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Simulation analysis of energy sharing effects in a cluster of buildings

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Background

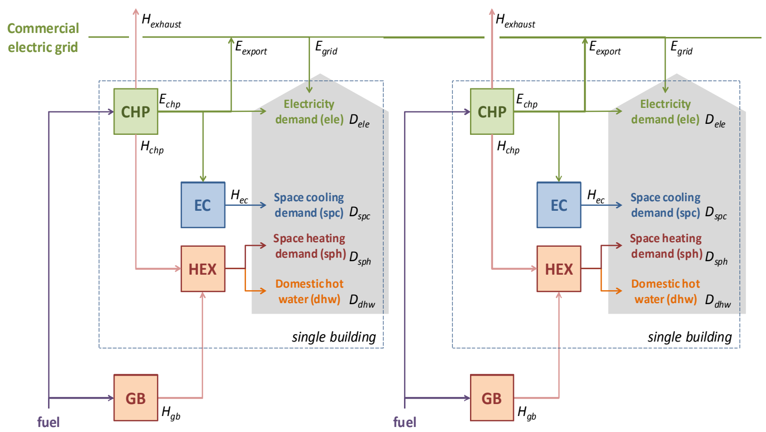
- Buildings account for roughly 40% of total energy consumptions in Europe, and the Energy Performance of Buildings directive (EPBD) was issued low energy consumption and emissions. All new buildings must be nearly zero energy building (ZEB) by 2020. However, it is said that achieving a ZEB status without the grid would be quite difficult.
- This study, thus, focuses on ZEB approaches not only single building but also some buildings, so called "energy community".
- **Hence, questions of the problem are what composition of energy system each building should have, how each building should be connected each other for sharing energies, or when and how much energies should be utilized among buildings. Simulation analysis, thus, was done to understand the effects.**

Zero Energy Community

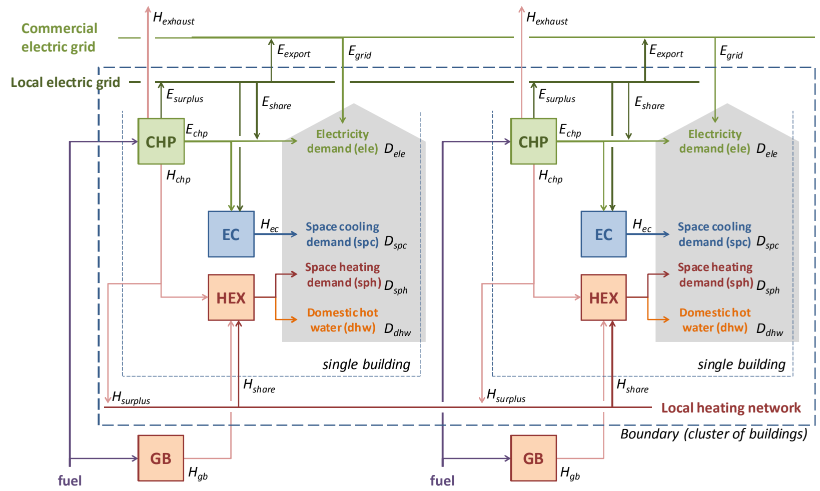
- a cluster of buildings, in which every building can generate both of electricity and heat with micro-generation technologies such as CHP or photovoltaic panels, and can share both of energies among themselves.

- Separated buildings vs. a cluster of buildings with sharing energy

Buildings boundary and energy flow in <u>two separated buildings</u>



Boundary and energy flow in the case of cluster of buildings with sharing energy

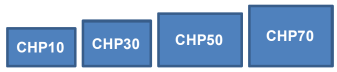


Four buildings

		Office 6,000m²	Hotel 6,000m²	Hospital 6,000m²	Shopping center 6,000m²
single building	case1	x			
	case2		x		
	case3			x	
	case4				x
cluster of buildings	case12	x	x		
	case13	x		x	
	case14	x			x
	case23		x	x	
	case24		x		x
	case34			x	x
	case123	x	x	x	
	case124	x	x		x
	case134	x		x	x
	case234		x	x	x
	case1234	x	x	x	x

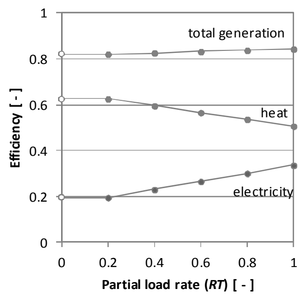
Local energy production (CHP)

