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Energy sharing effects in a cluster of buildings in the context of energy market changes

Genku Kayo

Department of Energy Technology, Aalto University, Espoo, Finland

genku.kayo@aalto.fi

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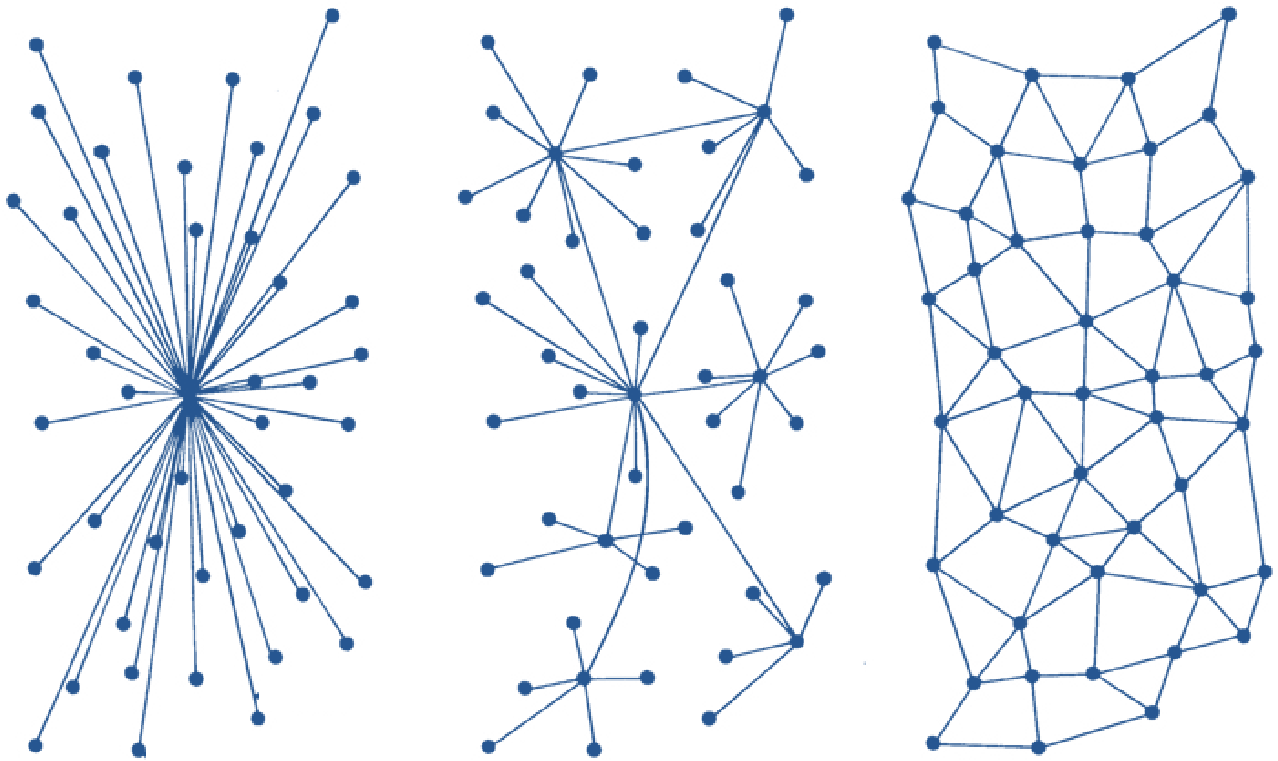
Background

- **Zero Energy Building (ZEB)/ Zero Carbon Building (ZCB)**
  - Energy Performance of Buildings directive (EPBD) says that all new buildings must be **nearly ZEB** by 2020.
  - However, it is said that achieving a ZEB status **without the grid** would be quite difficult.

- **Zero Energy Community/ Zero Carbon Community**
  - focuses on ZEB approaches not only single building but also a group of buildings, so called "**energy community**".
  - is **a cluster of buildings**, in which every building can generate both of electricity and heat with micro-generation technologies such as CHP or PV, and can share both of energy among themselves.

