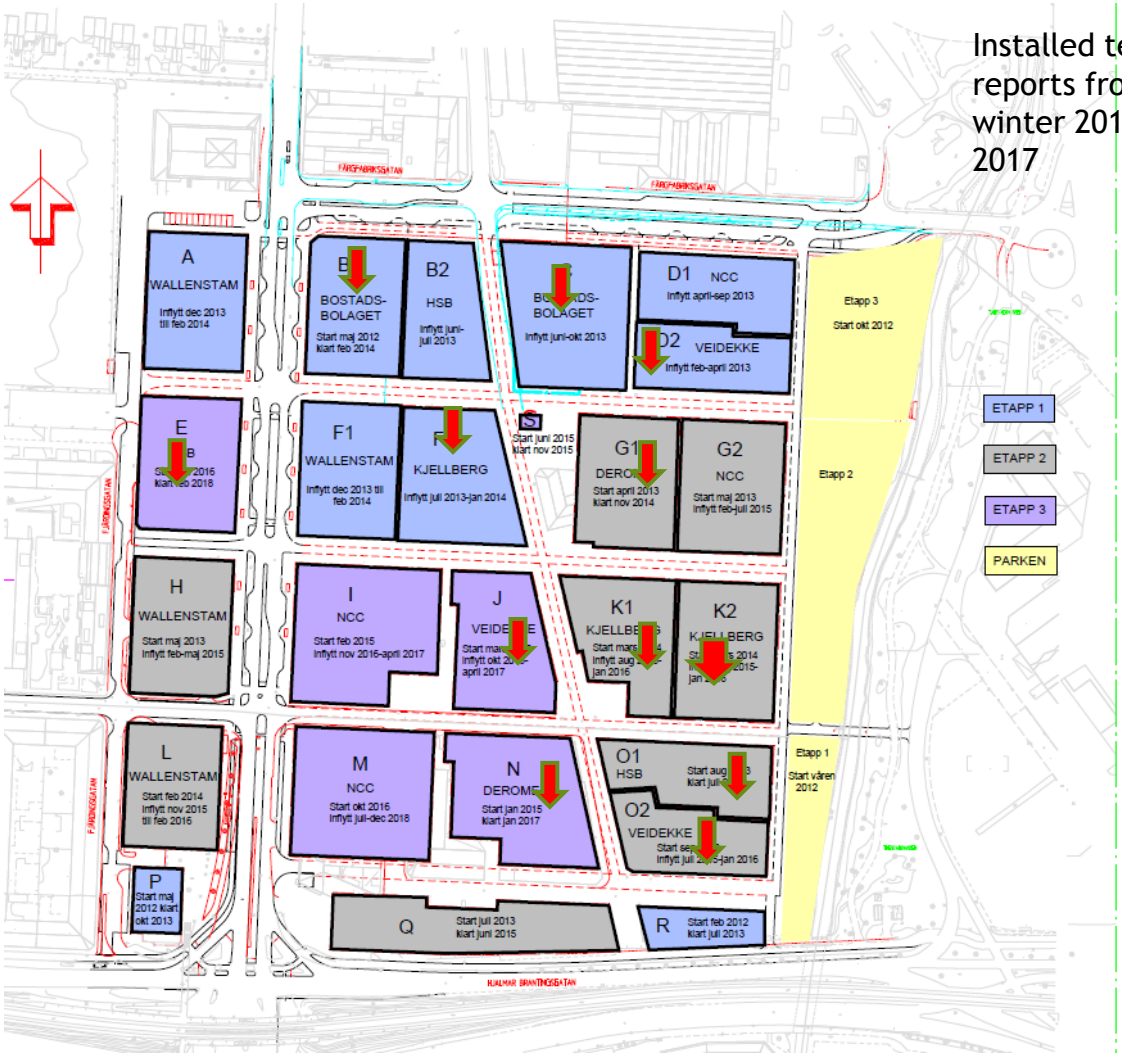
Large-Scale Implementation - Simulation



Sønderborg 2017-10-04

Göteborg Energi

Building as storage in Kvillebäcken



Installed test and reports from buildings winter 2016 and spring 2017

Sønderborg 2017-10-04

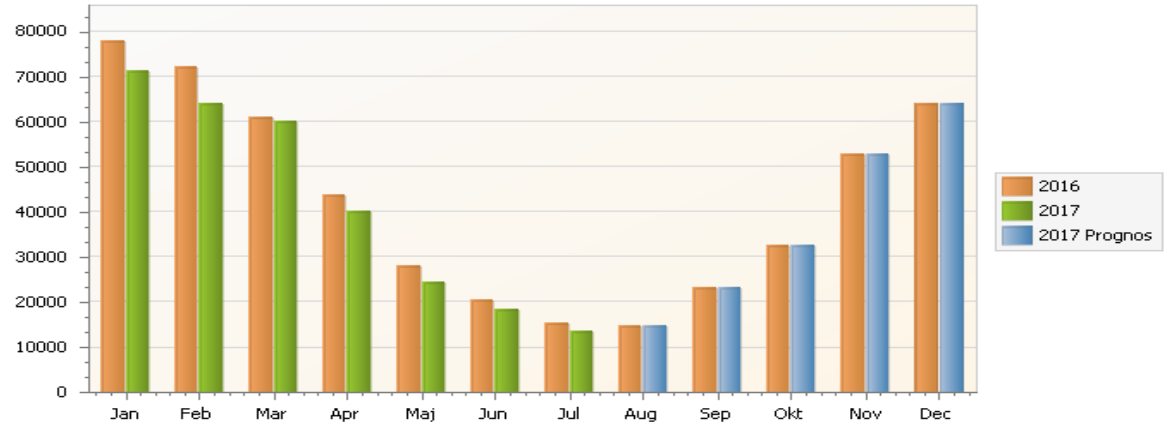
Göteborg Energi

Göteborg Energi

Normalårskorrigerad värmeanvändning 2017
30021149 Rundbäcksgatan 15

Anläggningsnr	30021149	Area	31,3
Kund	fv_alla	Momsregistr. Area	-
Adress	Rundbäcksgatan 15	Normalår (GD)	3379
Nodtyp	Mätare	Klimatdata	Degreedays
Klimatort	Göteborg A - Graddagar	Andel Varmvatten	28,0 %