- **Capacity**
  - Four sizes of capacity depending on peak electricity demand



$$P_{chp.e} = xE_{peak}$$
$$x \in [0.1 \quad 0.3 \quad 0.5 \quad 0.7]$$

- **Partial load rate**



- **Operation strategies**
  - Electricity tracking operation
  - Heat tracking operation
  - Constant operation

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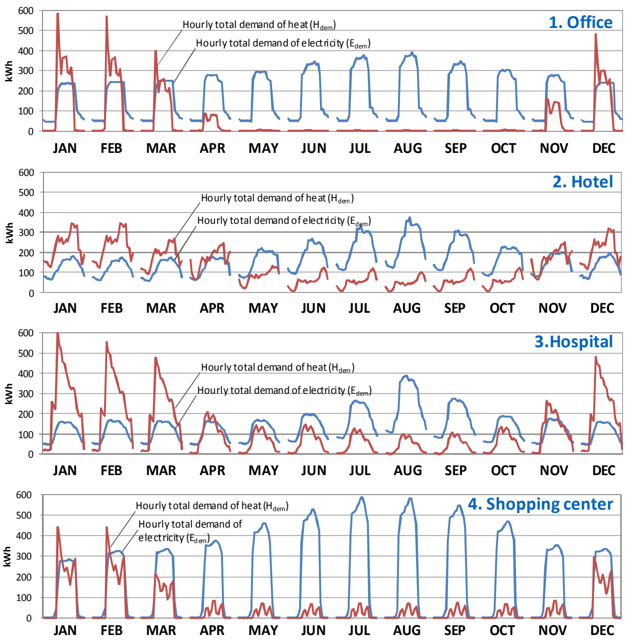
Demand data

- **CASCADE III**
  - Japanese averaged buildings data measured by gas company
  - Peak load (W/m^2) and annual load (kW/m^{2}a, MJ/m^{2}a)
  - Hourly data of averaged day (24hrs * 12 months = 288 data)
- **Demands**
  - Electricity (kWh), Domestic hot water (MJ), Space heating (MJ) and Space cooling (MJ)
- **Buildings**
  - Office[1], Hotel[2], Hospital[3], and Shopping center[4]



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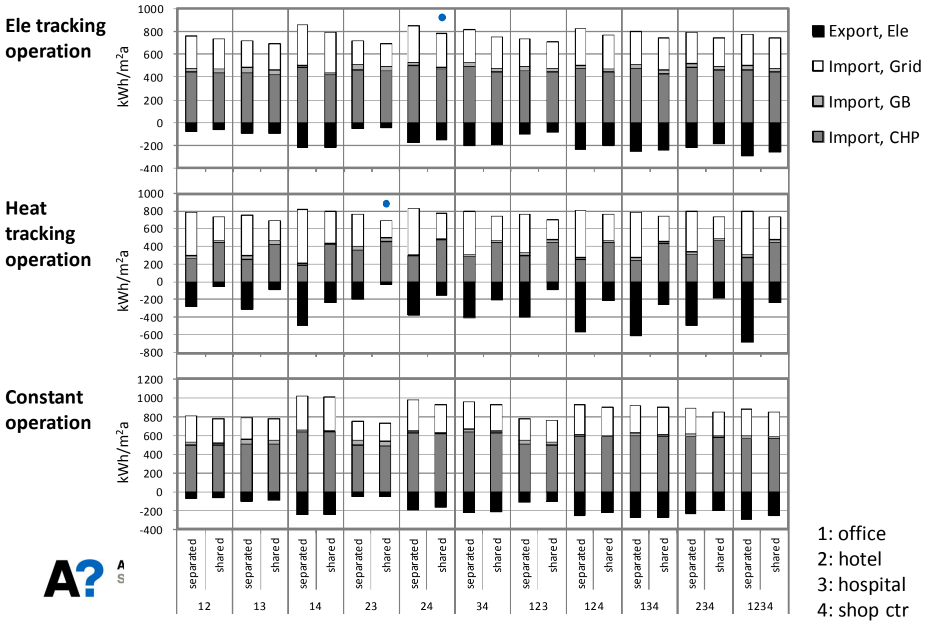
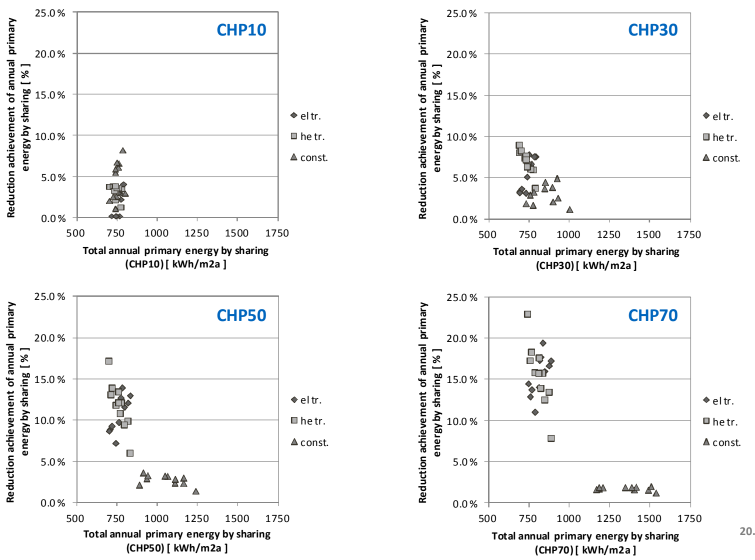
Annual primary energy per floor area (CHP30)