Network of energy distribution

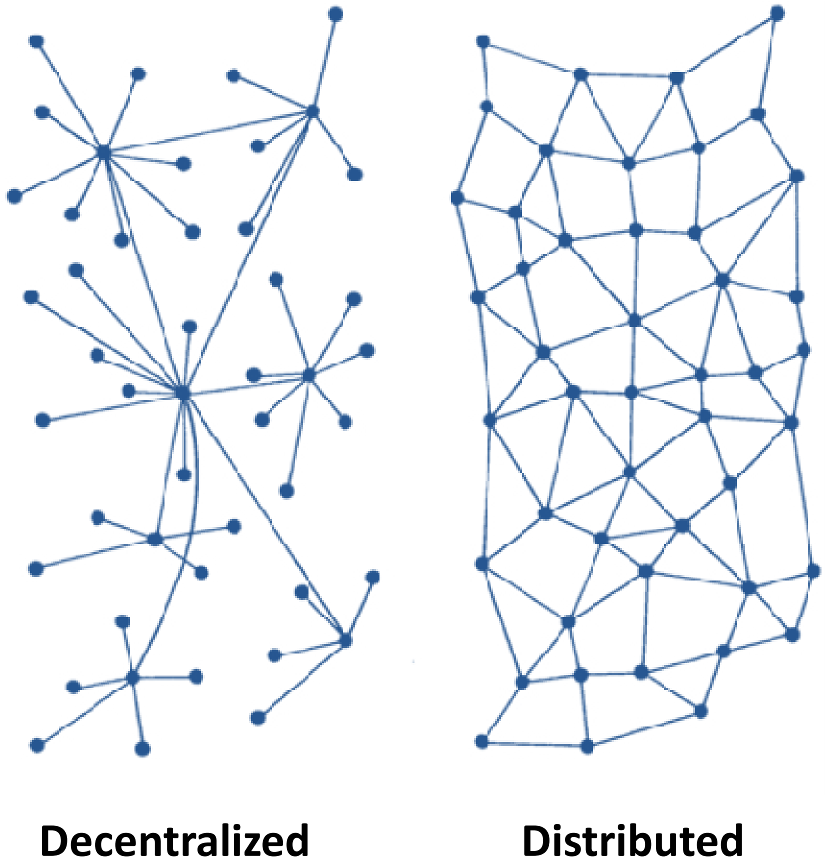


Centralized Decentralized Distributed

www.carlsterner.com/research/2009_resilience_and_decentralization.shtml

Questions

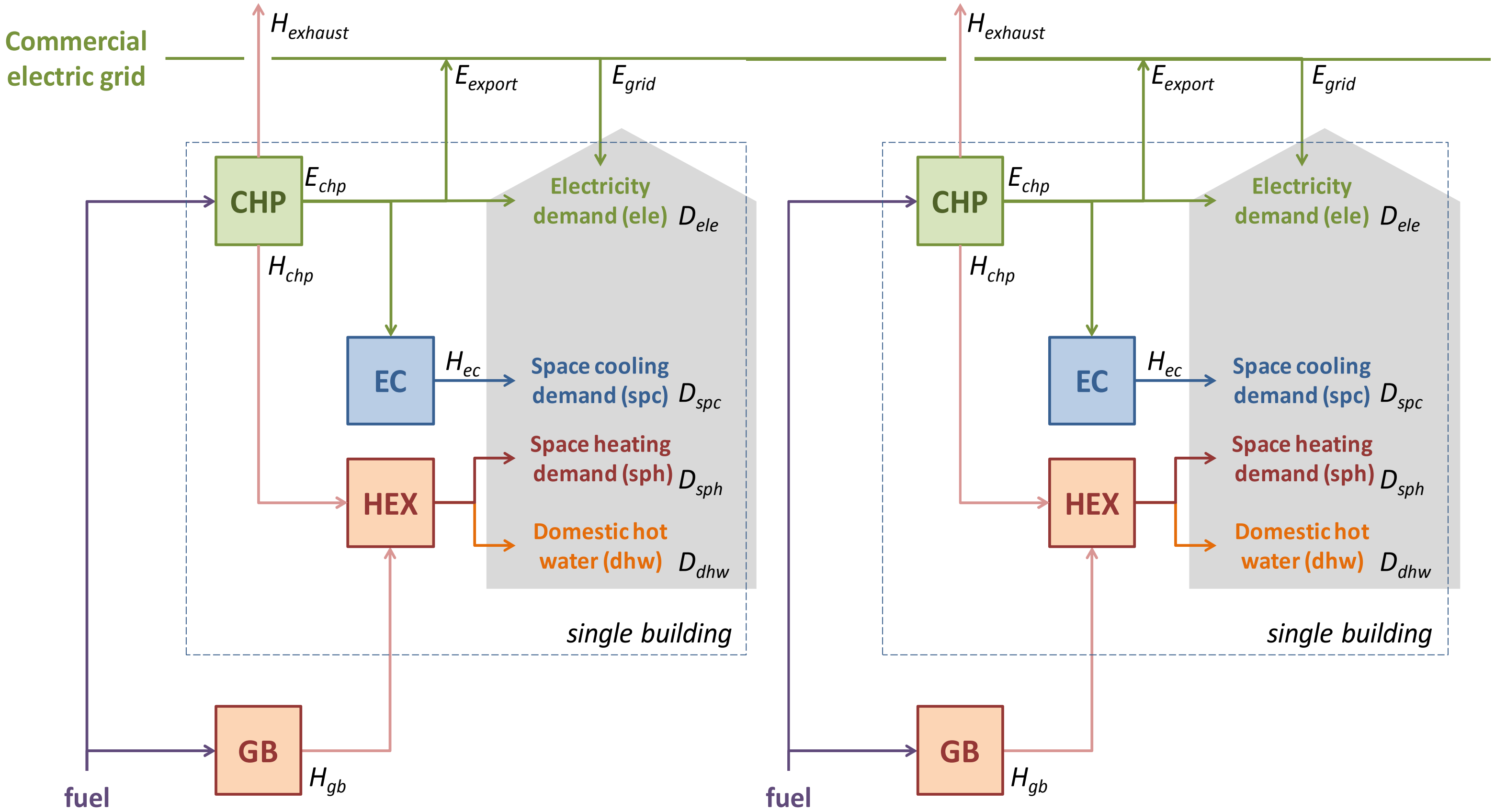
- Best coupling of buildings.
- When and how much energies should be utilized among buildings.
- Optimal capacities of generation, and optimal operation modes.
- Ideal energy system composition of each building (CHP, renewables, etc.).
- Integration of local energy systems and building energy systems. (e.g. District heating network)