Rubrik	Enhet	2014	2015	2016	2017	16/17
Värmeanvändning	MWh	477,2	506,87	482,62	245,63	-49,1 %
Graddagar	GD	2829	3019	3151	3209	1,8 %
Korrigerad värmeanvändning	MWh	541,4	553,76	505,57	259,47	-48,7 %
Korrigerad värmeanvändning per m²	kWh/m²	17325	17720	16178	8303	-48,7 %



Månad	Graddagar				Användning Värme					Budgeterad användning	
					Verklig		Normalårskorrigerad				
	Norm	2016	2017		2016 MWh	2017 MWh	2016 MWh	2017 MWh	Diff	2017 MWh	Diff
Jan	528	590	500		85,6	68,02	78,01	71,14	-8,8 %	-	-
Feb	484	462	449		69,55	60,35	72,23	64,13	-11,2 %	-	-
Mar	464	422	412		56,51	54,5	60,98	59,93	-1,7 %	-	-
Apr	322	311	328		42,64	40,43	43,76	39,88	-8,9 %	-	-
Maj	176	125	152		22,99	22,33	27,99	24,38	-12,9 %	-	-
Jun	83	36	50		15,4	15,15	20,37	18,28	-10,3 %	-	-
Jul	27	22	23		14,61	13,03	15,17	13,42	-11,5 %	-	-
Aug	38	39	38		14,59	14,49	14,49	14,49	0,0 %	-	-
Sep	126	43	126		15	23,16	23,16	23,16	0,0 %	-	-
Okt	260	285	260		34,71	32,51	32,51	32,51	0,0 %	-	-
Nov	382	411	382		55,9	52,79	52,79	52,79	0,0 %	-	-
Dec	489	405	489		55,12	64,12	64,12	64,12	0,0 %	-	-
Jan-Jul	2084	1968	1914		307,3	273,81	318,5	291,17	-8,6 %	-	0,0 %
Tot:	3379	3151	3209	Tot:	482,62	460,88	505,57	478,24	-5,4 %	-	0,0 %

2017-08-28 11:19

Sønderborg 2017-10-04

Göteborg Energi

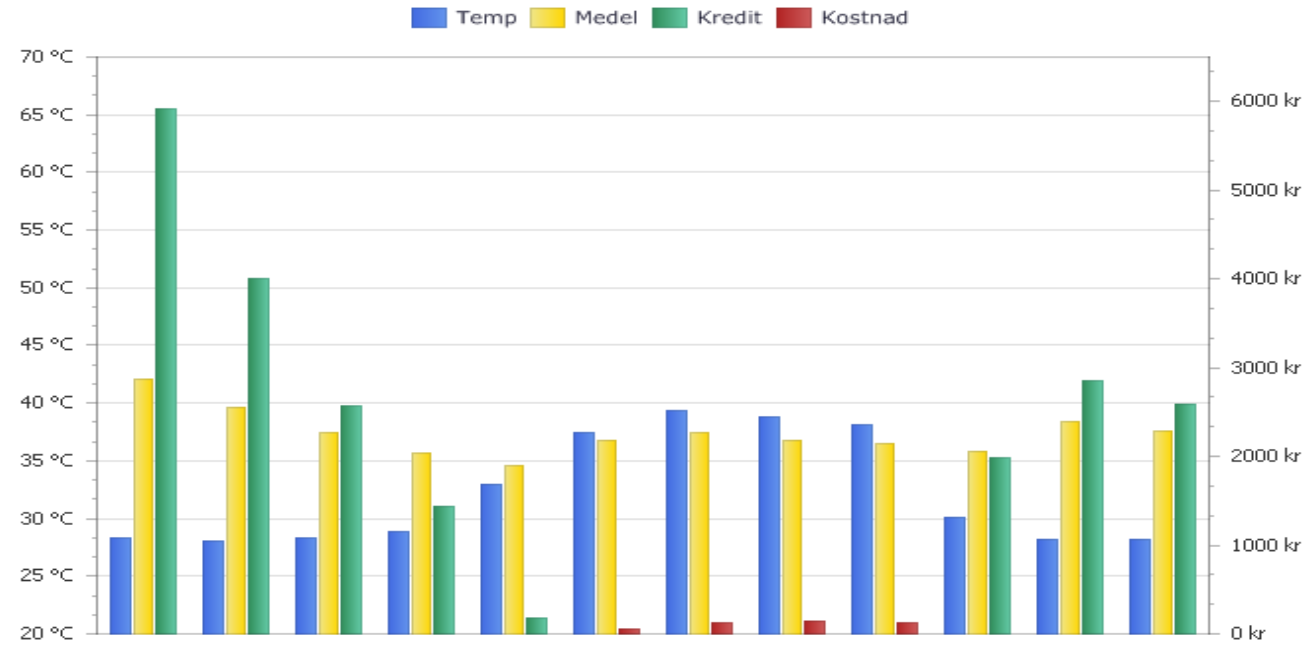
Göteborg Energi

Returtemperatur - 2016

Kund	fv_alla	**Area**	31 m²
Nodtyp	Mätare	**Momsreg. area**	
Adress	Rundbäcksgatan 15		
Anläggningsnr	30021149		
Period	2016		

