Aalto University
School of Engineering

Sharing heat and electricity in a building cluster

IBPSA-Nordic Seminar 2013

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Background

- Roughly 40 % of energy consumption comes from buildings.
- Incentive towards nearly zero energy buildings (nZEB) in Europe and Japan.
- Increasing popularity of CHP in Japan.

Energy mismatch in nZEB

- Solar and wind energy not matched to demand
- CHP waste
  - Heat and electricity needs differ
  - Idle capacity
- Buying and selling energy not equally valuable

⇒ Large storages or energy sharing

Net zero energy clusters

Equip buildings with renewable energy generation and combine them into a cluster.

- Share heat and electricity within the cluster
  - Lower relative peak demand
    - Less maximum generation capacity needed per building
  - Less storage capacity needed
  - Less energy wasted
  - Neighbours benefit from green energy

Basic setup

TRNSYS simulation with premade energy consumption profiles for office (5000 m^2) and residential (20 000 m^2) buildings. The energy system consists of

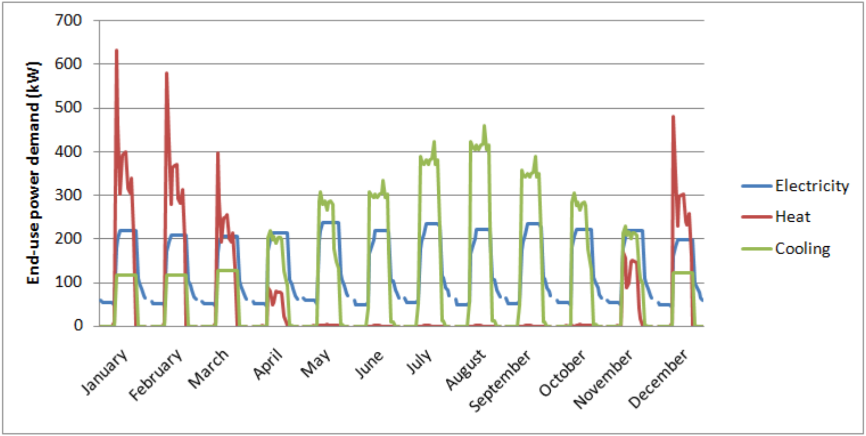
- Electricity
  - CHP
  - Grid
- Heating
  - CHP
  - Boiler
  - Thermal storage
- Cooling
  - Absorption chiller
  - Vapor compression chiller

CHP and fuel

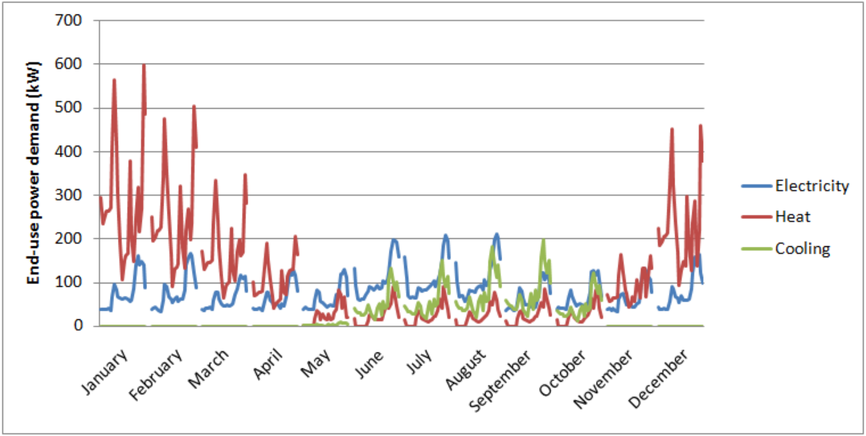
Energy type	CHP efficiency
Electrical	33 %
Thermal	50 %

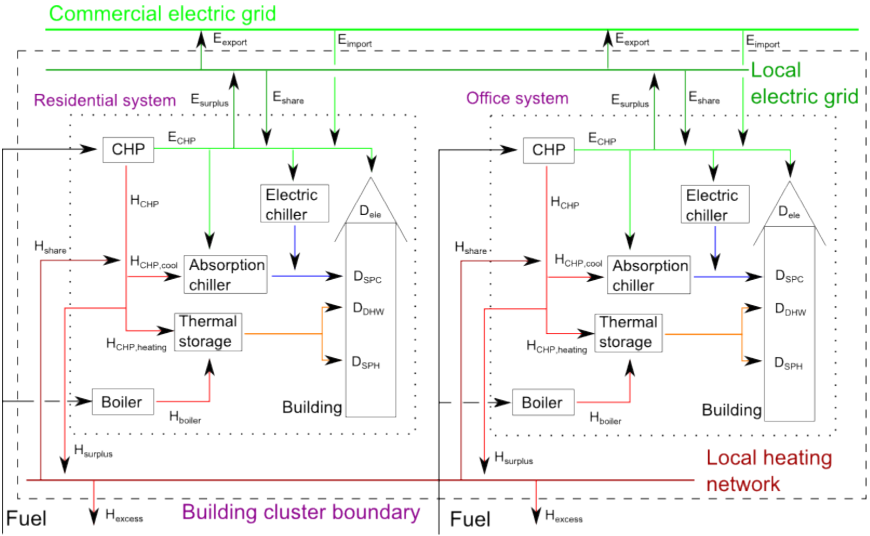
Energy source	PEF ($\mathrm{kWh}_{PE}/\mathrm{kWh}_{end-use}$)
Biogas	0,14
Natural gas	1,05
Grid electricity	2,77