Reduction achievement of annual primary energy by sharing



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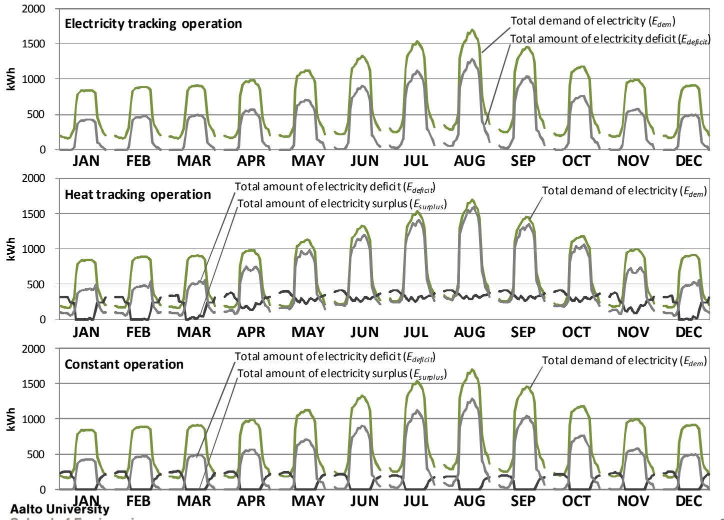
Hourly surplus and deficit of each month day, Electricity balance (CHP30, case1234)



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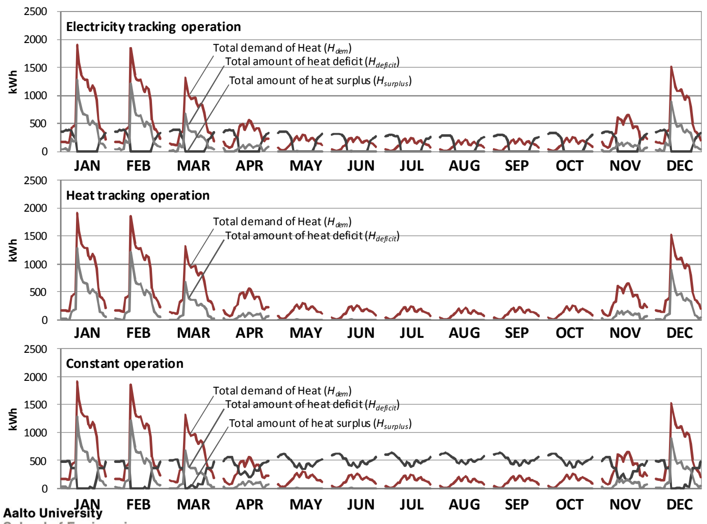
Hourly surplus and deficit of each month day, Heat balance (CHP30, case1234)



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Conclusions

- The comparisons of primary energy consumption show that the energy sharing cases have advantage of energy management within the boundary compared with buildings as separated cases.

- Energy sharing with **small CHP (CHP30)**, it is effective among combinations of buildings that have electricity dominant and heat dominant demand;
  - a hotel and a shopping center with electricity tracking op. is expected to reduce 7.8% PE.
  - a hotel and a hospital with heat tracking op. is expected to reduce about 9% PE.
- Energy sharing with **large CHP (CHP70)**, it is expected among buildings with the combinations of both of electricity dominant or both of heat dominant;
  - a hotel and a hospital by heat tracking op. is expected to reduce 23% PE.

- The results of this study show the advantage of energy sharing depends on the combination of the types of the buildings and the CHP operation strategies.

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Thank you for your attention

Question?

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