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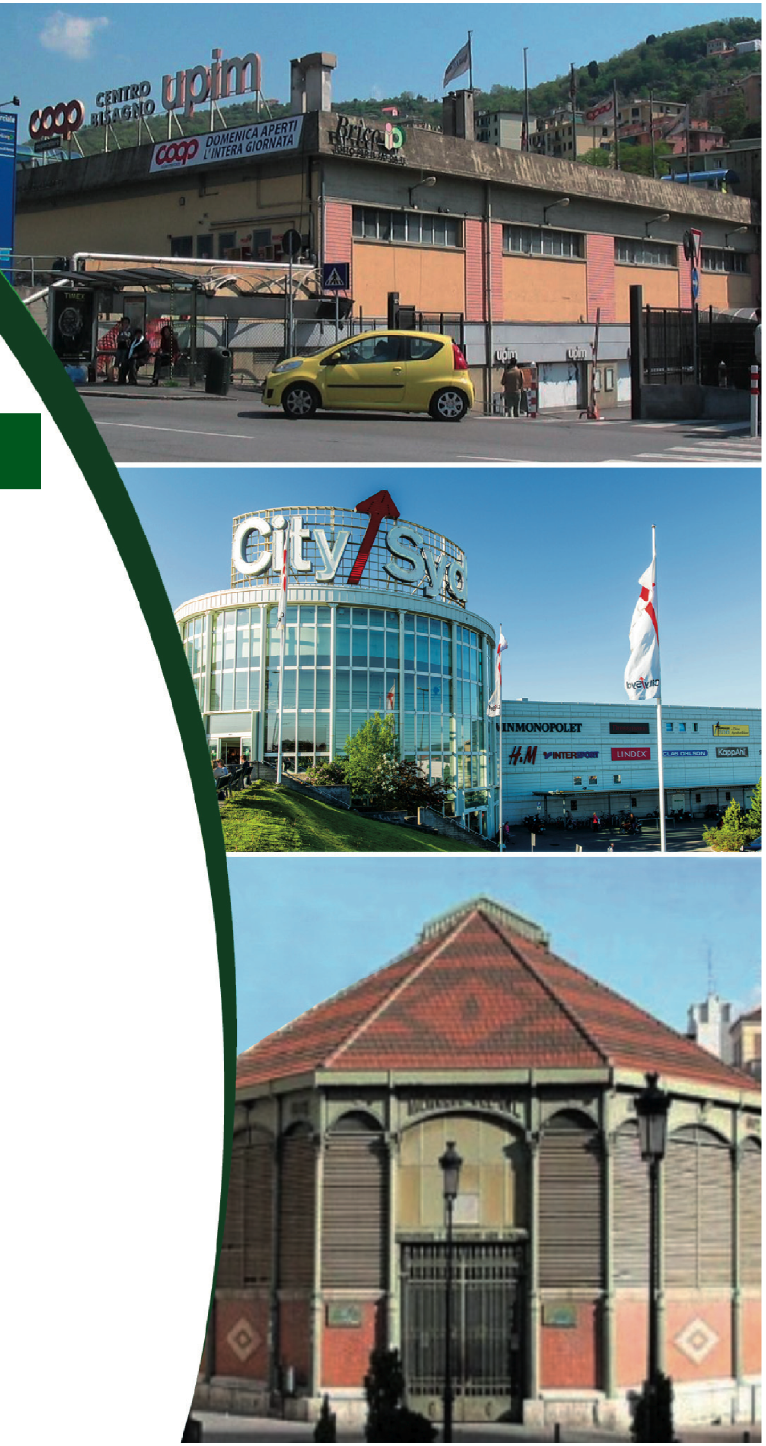
Capacities in Shopping centres to supply grid services

Matthias Haase, Ruth Woods and Kristian Skeie
SINTEF Building and Infrastructure
25/09/2014

SINTEF

SEVENTH FRAMEWORK PROGRAMME



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Content

- Background
- Purpose
- Theoretical framework
- Results and conclusions
- Implications for ‘Resilience the New Research Frontier’

Background

The CommONEnergy project wants to transform shopping malls into lighthouses of energy efficient architectures and systems.

The objective is to re-conceptualize shopping malls through deep retrofitting utilizing an holistic systemic approach involving innovative technologies and solution sets.

Performance targets:

- Up to 75% reduction of energy demand (factor 4)
- Power peak shaving
- 50% increased share of renewable energy source favoured by intelligent energy management and effective storage
- Improvement of comfort and health conditions for occupants and visitors

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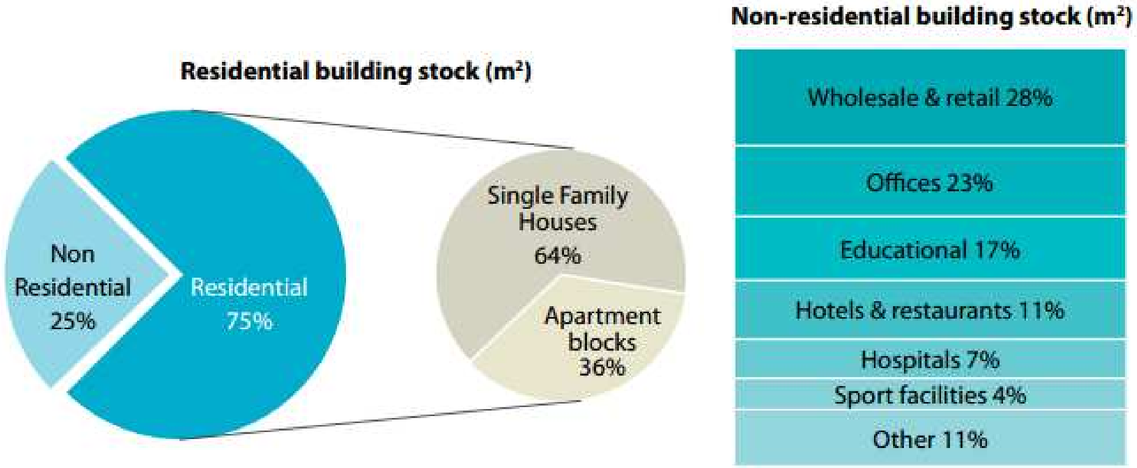
Partners

- Monitoring and control system manufacturer
- HVAC, Refrigeration and Lighting manufacturer
- Storage systems manufacturers
- Solar system manufacturer
- Materials manufacturer
- Building enterprises
- R&D experts (building physics, HVAC+R systems, monitoring, lighting, materials)
- Engineering/Architectural consultants
- Building owners

Purpose

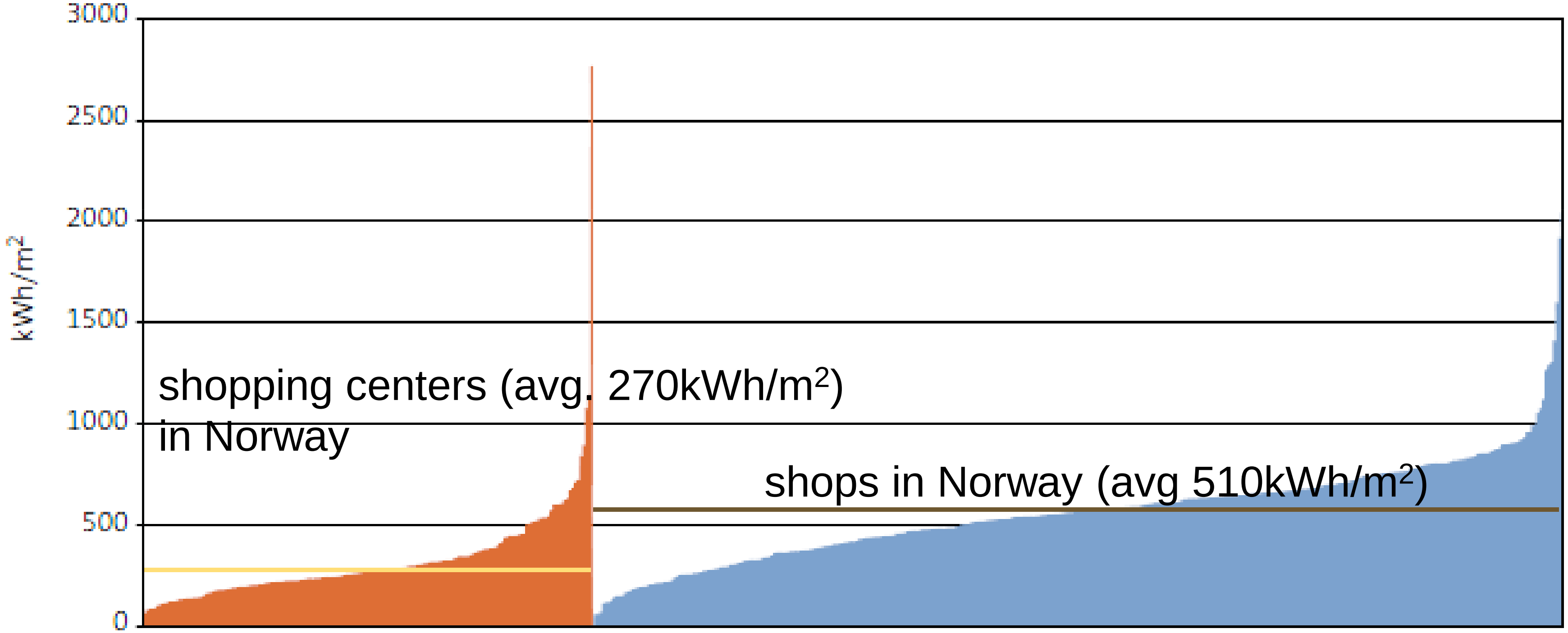
Identification of potential in shopping malls to supply grid services, reducing the impact on power demand through

- peak shaving of its demand curve or its adaptation to the conditions of generation of the utilities, based on the classification of the demand.
- use of generation coming from renewable energy sources in moments of mismatch between energy supply and demand, either directly or from storage.