Antal mätare per stapel: 1

Returtemperatur + kostnad



	Jan	Feb	Mars	April	Maj	Juni	Juli	Aug	Sept	Okt	Nov	Dec
Temp	28,3	28,1	28,3	28,9	33	37,5	39,3	38,8	38,1	30,1	28,2	28,2
Medel	42,1	39,6	37,4	35,6	34,6	36,7	37,5	36,8	36,5	35,8	38,4	37,6
Deb/Kred	-5906	-3996	-2571	-1430	-184	62	131	146	120	-1978	-2851	-2590

Sønderborg 2017-10-04

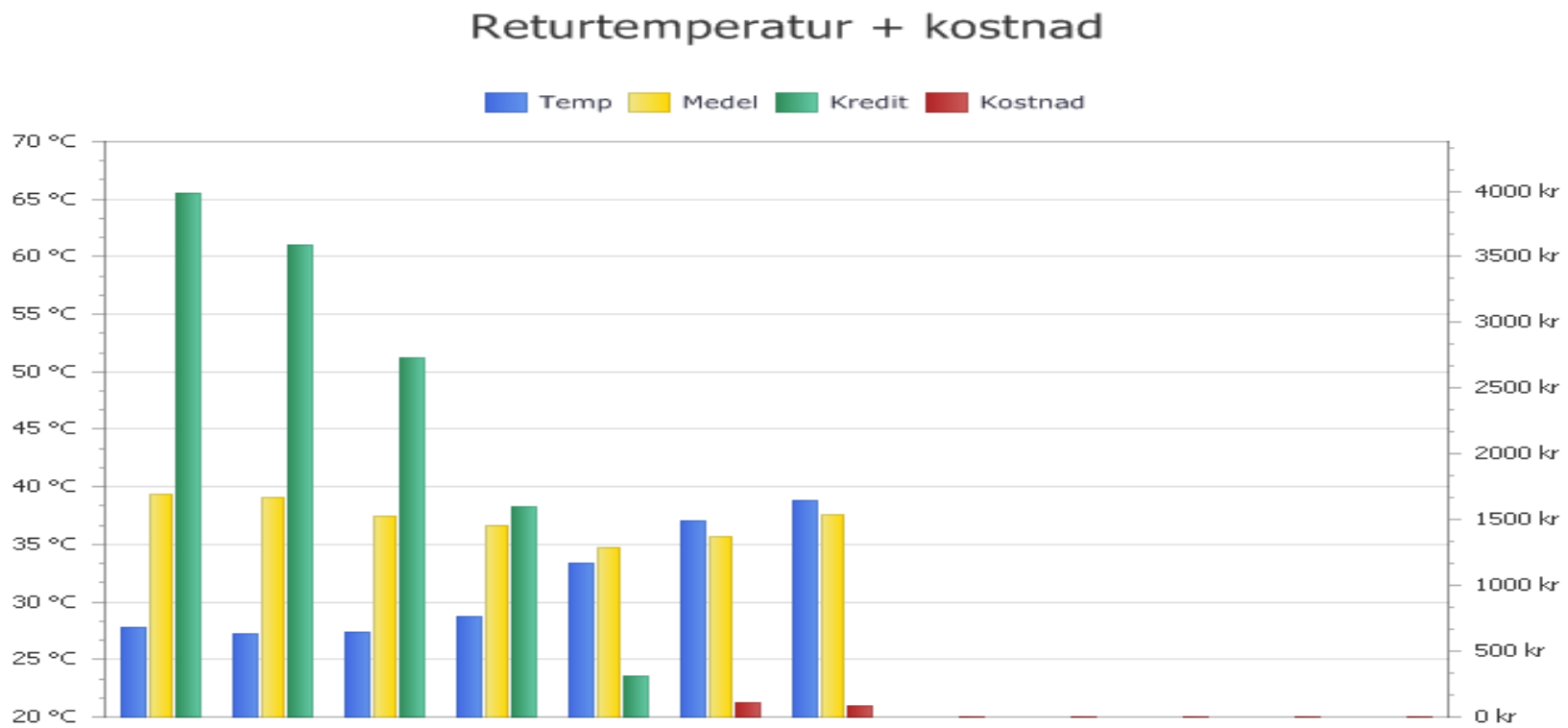
Göteborg Energi

Göteborg Energi

Returtemperatur - 2017

Kund	fv_alla	**Area**	31 m²
Nodtyp	Mätare	**Momsreg. area**	
Adress	Rundbäcksgatan 15		
Anläggningsnr	30021149		
Period	2017		