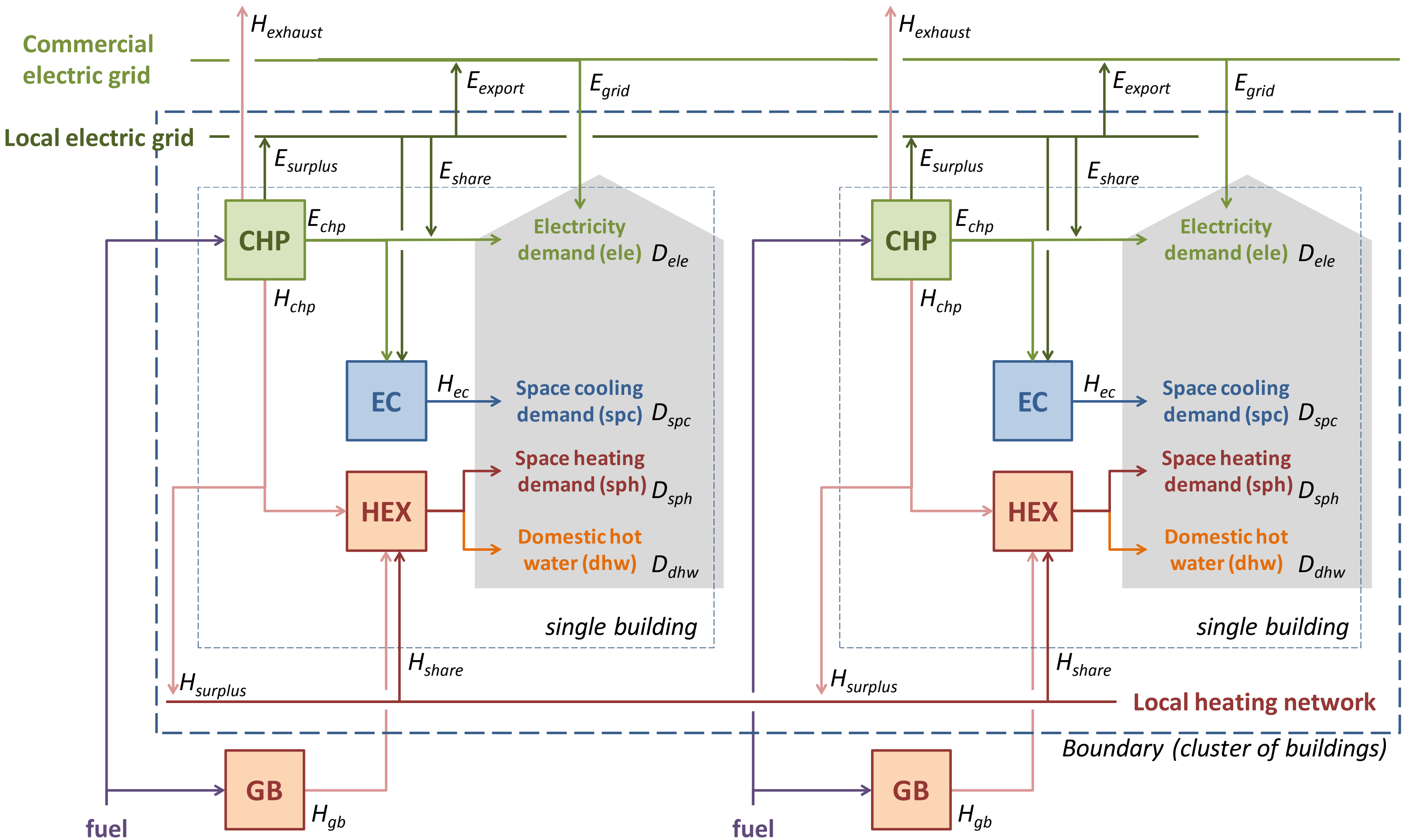
Methodology

– Energy system
– Case study
– Demand profile
– Local energy production (CHP)