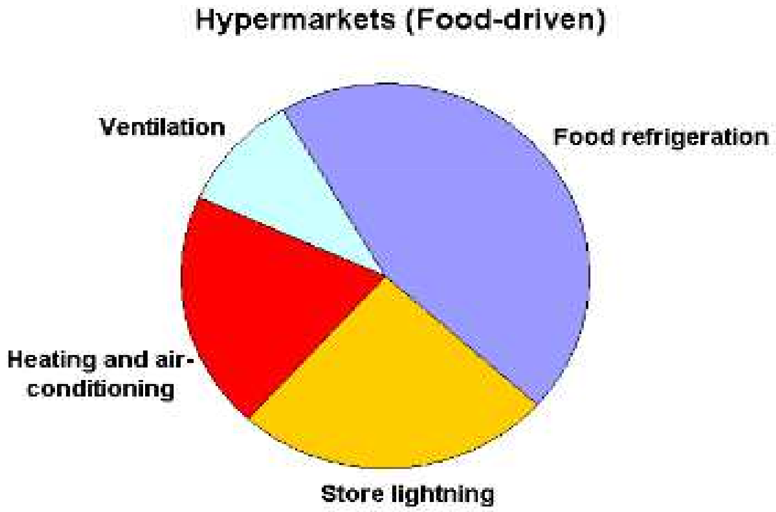
BPIE, 2011

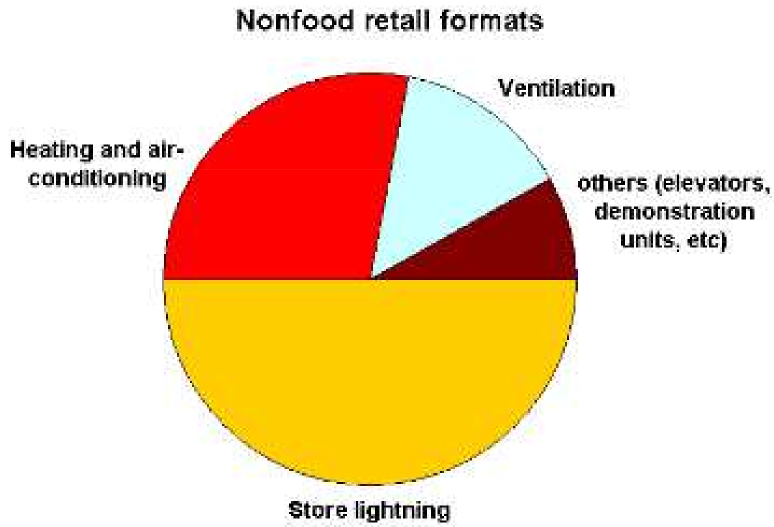
Energy use



Haase and Woods, 2013

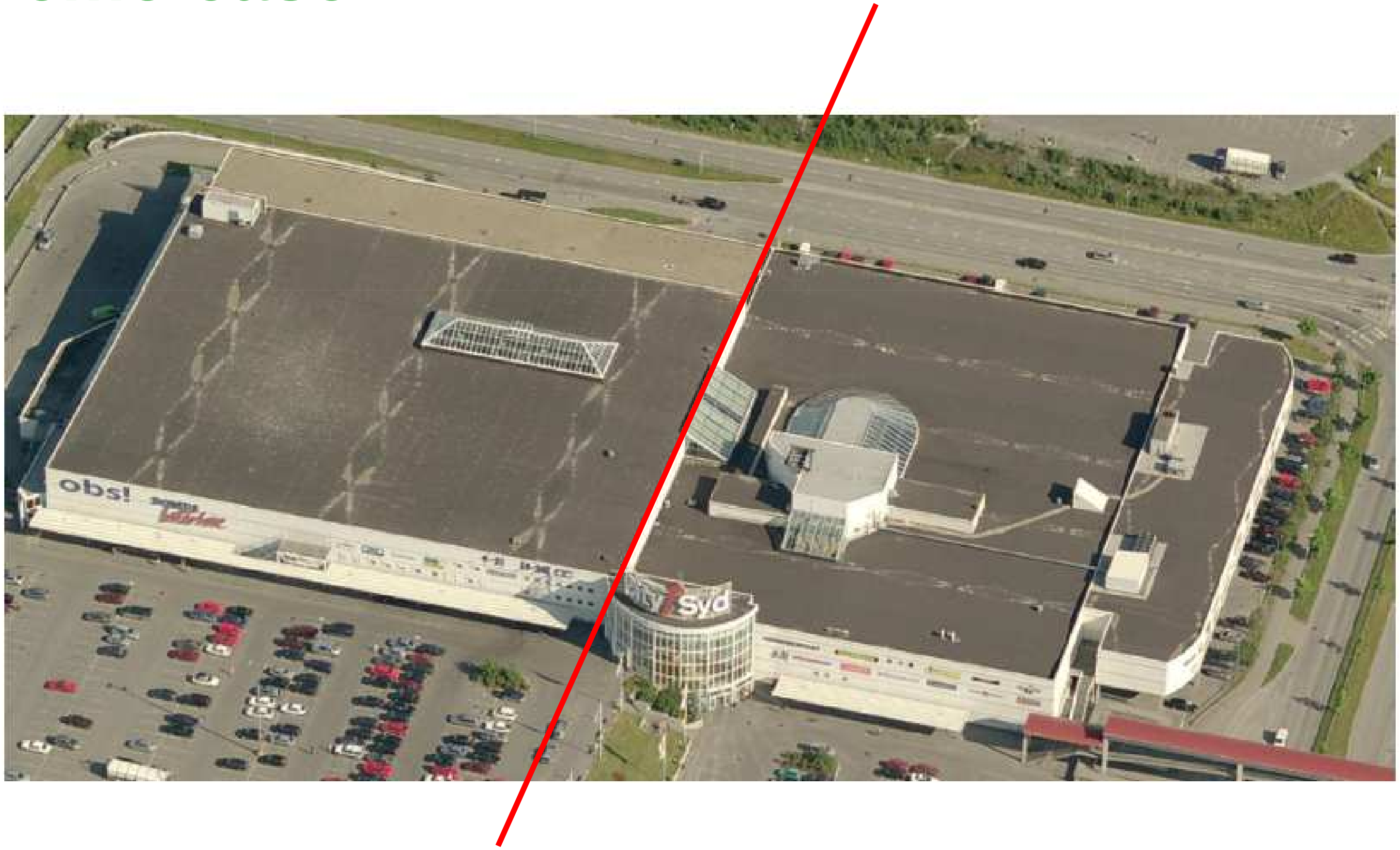
Energy use





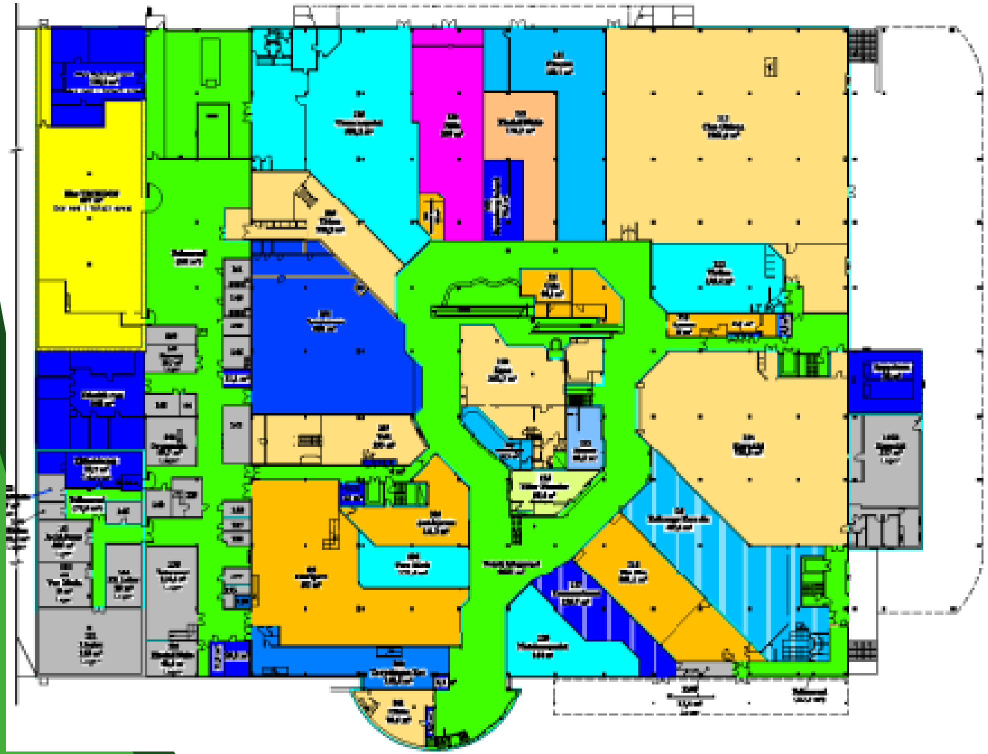
Retail forum for sustainability, 2009

Demo case

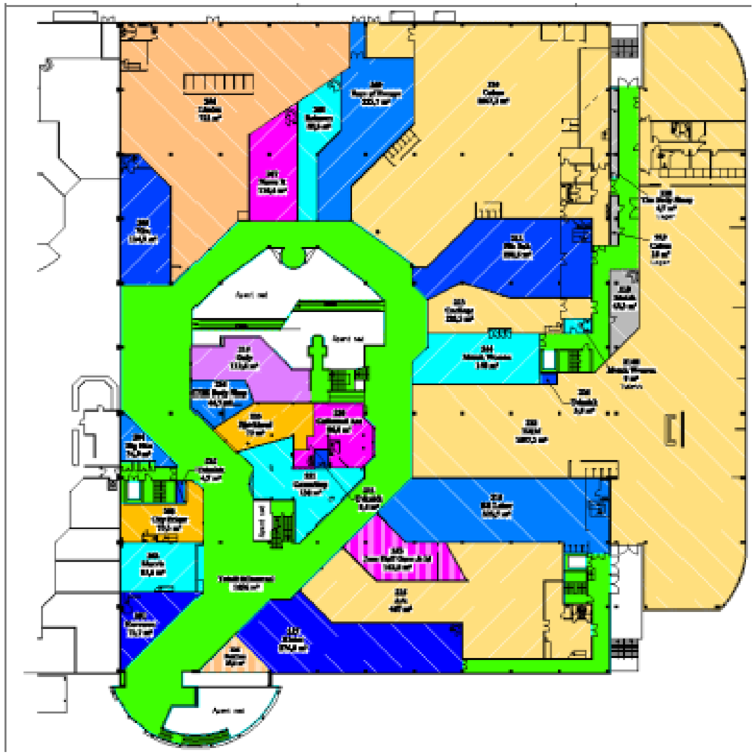


Baseline plans

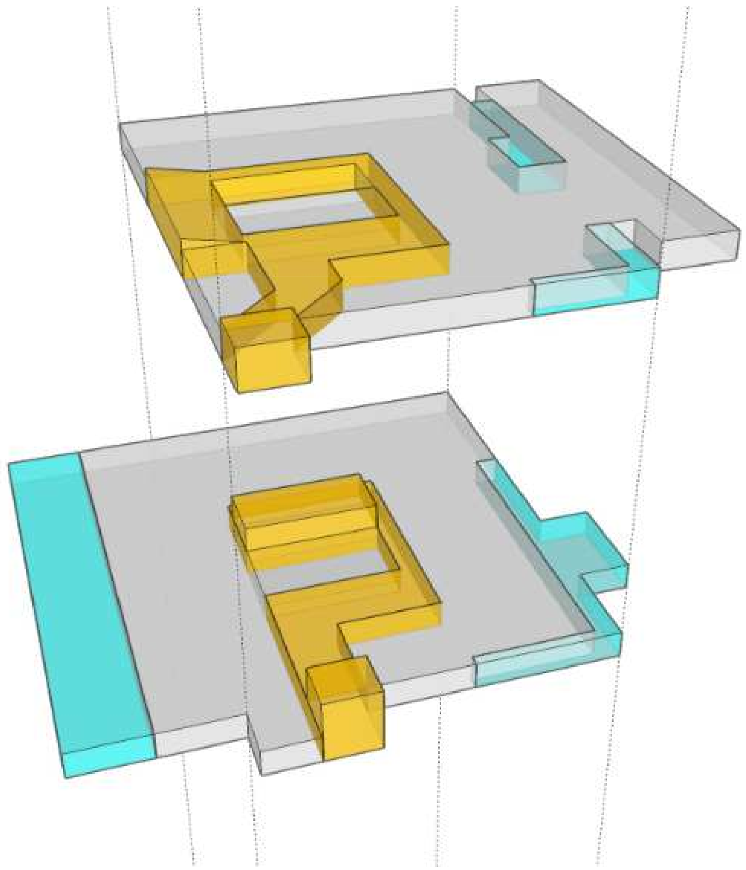
Ground floor



First floor



Baseline zoning with grid



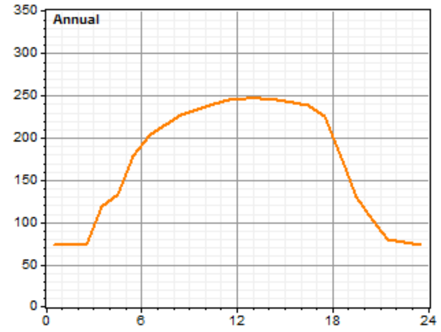
Baseline

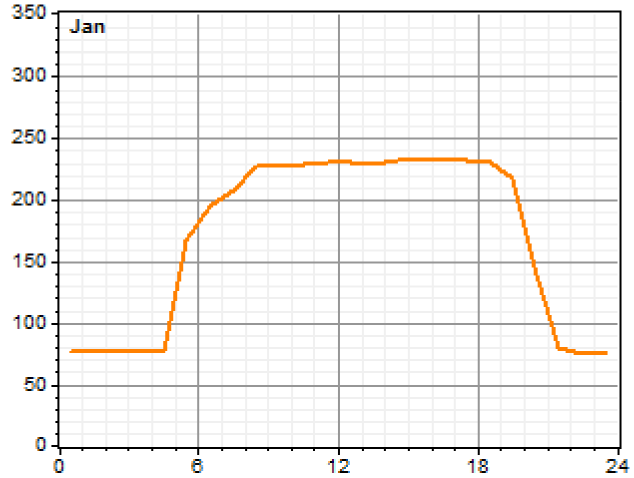
Constructions

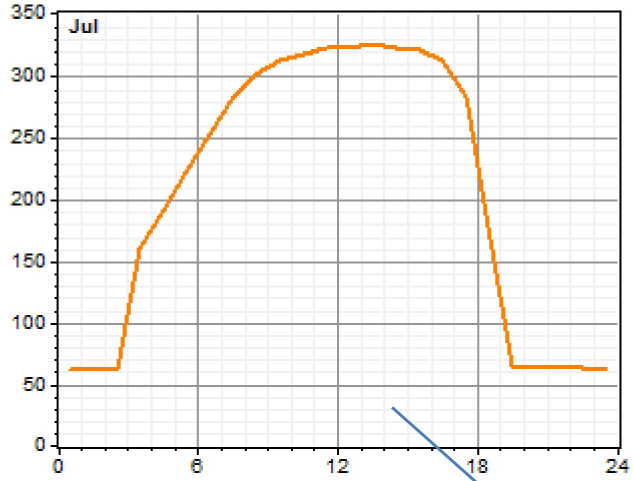
Building codes	TEK-1985	TEK-1987	TEK-1997	TEK-10
Description	*Building codes' as built to std. 1985'*	*Building codes year of completion*	*Redevelopment in 2000 (extension)*	*Current min. std. (for reference)*
U-value ext. wall (W/(m²K))	0,45*	0,30	0,22	0,18
U-value roof (W/(m²K))	0,23	0,23	0,15	0,13
U-value floor (W/(m²K))	0,30	0,30	0,15	0,15
U-value windows / doors (W/(m²K))	*to be included in the facade.	2,40	1,6 - 2,0	1,2
U-value doors / ports (W/(m²K))	2,0	2,0	2,0	1,2
air tightness c (ach)			1,50	
heat recovery d (%)				80 %
specific fan power (kW/(m³/s))				2,0/1,0