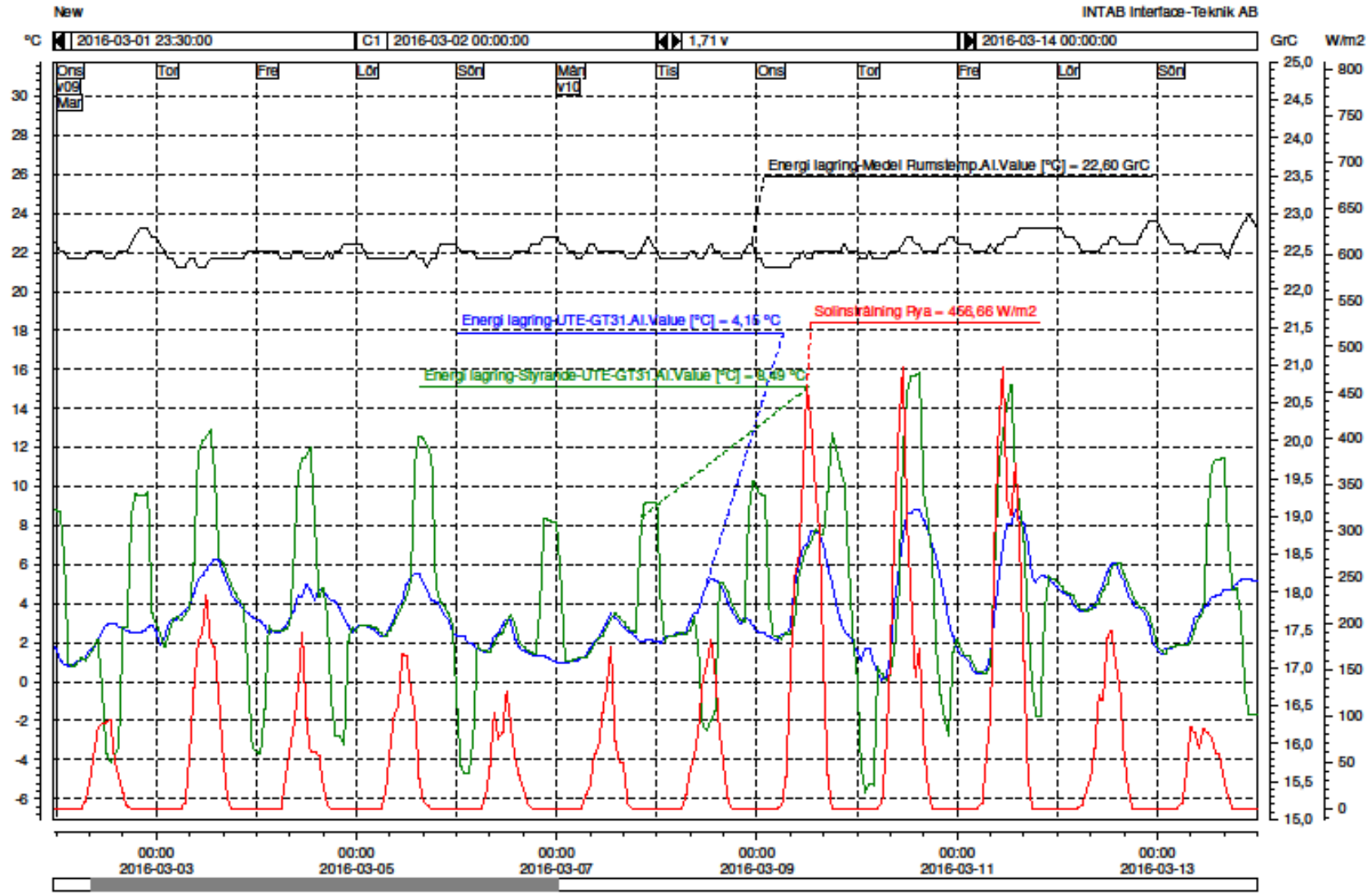
Antal mätare per stapel: 1



	Jan	Feb	Mars	April	Maj	Juni	Juli	Aug	Sept	Okt	Nov	Dec
Temp	27,7	27,2	27,4	28,7	33,33	37,06	38,86					
Medel	39,4	39,1	37,4	36,6	34,7	35,7	37,6					
Deb/Kred	-3978	-3594	-2725	-1596	-307	103	82					

Sønderborg 2017-10-04

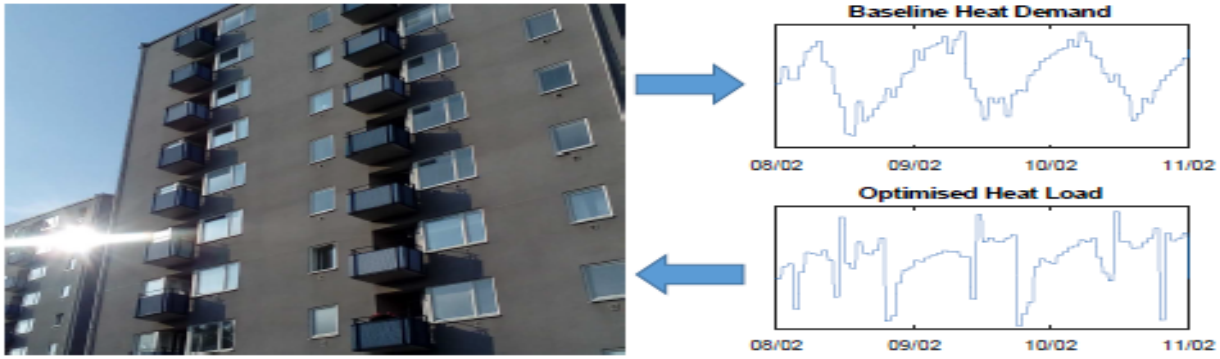
Göteborg Energi



Sønderborg 2017-10-04

Göteborg Energi

CHALMERS
UNIVERSITY OF TECHNOLOGY



Marginal Price Control of Buildings Utilised as Thermal Energy Storage

Optimising the heating cost of a modelled residential building with respect to the district heating network marginal generation cost

Master thesis in Complex Adaptive Systems

Jens Carlsson

Sønderborg 2017-10-04

Göteborg Energi

Thermal Energy Storage In Buildings is:

- A technical possibility

- Economically profitable

- …but lacks a solid business model

Göteborg Energi

Pilot "Buildings as energy storage"