Boundary and energy flow in the case of two separated buildings



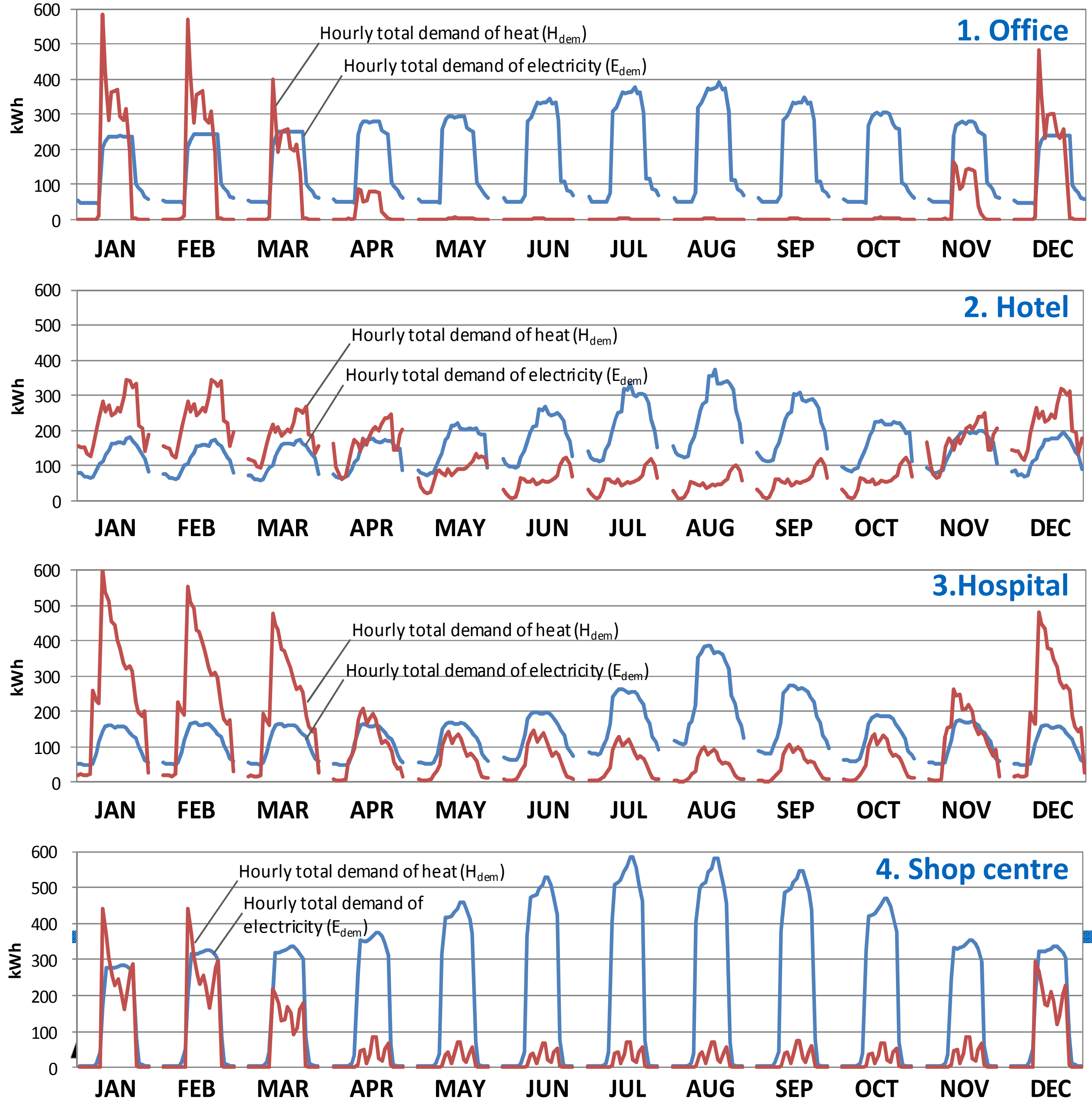
Boundary and energy flow in the case of cluster of buildings with sharing energy



Four different buildings in this study

	1: Office 6,000m²	2: Hotel 6,000m²	3: Hospital 6,000m²	4: Shop centre 6,000m²
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

Demand profile



Averaged buildings data measured by gas company, Japan

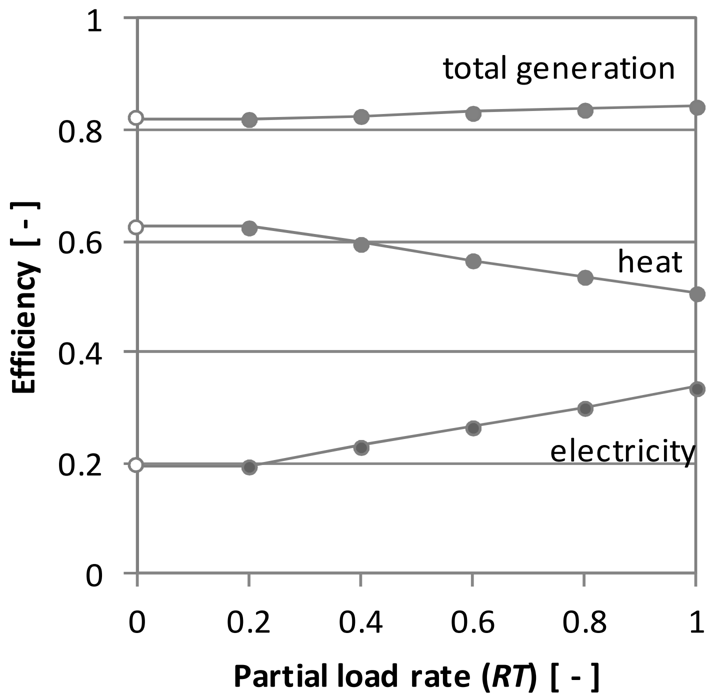
Hourly data of averaged day (24hrs * 12 months = 288 data)

Local energy production (CHP)

- **Capacity: $P_{chp.e}$**
  - Depending on peak electricity demand

$$P_{chp.e} = 0.3E_{peak}$$

No.	Building type	$P_{chp.e}$
1	Office	117
2	Hotel	111
3	Hospital	116
4	Shopping centre	175