Measured data 2012

Avg. electricity profile



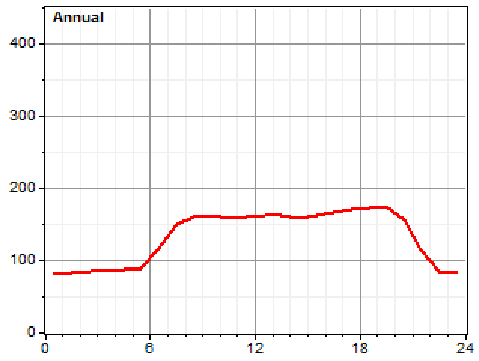


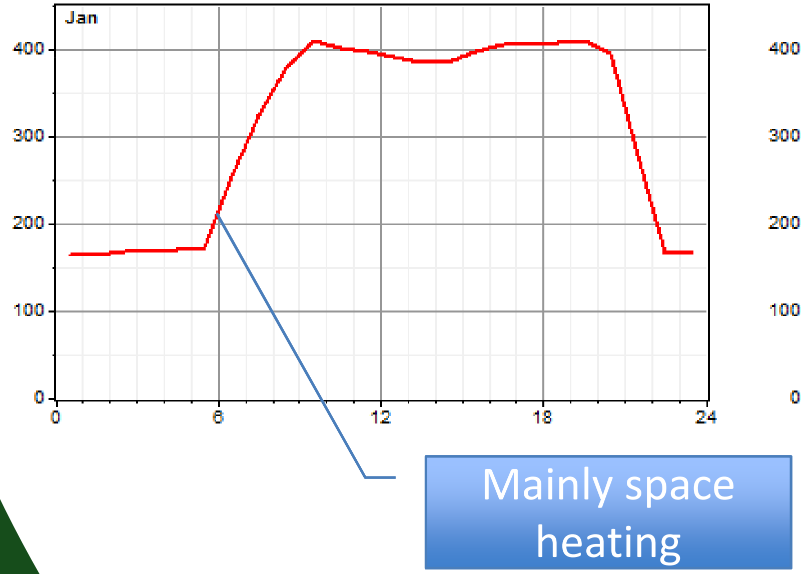


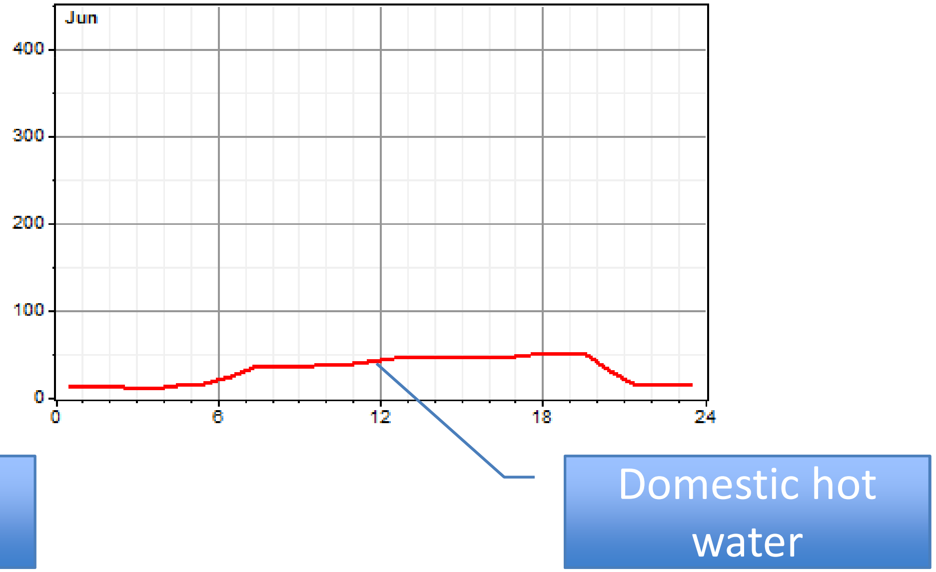
Increased electricity use

Measured data 2012

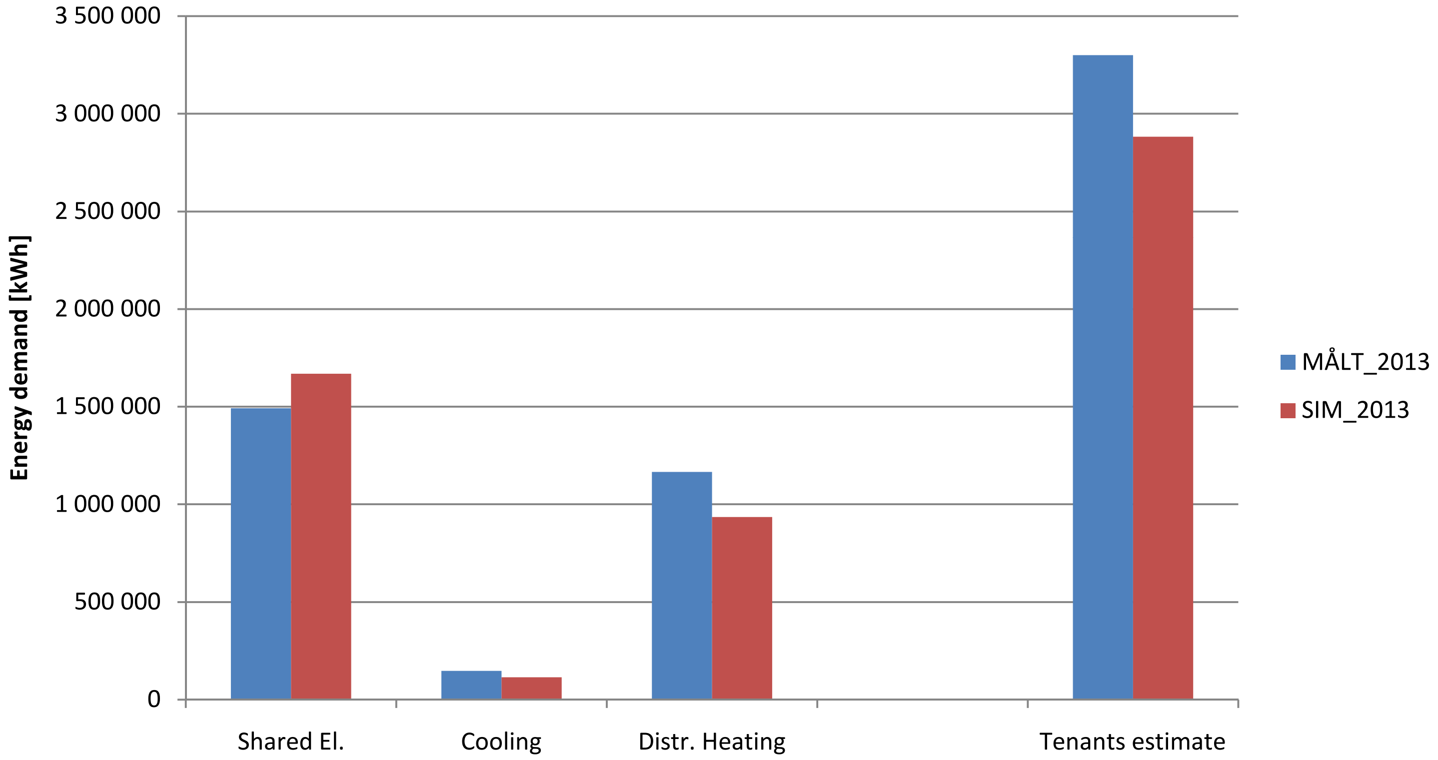
Avg. district heating profile







Validated model



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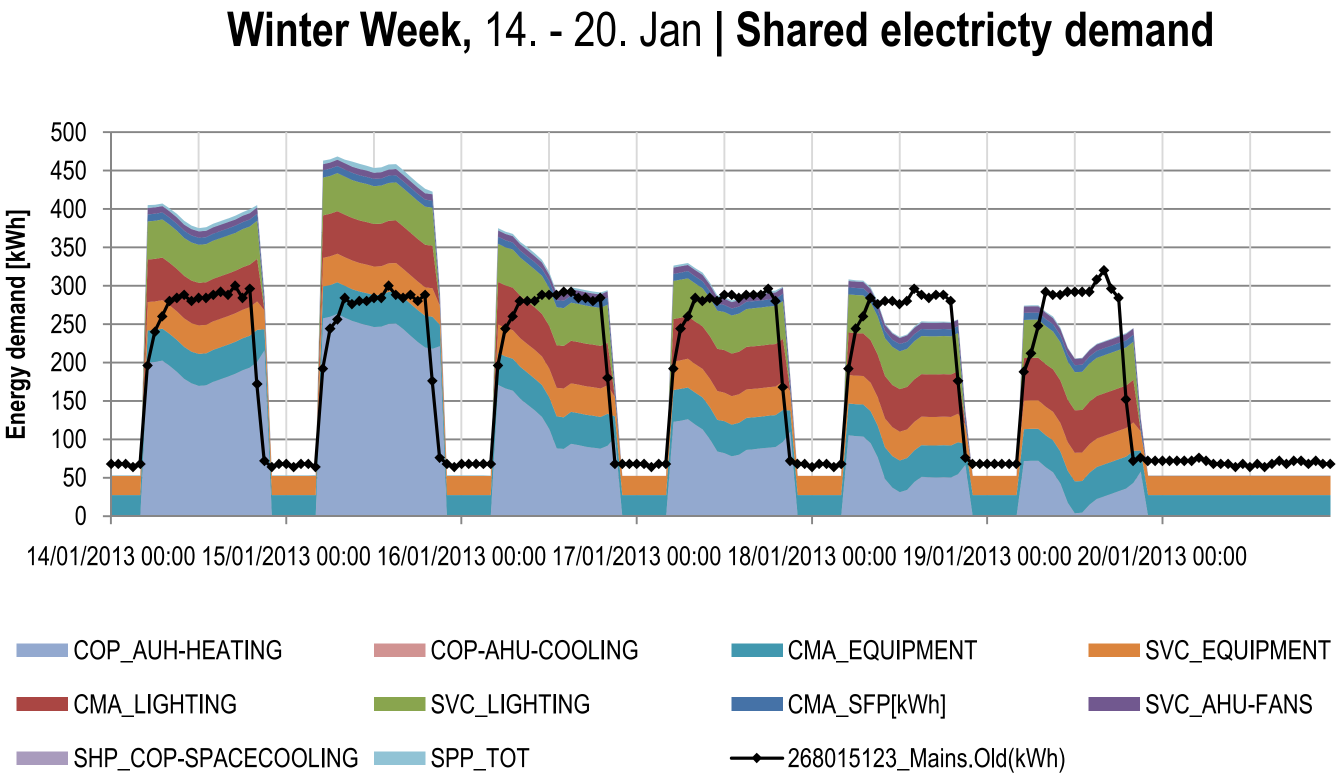
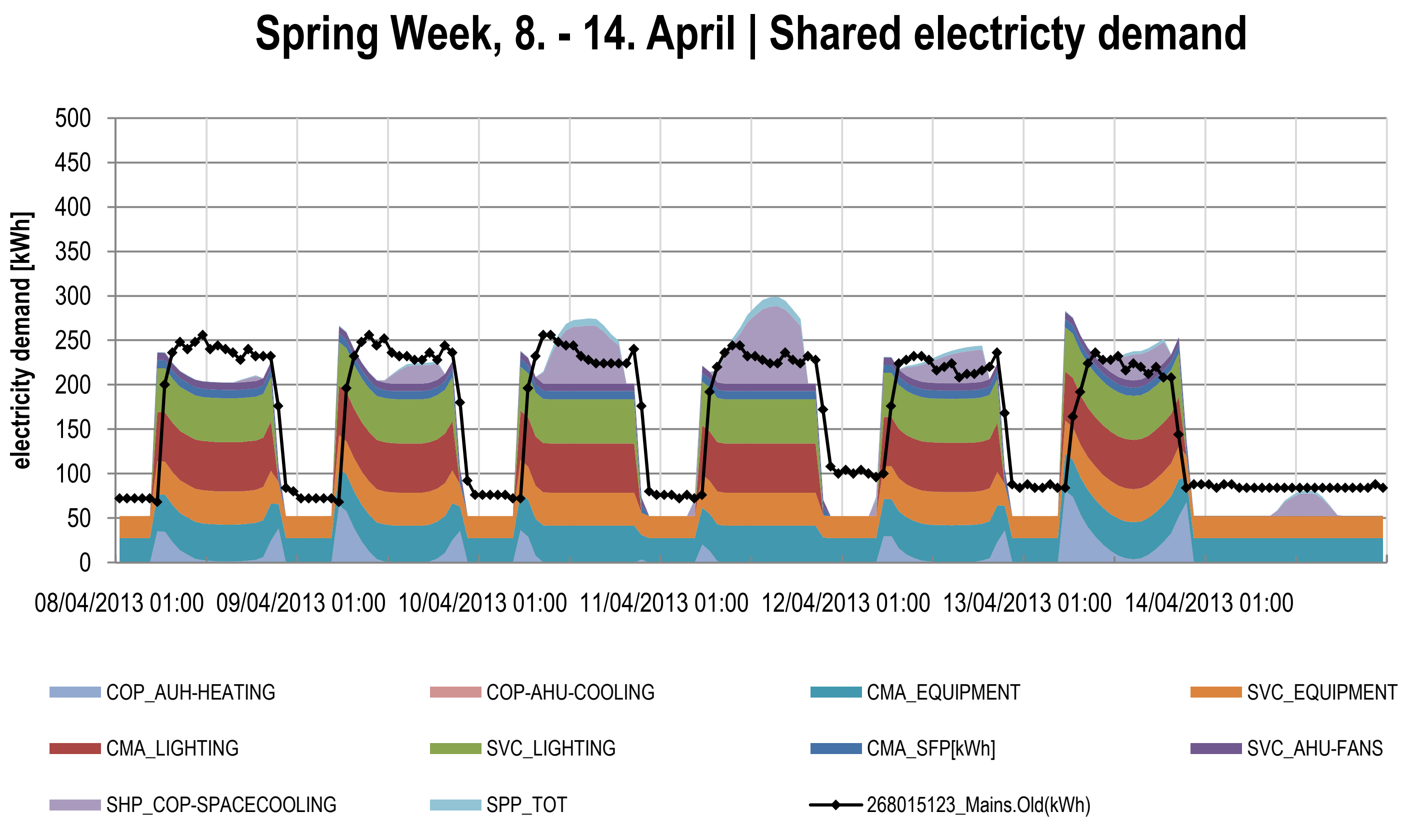
Results