Energy demands of the office for one typical day of each month



Energy demands of the residential buildings for one typical day of each month




Commercial electric grid
E_export
E_import
E_export
E_import
Local electric grid
Residential system
E_surplus
E_share
Office system
E_surplus
E_share
CHP
E_CHP
H_CHP
Electric chiller
D_ele
H_share
H_CHP,cool
Absorption chiller
D_SPC
D_DHW
Thermal storage
H_CHP,heating
D_SPH
Boiler
H_boiler
Building
H_surplus
Local heating network
Fuel
H_excess
Building cluster boundary

Cases

16 cases with one or two CHP plants.
Different CHP operation modes and sizes.

1. Peak electric tracking
2. Constant operation
3. Electric tracking
4. Thermal tracking
5. Hybrid tracking

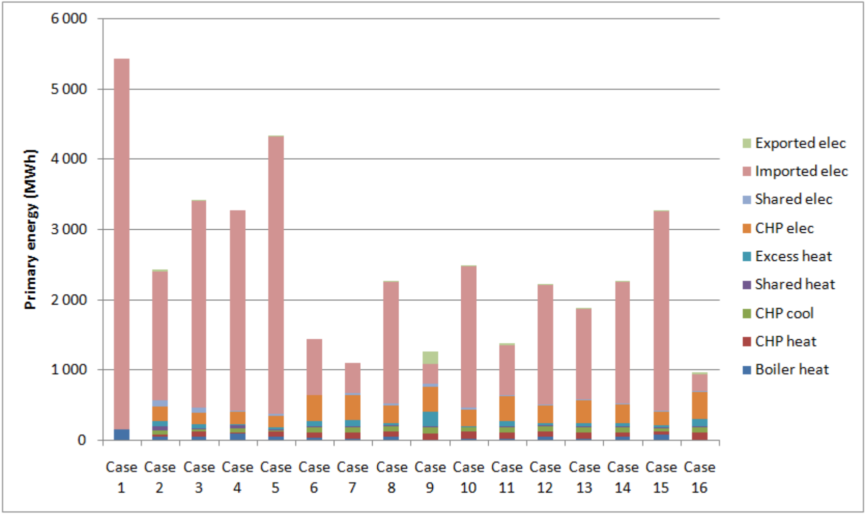
Individual tracking, only excess is shared.
Biogas and natural gas as fuel.

Gross CHP capacities and operation modes.

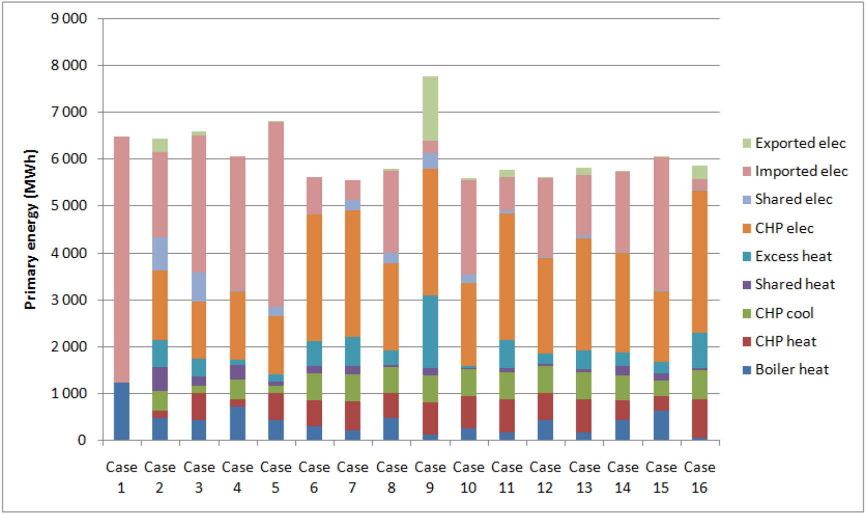
Case	Residential CHP capacity (kW)	Office CHP capacity (kW)	Residential CHP mode	Office CHP mode
1	0	0	-	-
2	0	450	-	2
3	350	0	2	-
4	0	450	-	5
5	350	0	5	-
6	350	450	3	3
7	350	450	3 *	3
8	350	450	1	1
9	350	450	2	2
10	350	450	4	4
11	350	450	5	5
12	350	450	3	4
13	350	450	4	3
14	120	450	2	5
15	120	160	2	2
16	500	600	5	5

* Residential system follows the combined electric load of office and residential.