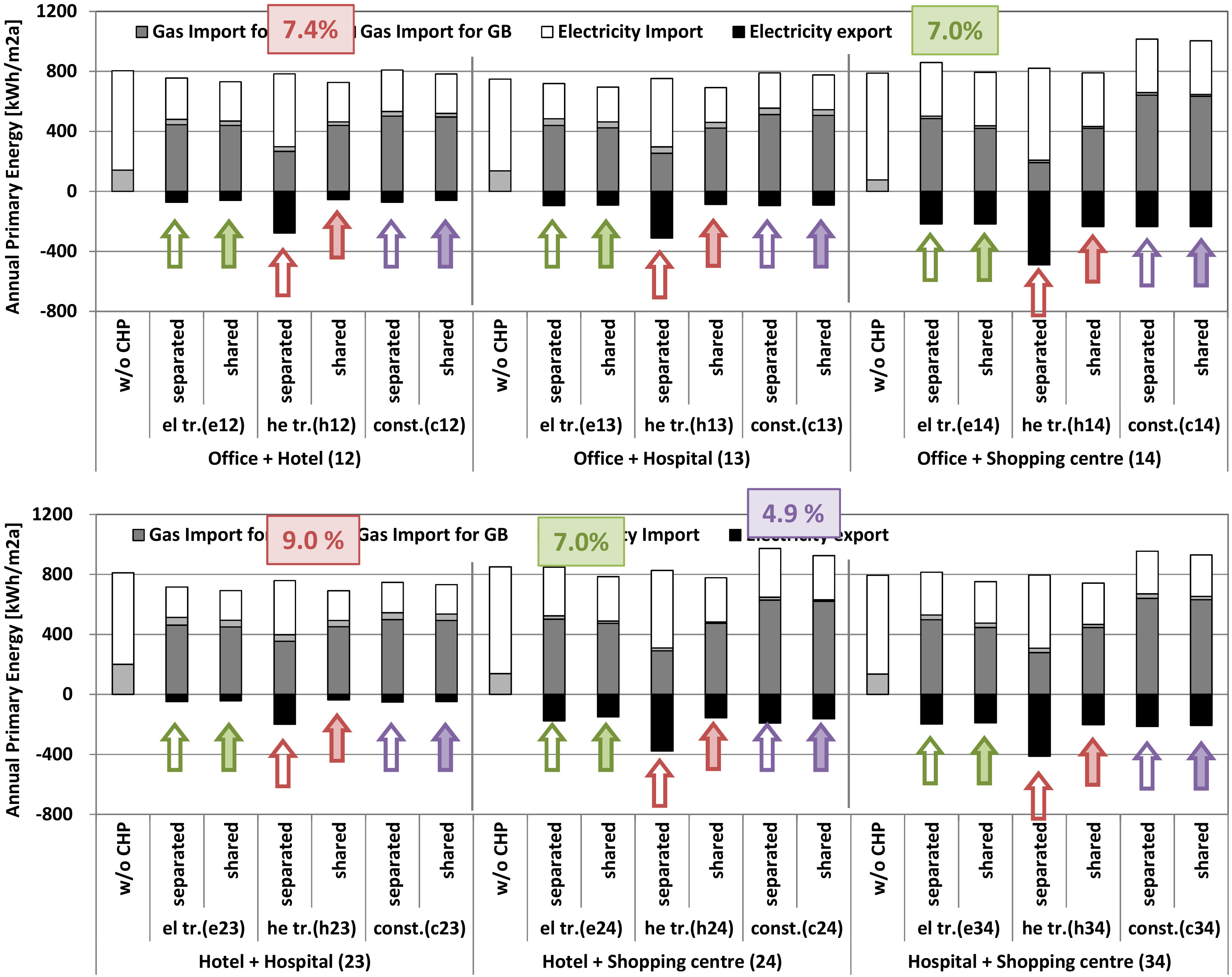


- **Operation strategy**
  - Electricity tracking operation (*el tr.*)
  - Heat tracking operation (*he tr.*)
  - Constant operation (*const.*)

Result

– **Annual primari energy**

Annual primary energy (Connected 2 buildings)