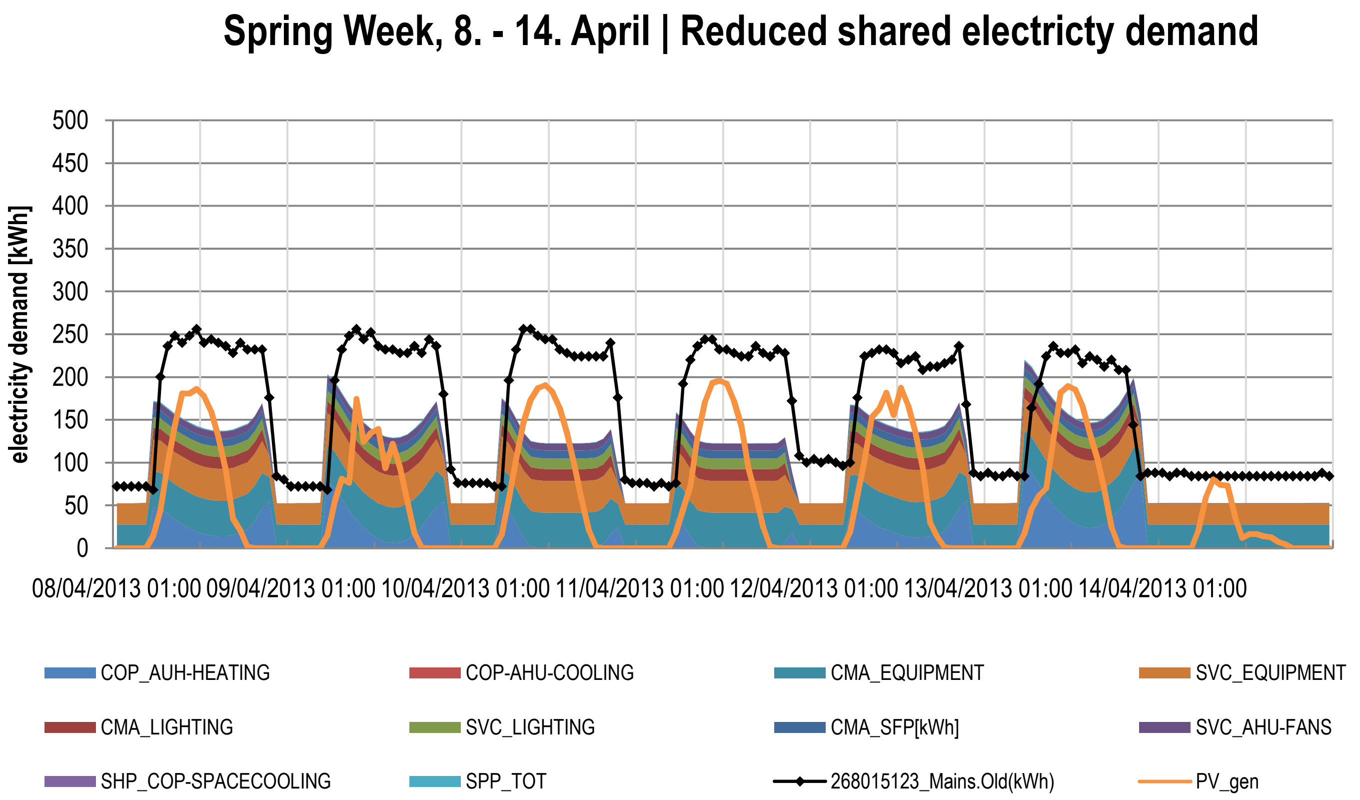


Results



Spring Week, 8. - 14. April | Shared electricty demand
electricity demand [kWh]
500
450
400
350
300
250
200
150
100
50
0
08/04/2013 01:00
09/04/2013 01:00
10/04/2013 01:00
11/04/2013 01:00
12/04/2013 01:00
13/04/2013 01:00
14/04/2013 01:00
COP_AUH-HEATING
COP-AHU-COOLING
CMA_EQUIPMENT
SVC_EQUIPMENT
CMA_LIGHTING
SVC_LIGHTING
CMA_SFP[kWh]
SVC_AHU-FANS
SHP_COP-SPACECOOLING
SPP_TOT
268015123_Mains.Old(kWh)

Results


Spring Week, 8. - 14. April | Reduced shared electricty demand
electricity demand [kWh]
500
450
400
350
300
250
200
150
100
50
0
08/04/2013 01:00 09/04/2013 01:00 10/04/2013 01:00 11/04/2013 01:00 12/04/2013 01:00 13/04/2013 01:00 14/04/2013 01:00
COP_AUH-HEATING
COP-AHU-COOLING
CMA_EQUIPMENT
SVC_EQUIPMENT
CMA_LIGHTING
SVC_LIGHTING
CMA_SFP[kWh]
SVC_AHU-FANS
SHP_COP-SPACECOOLING
SPP_TOT
268015123_Mains.Old(kWh)
PV_gen

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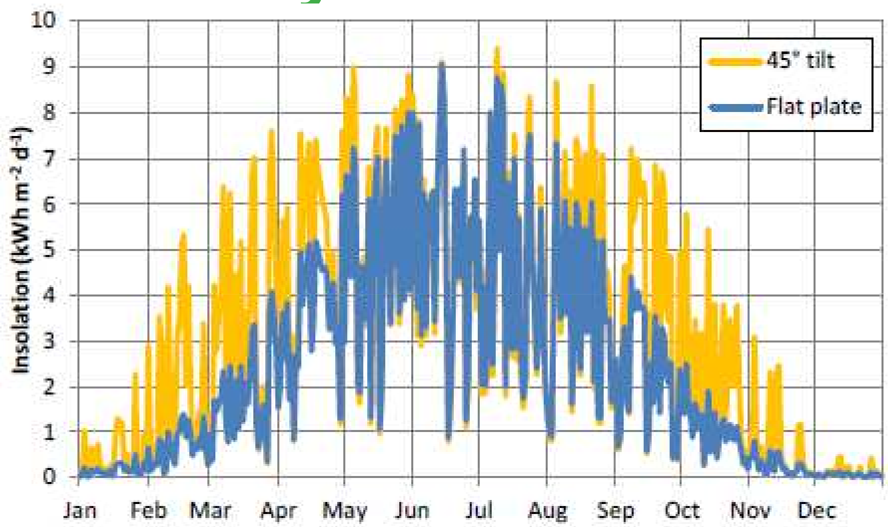
PV system