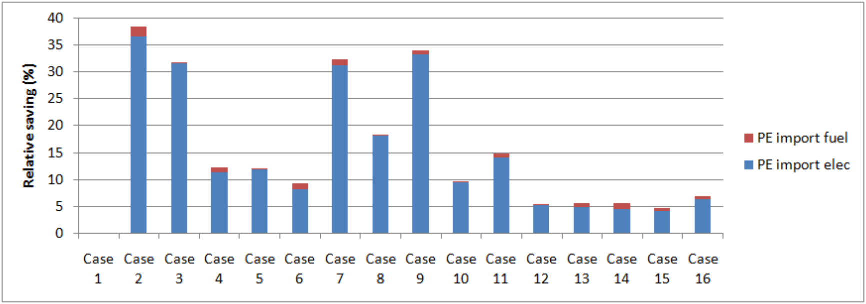
Primary energy consumption with biogas



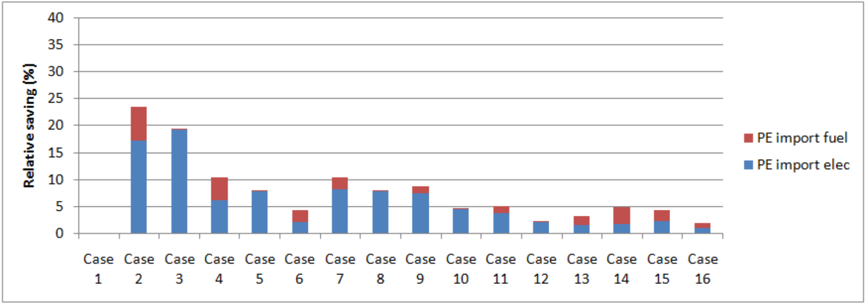
Primary energy consumption with natural gas



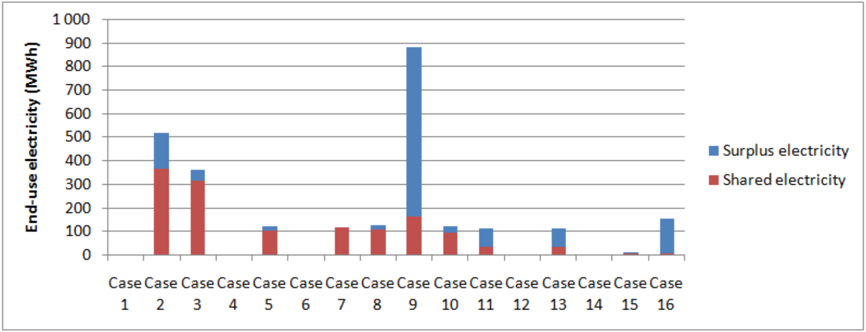
Reduction in PE consumption due to sharing with biogas



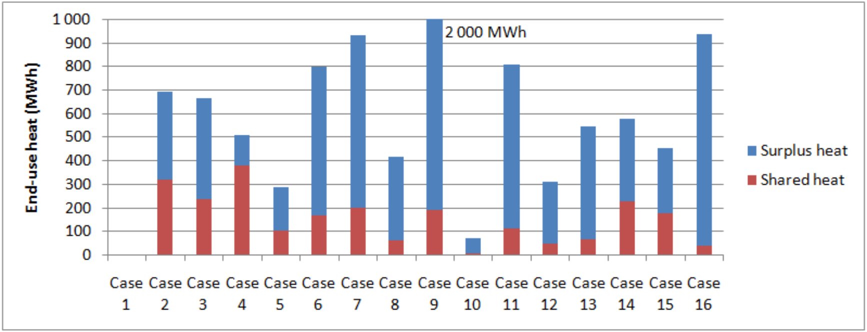
Reduction in PE consumption due to sharing with natural gas



Surplus electricity that was exported or shared to neighbour



Surplus heat that was wasted or shared to neighbour



Conclusions

Local energy sharing decreased primary energy consumption by 5 . . . 38 % with biogas and by 2 . . . 23 % with natural gas.

Main PE benefit of heat sharing came from reduced electric cooling demand.

If demand peaks differ, idle capacity from smaller CHPs can be leased to neighbours to meet the same demand as with larger CHPs, but with less wasted energy.

Excess energy was minimized when using just a single demand tracking CHP.

Future steps

- Economics
    - Money from exporting vs. sharing
    - Varying electricity prices depending on time
- Different consumption profiles
    - Variance between domestic buildings
    - Other building types
    - More buildings
- Solar and wind energy

THANK YOU FOR LISTENING!