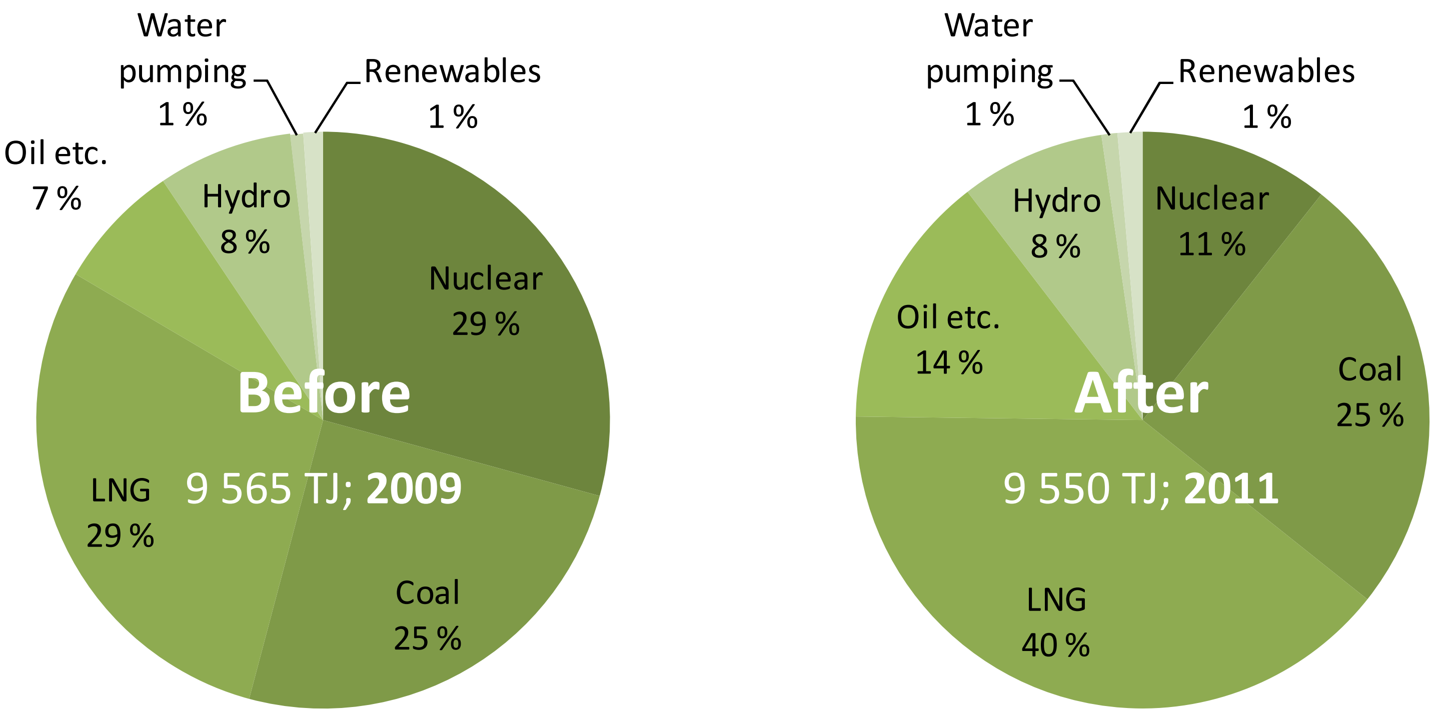
Ecological and economical study

- CO_2 emission
- Operation cost

Dramatic changes in energy situation

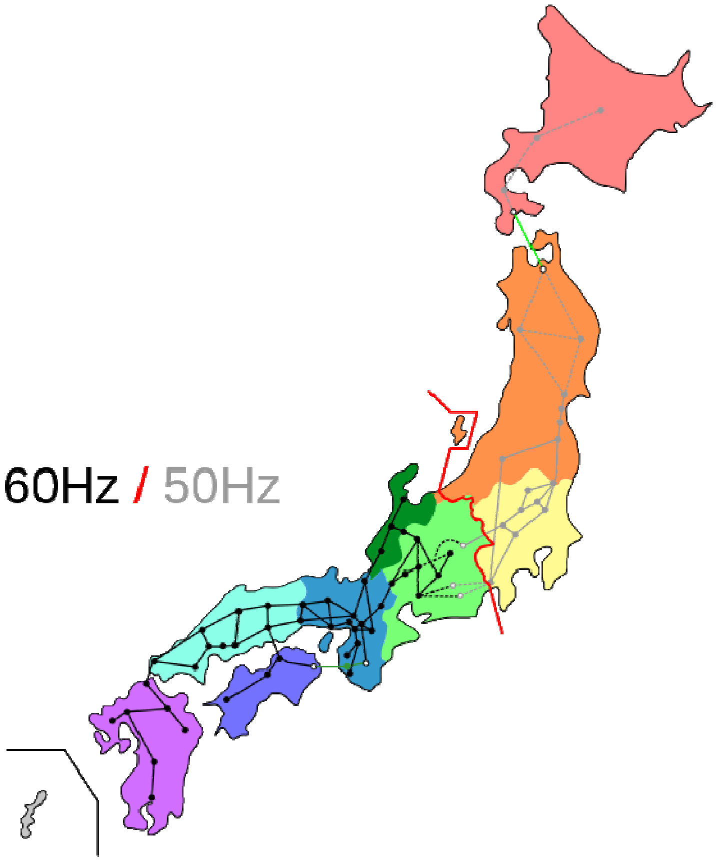
before and after the accident, March 2011

Power Supply Configuration in Japan



Energy white paper 2013, Agency for Natural Resources and Energy
www.enecho.meti.go.jp/topics/hakusho/2013energyhtml/2-1-4.html