- Trondheim: 63° 25’ N, 10° 23’ E (south of Arctic circle)
- Average solar resource: 2.38 kWh m-2 d-1 onto a flat plate, 3.03 kWh m-2 d-1 onto a PV panel tilted 45° to the south.
- Here: 500kW (3200m2), 1MW, almost horizontal installation

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Concepts/scenarios for decrease mismatch

		Indicator category	
		Load matching	Grid interaction
Data requirements	On-site load and generation	I Load match index[1] Solar fraction[2] Cover factor[4] Self-consumption factor[7] Loss of load probability[4]	II Grid interaction index[1] Capacity factor[4] Peak power indicators[4] Grid citizenship tool[8]
	Additional data	III Mismatch compensation factor[5] Market matching[3]	IV Profile addition indicators[5] Coincidence factor[6]

[1]Voss et al (2010), [2]Widén et al (2009), [3]Widén and Wäckelgard (2010), [4]Verbruggen et al (2001), [5] Lund et al (2011), [6] Willis and Scott (2000), [7] Castillo-Cagical et al (2010), [8] Colson and Nehrir (2009)

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Concepts/scenarios for decrease mismatch

- Load Cover Factor

$$\gamma_{load} = \frac{\int_{\tau_1}^{\tau_2} min[g(t) - S(t) - \zeta(t), l(t)]dt}{\int_{\tau_1}^{\tau_2} l(t)dt}$$

- Supply Cover Factor

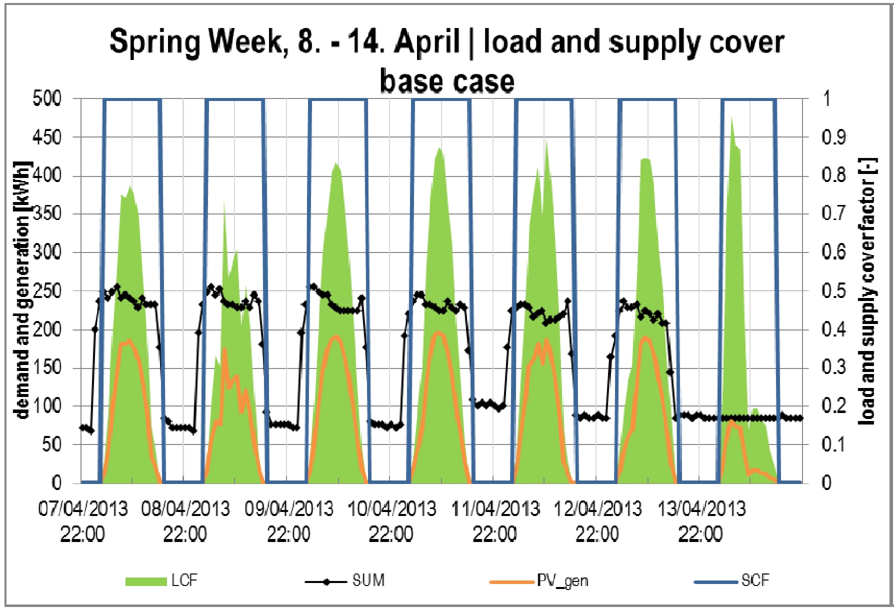
$$\gamma_{supply} = \frac{\int_{\tau_1}^{\tau_2} min[g(t) - S(t) - \zeta(t), l(t)]dt}{\int_{\tau_1}^{\tau_2} g(t)dt}$$

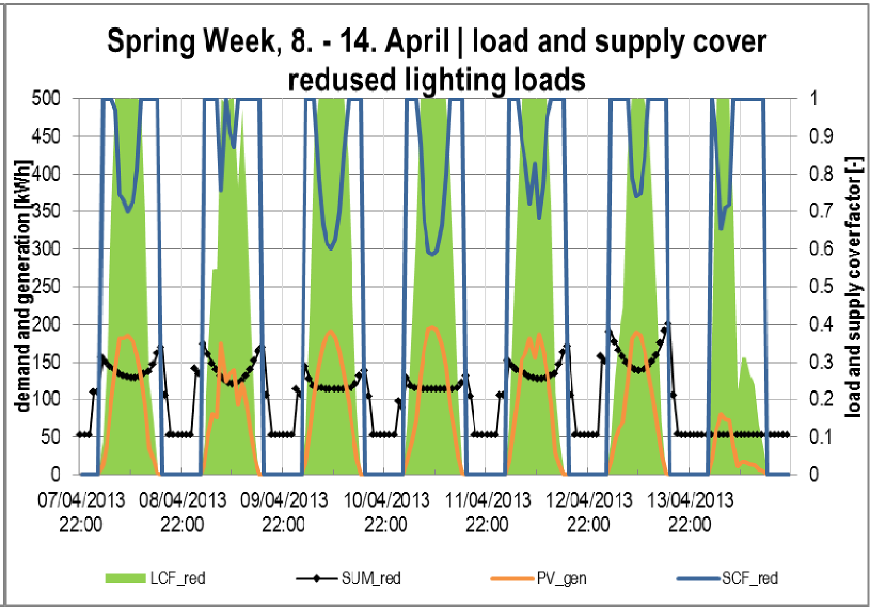
- Grid interaction

$$\boldsymbol{GI} = \frac{\boldsymbol{g(t)}}{\boldsymbol{l(t)}}$$

SEVENTH FRAMEWORK PROGRAMME

Results





- 500kW PV system

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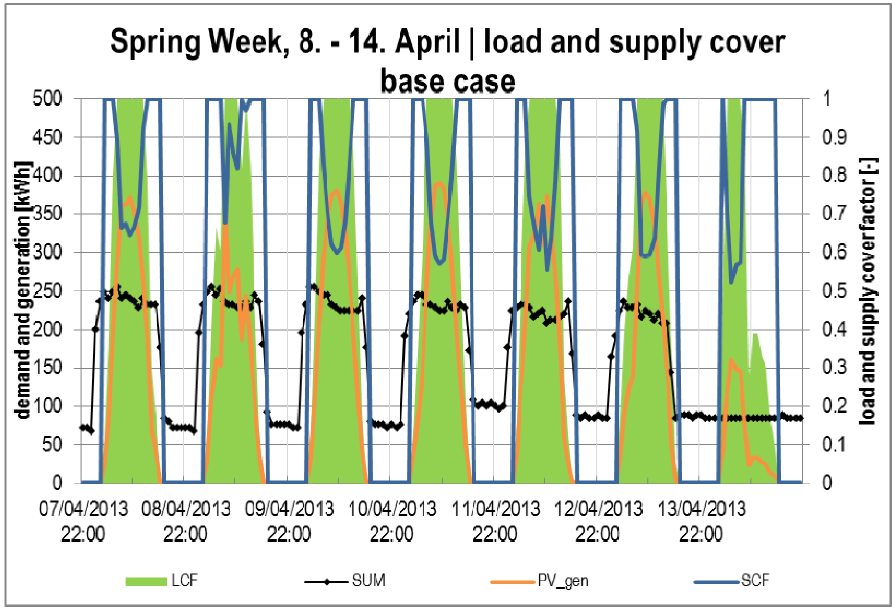
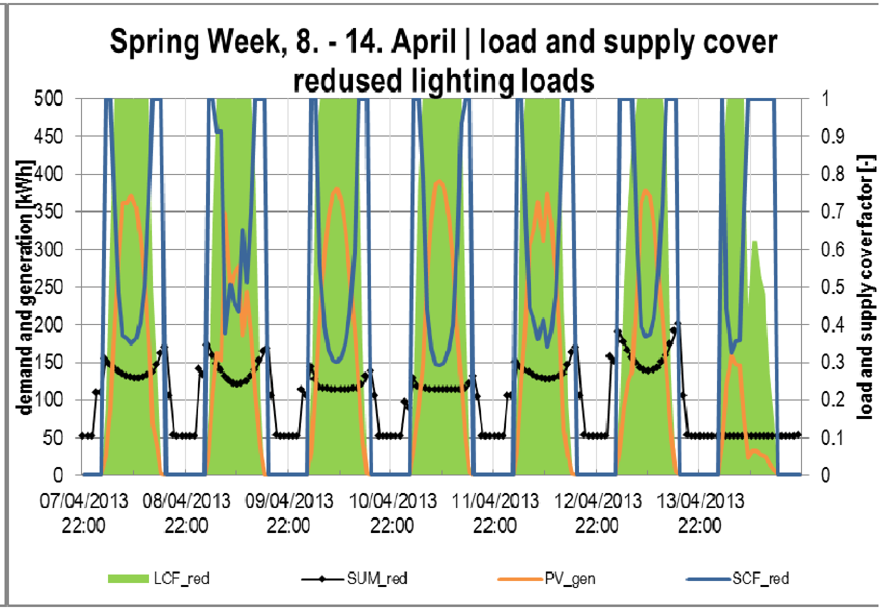
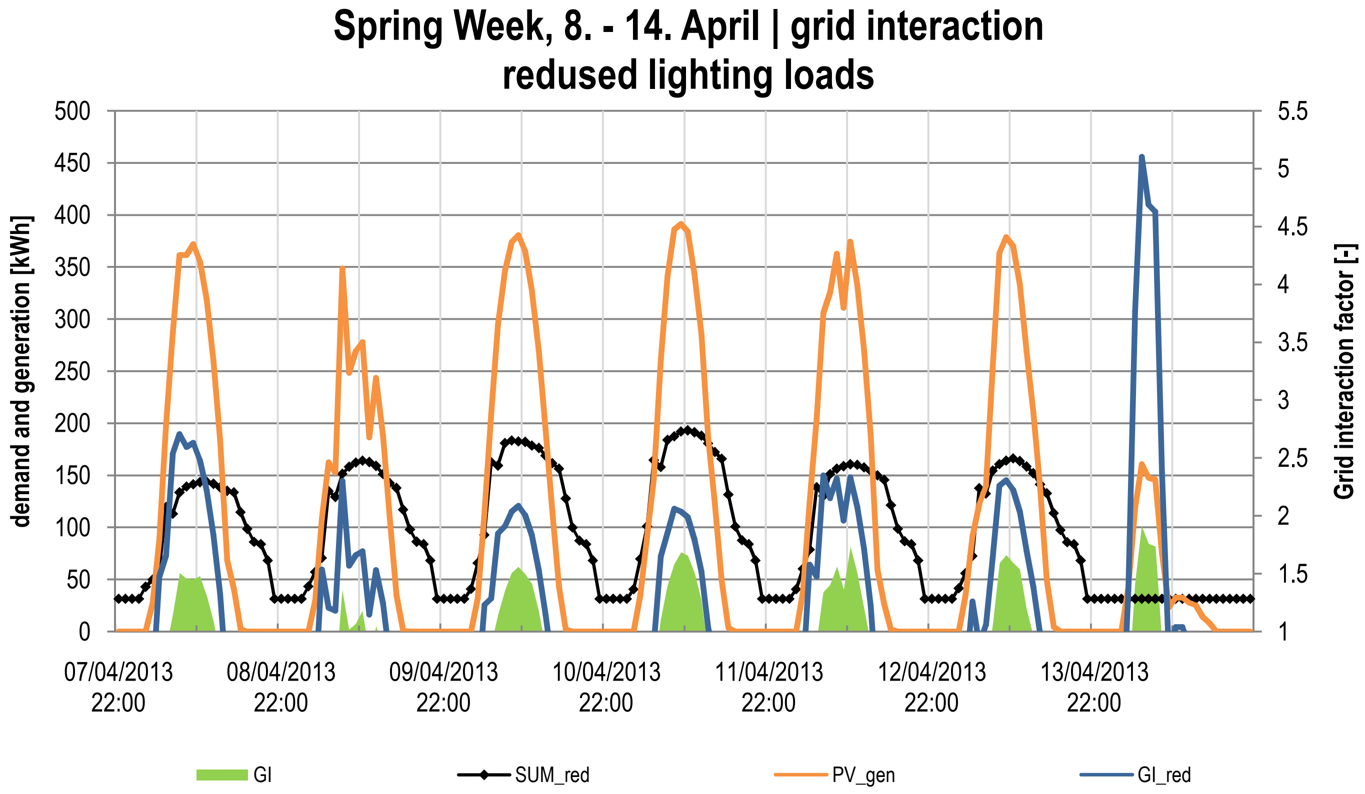
Results