Use the building and management of 2 areas

Total estimated power reduction 2 - 3 MW

Sønderborg 2017-10-04

Göteborg Energi

Big pilot test

- 22 substations - 2000+ apartments
- 2-3 MW control capacity for 9 hours
- Marginal cost operation
- Optimization after minimum heating cost?
- With hourly rates at FV

Sønderborg 2017-10-04

Göteborg Energi

Control system structure

Weather forecast

NODA
Optimize heating to minimize heating costs = Total over time for heating costs * Heat use

Once a day:
Send price of heat for each hour (next 72 hours) = every hour forecasted cost

One of these (depending on system settings):
- Input temp. Setpoint
- Radiator temp? setpoint
- Adjustment to signal from Outdoor Temperature Sensors

-Indoor temp in> 5 apartments
- Utetemp
- Radiator temp & flow
- DH temp & flow
- Valve positions
- Etc.

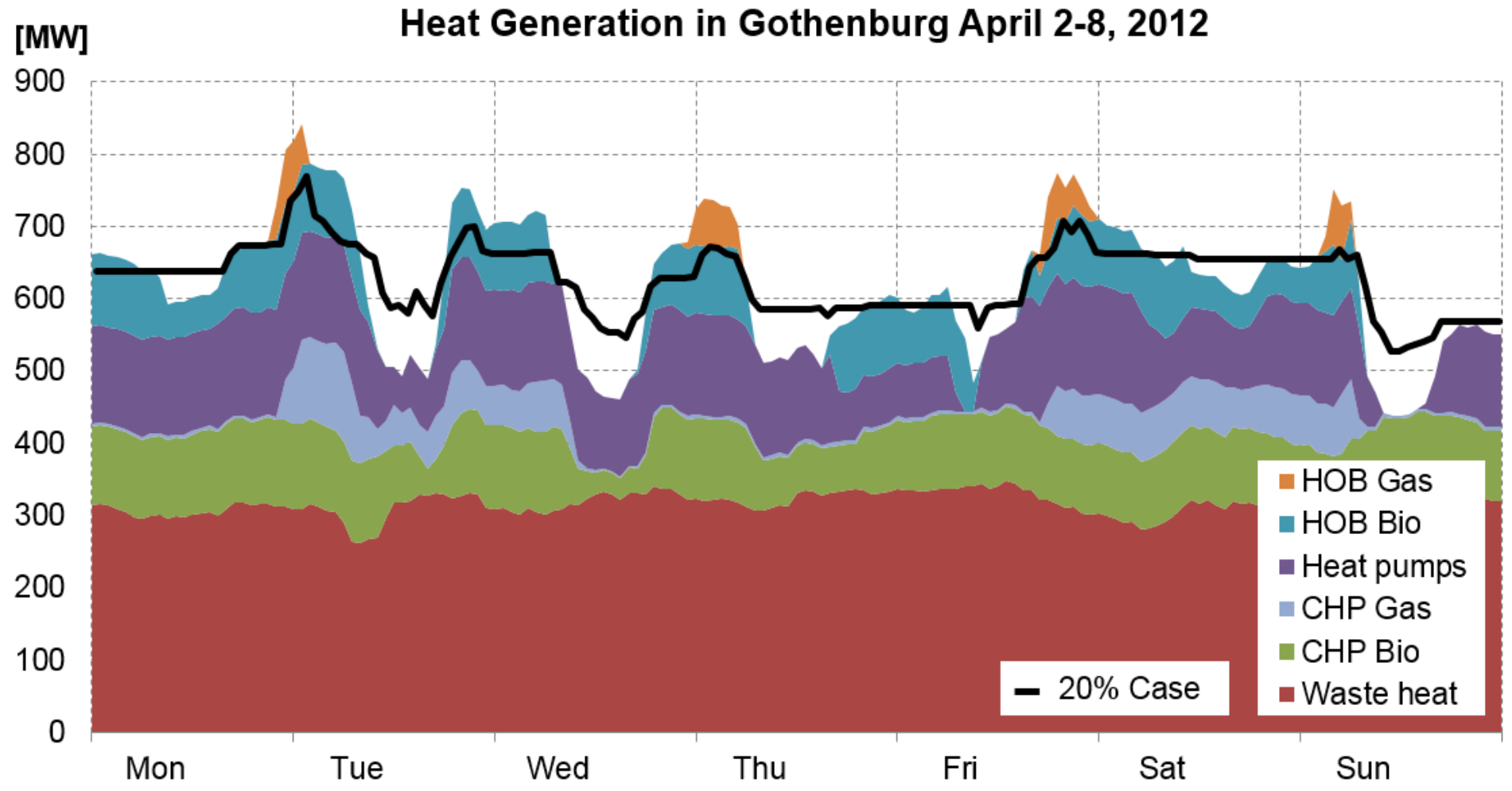
Göteborg Energi