CO_2 emission factors of power companies

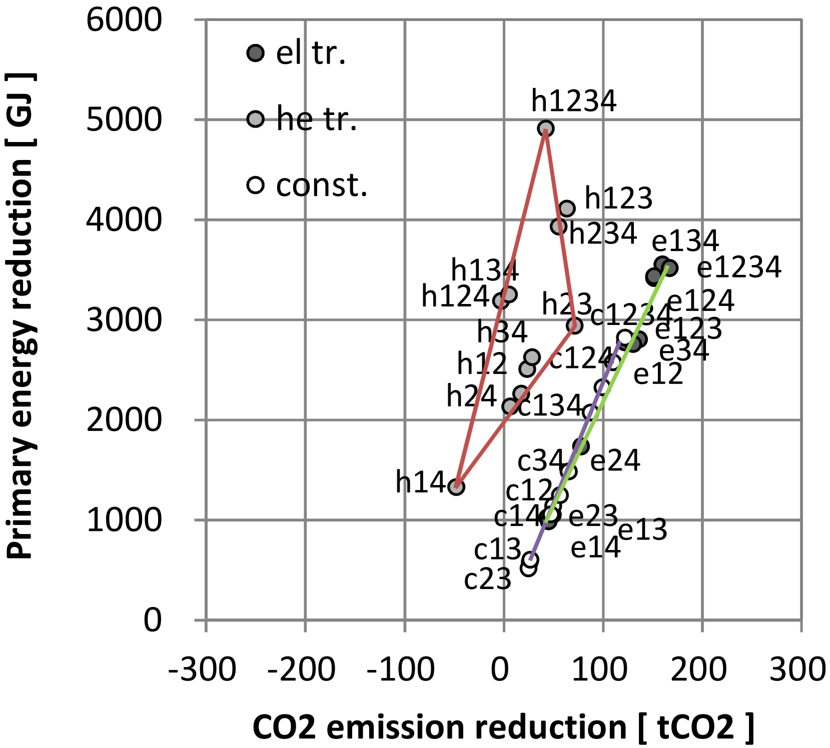


$kg\text{-}CO_2/kWh$	Before the accident 2009	After the accident 2012	
Hokkaido	0.433	0.688	159 %
Tohoku	0.468	0.600	128 %
Tokyo	0.384	**0.525**	137 %
Chubu	0.474	0.516	109 %
Hokuriku	0.374	0.663	177 %
Kansai	0.294	0.514	175 %
Chugoku	0.628	0.728	116 %
Shikoku	0.407	0.700	172 %
Kyusyu	0.369	0.612	166 %
Okinawa	0.931	0.903	97 %

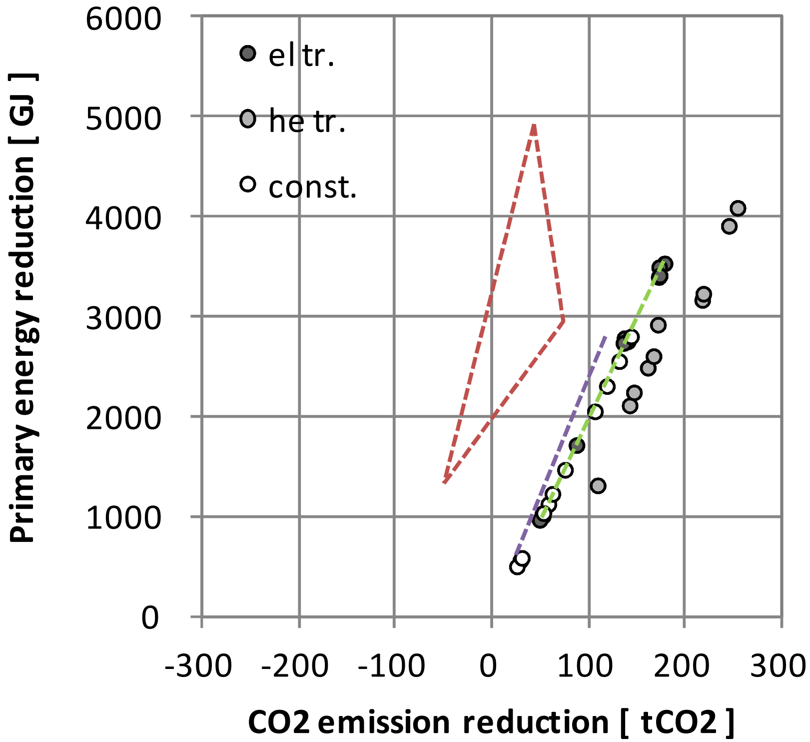
www.sapporo-convention.net/toolkit/coefficient.html
www.itmedia.co.jp/smartjapan/articles/1312/26/news014.html
ja.wikipedia.org/wiki/%E9%9B%BB%E7%B7%9A%E8%B7%AF