- 1 MW PV system

Results


Spring Week, 8. - 14. April | grid interaction
redused lighting loads
demand and generation [kWh]
Grid interaction factor [-]
500
450
400
350
300
250
200
150
100
50
0
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
07/04/2013 22:00
08/04/2013 22:00
09/04/2013 22:00
10/04/2013 22:00
11/04/2013 22:00
12/04/2013 22:00
13/04/2013 22:00
GI
SUM_red
PV_gen
GI_red

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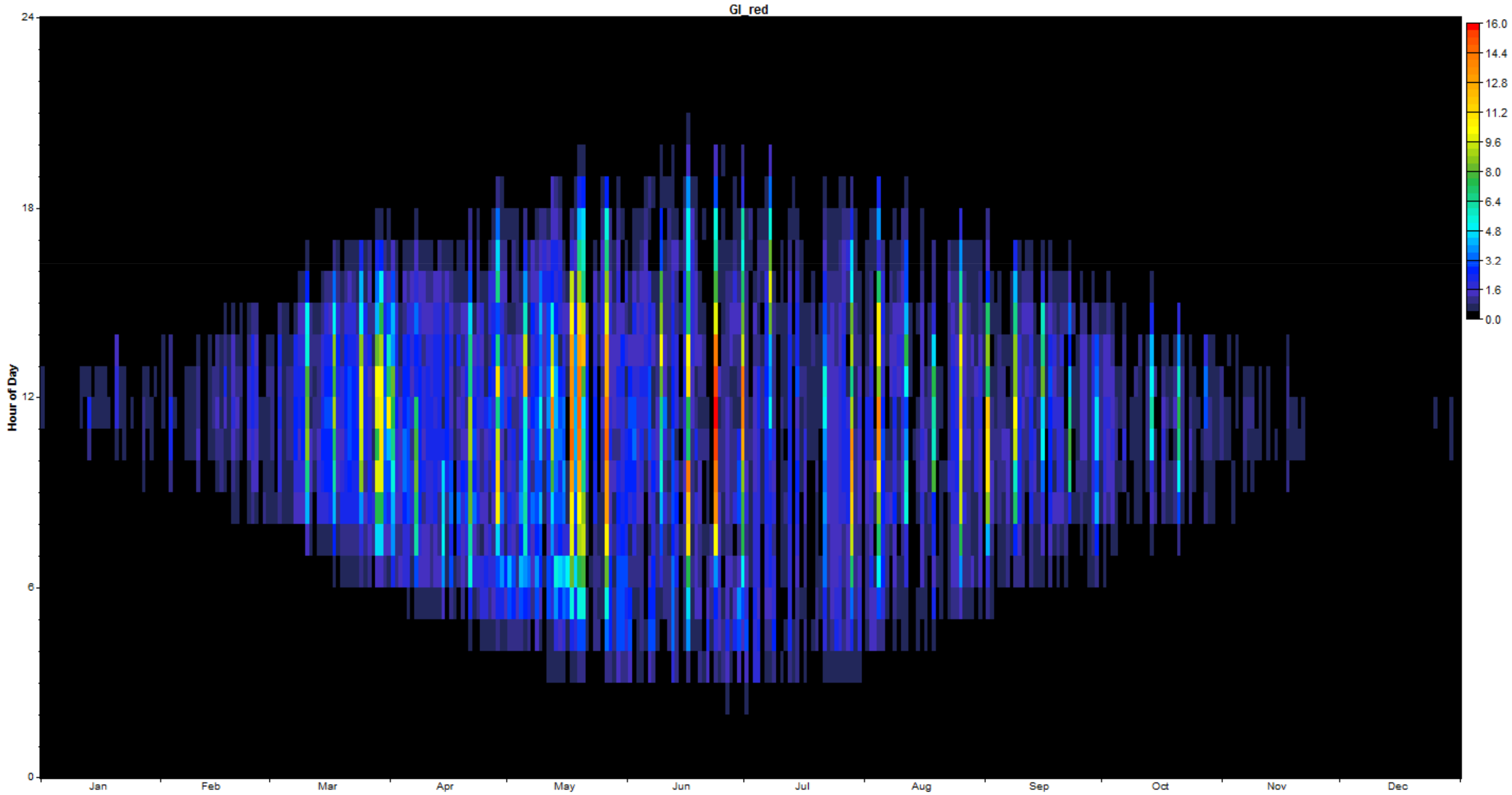
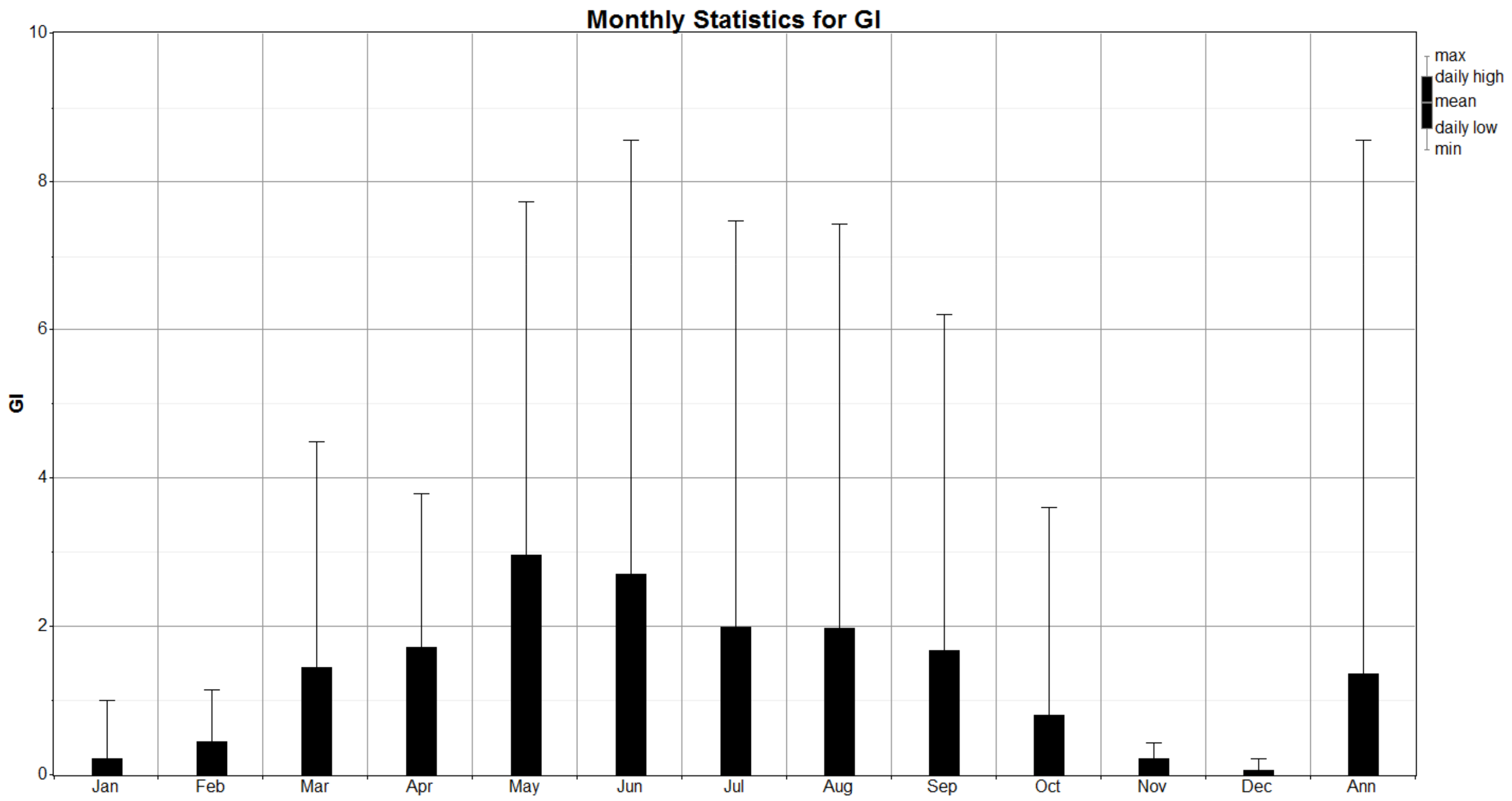
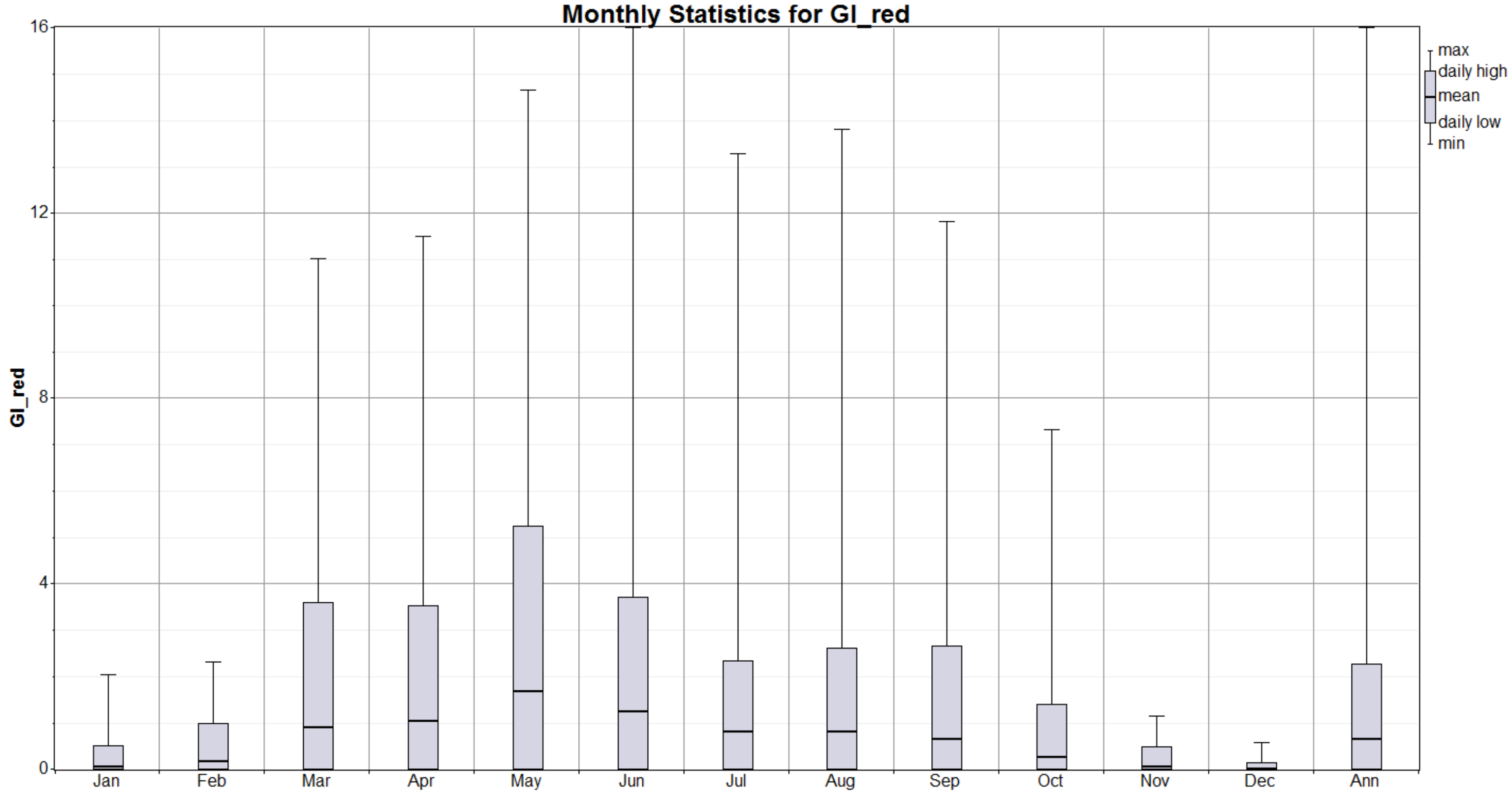


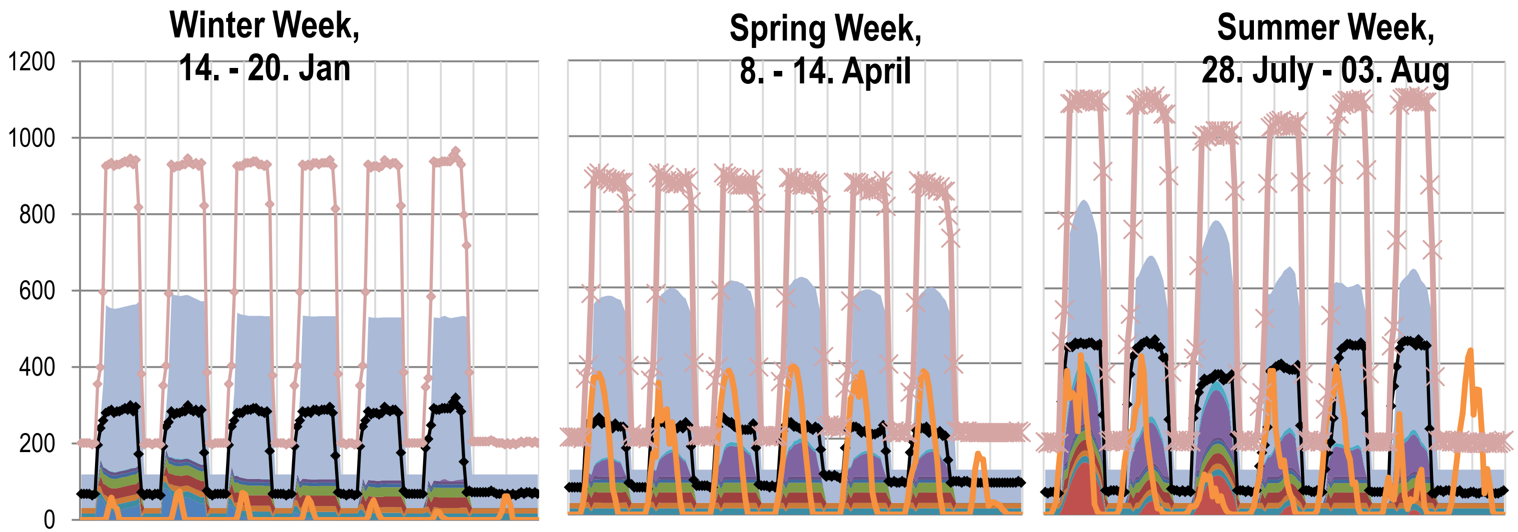
Results


Monthly Statistics for GI
GI
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ann
max
daily high
mean
daily low
min

Results


Monthly Statistics for GI_red
GI_red
16
12
8
4
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ann
max
daily high
mean
daily low
min

Results – including tenants



- 1 MW PV system

Conclusions

- The results show that there is considerable potential for the use of generation coming from renewable energy sources.
- Peak shaving of power demand is possible but limited. It seems that PV production will exceed the energy needs only if they are strongly reduced.
- Grid interaction increases which gives options for energy storage (batteries).

- When tenants energy use is included, more work is needed in order to optimize the design of the building and the technical systems.
- Other RE sources should be considered (Wind power?).

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THANK YOU!