Byggnaden utnyttjas som lagring

Sønderborg 2017-10-04

Göteborg Energi

Use the stored heat of the building to control fossil-dependent production



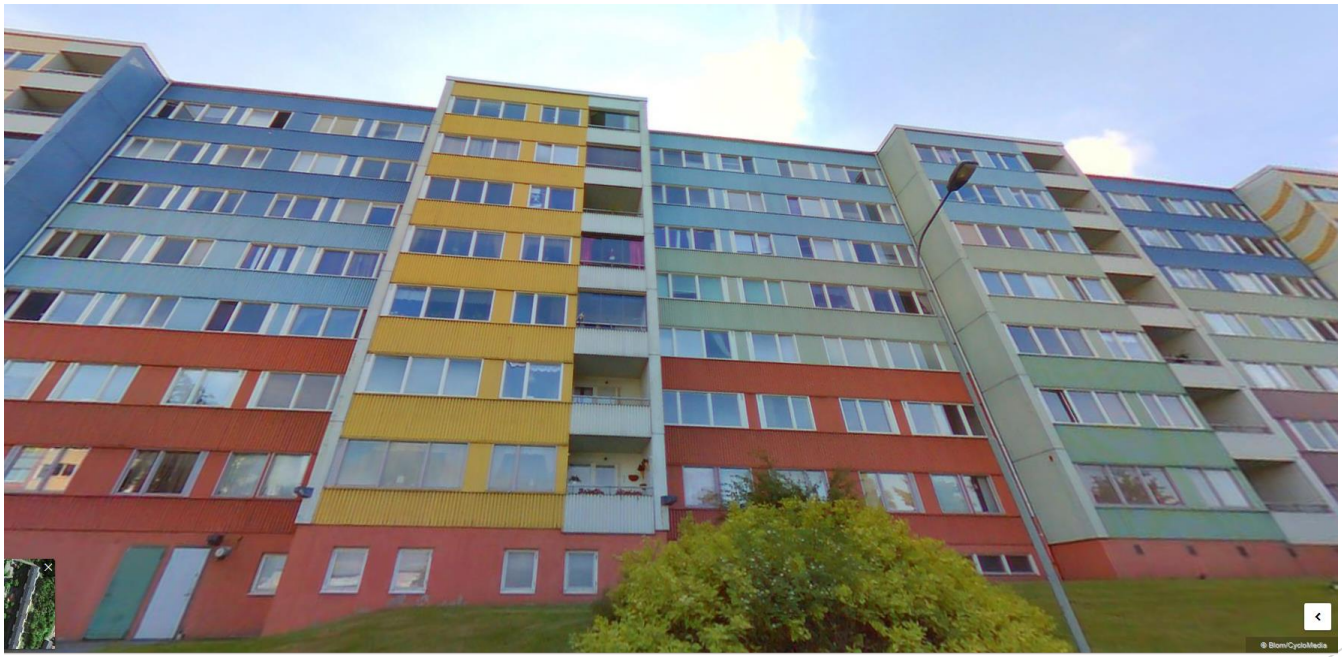
Göteborg Energi

Siriusgatan 12 properties and the area around Rymdtorget 7 properties

Sønderborg 2017-10-04

Göteborg Energi

Siriusgatan
Bergsjön



Sønderborg 2017-10-04

Göteborg Energi

Management based on forecast from the financial control room

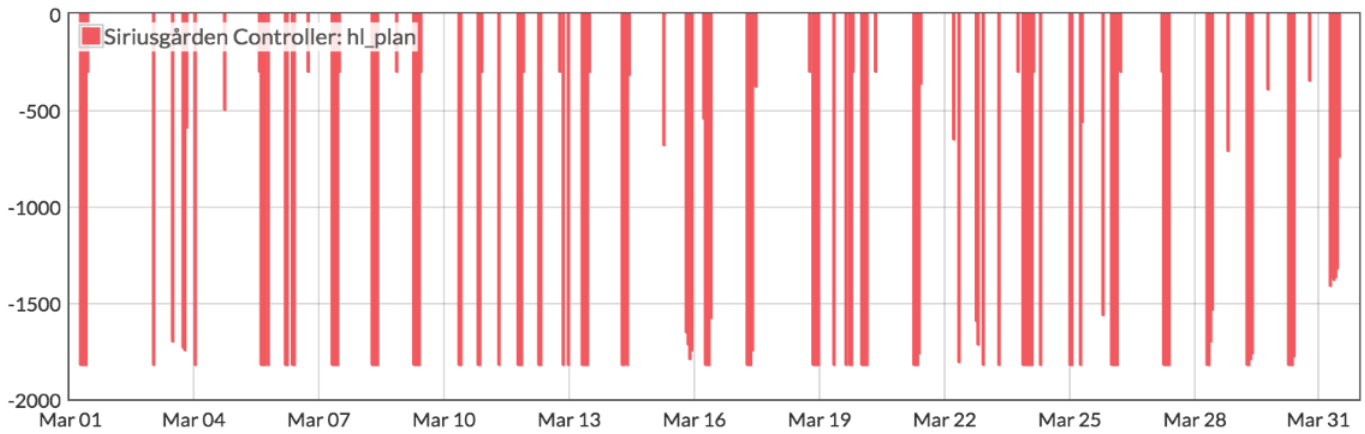


Bild 2: Mottagen styrplan för mars 2017

Sønderborg 2017-10-04

Göteborg Energi

Steering plan
Effect and flow reduction

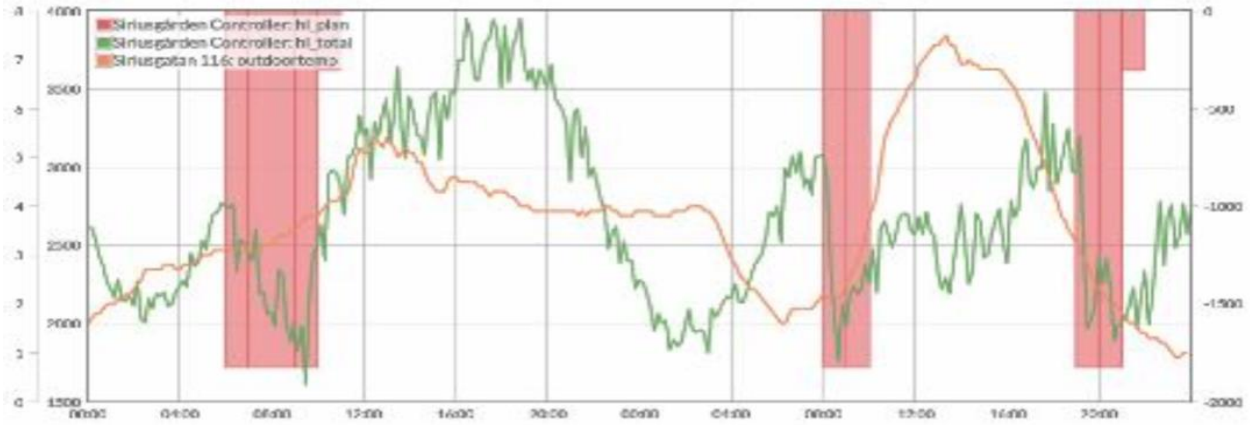


Bild 3: Styrplan, total värmelast samt utomhustemperatur i fastighetsklustret den 9:e mars 2017

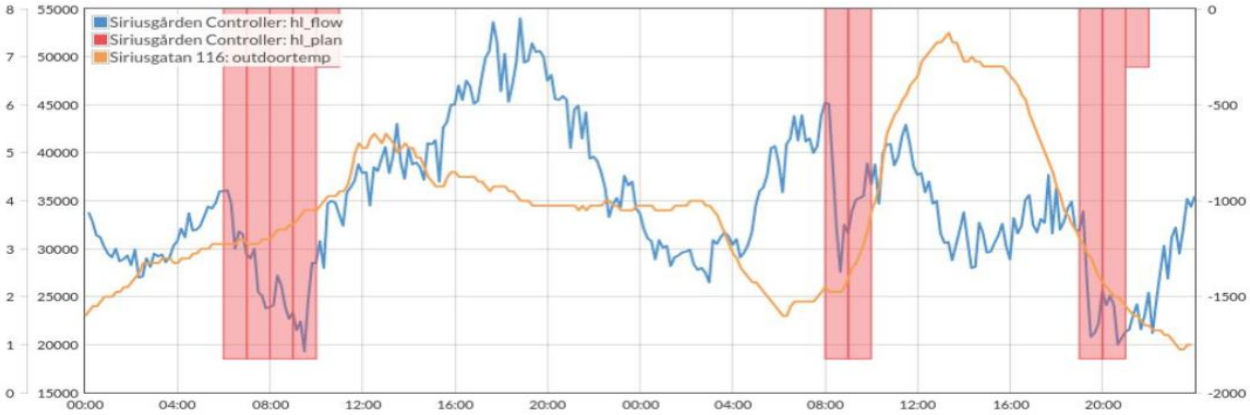


Bild 4: Styrplan, totalt flöde samt utomhustemperatur i fastighetsklustret den 9:e mars 2017

Sønderborg 2017-10-04

Göteborg Energi

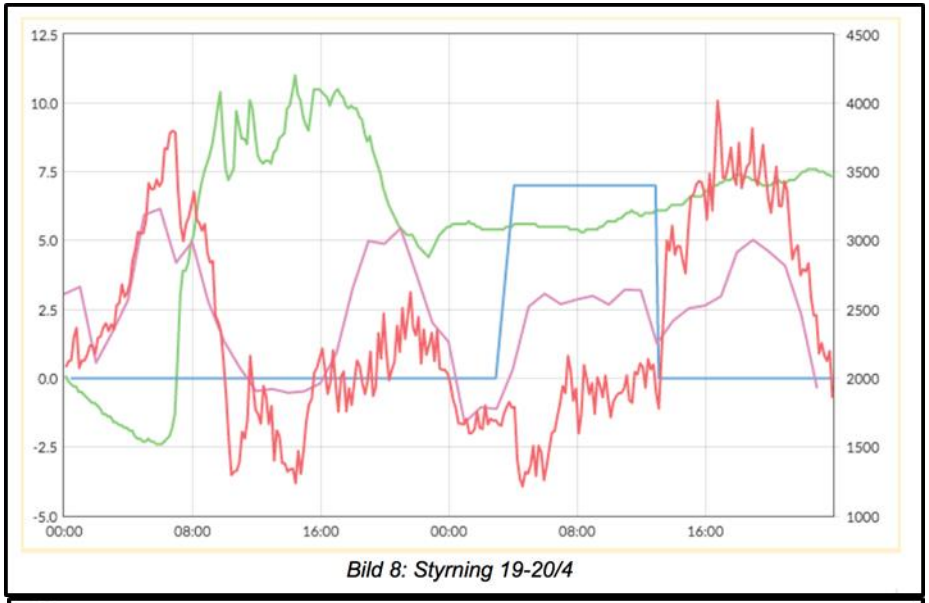


Bild 8: Styrning 19-20/4

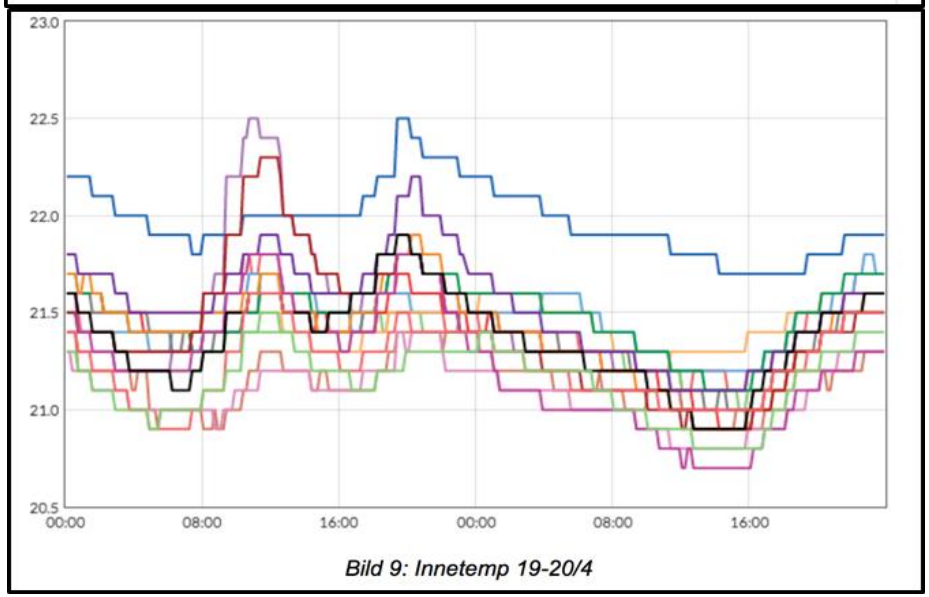


Bild 9: Innetemp 19-20/4

Red line: Power (Y-axis on the right side)
Green line: Outside temperature (y-axis on left side)?
Blue line: Outdoortemp_offset (y-axis on the left), thus indicating that a control is in progress.
Purple Line: Heat Load Forecast

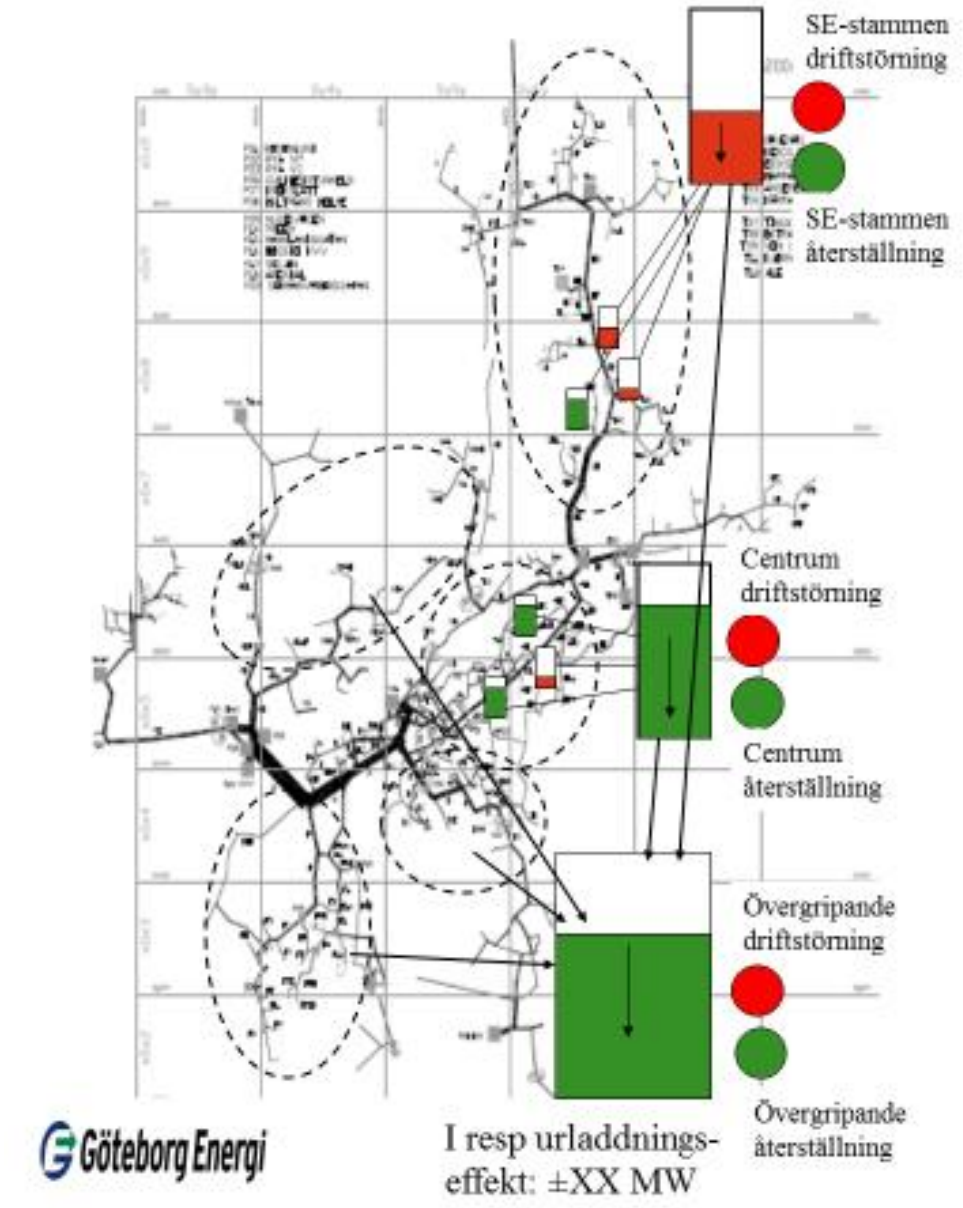
The temperature (average) in the property decreases about 0.3-0.4 degrees

Sønderborg 2017-10-04

Göteborg Energi

Energy Storage

- In an apartment building built in concrete, an energy storage of approximately 0.1 kWh / sqm (floor area) can be utilized without giving rise to a worse indoor climate.



Sønderborg 2017-10-04

Göteborg Energi


Distriktheating our Future

THANK YOU

Sønderborg 2017-10-04

Göteborg Energi