CO2 emission reduction by energy sharing

Before the accident; 2009
0.384kg-CO_2/kWh



After the accident; 2012
0.525kg-CO_2/kWh



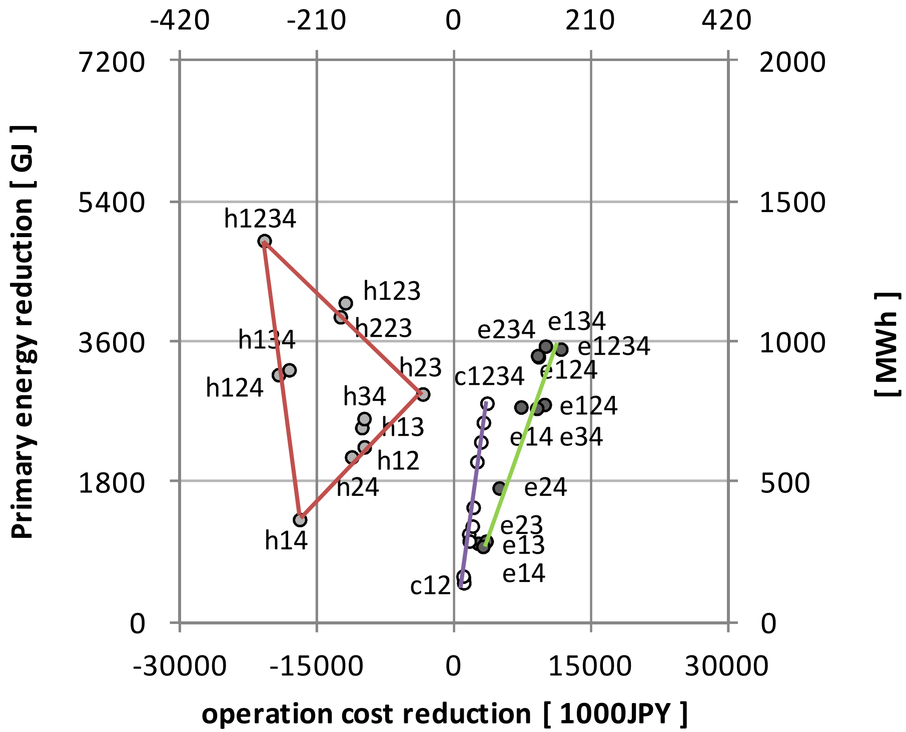
Gas: 0.175kg-CO_2/kWh

/m2

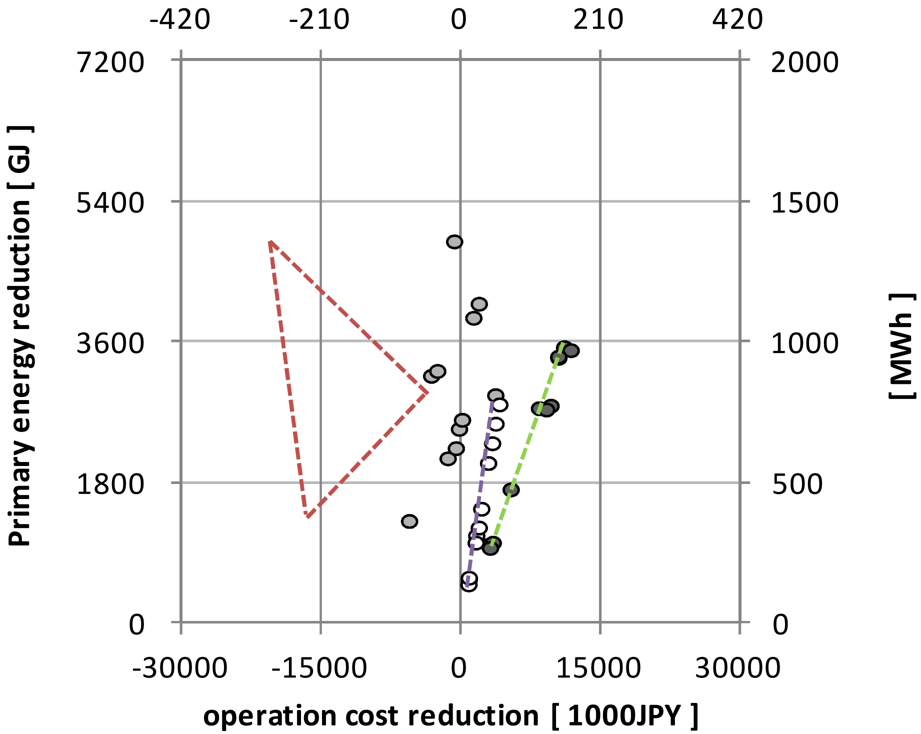
Operation cost reduction by energy sharing

If the electricity price were raised,

Electricty price; 21 JPY/kWh



Electricty price; <u>31.5</u> JPY/kWh



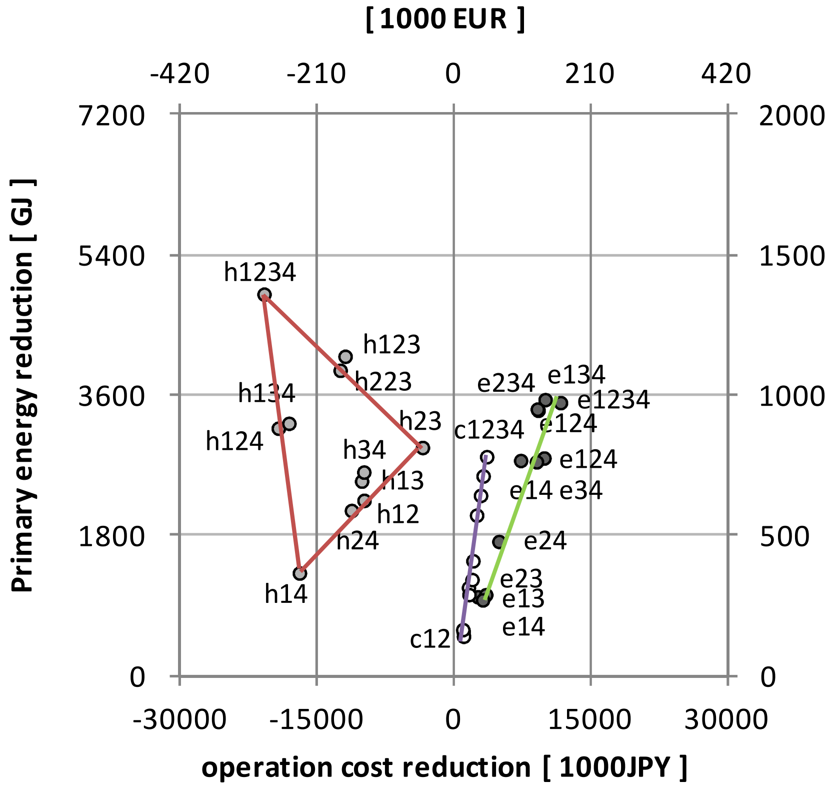
Gas: 12.5 JPY/kWh

/m2

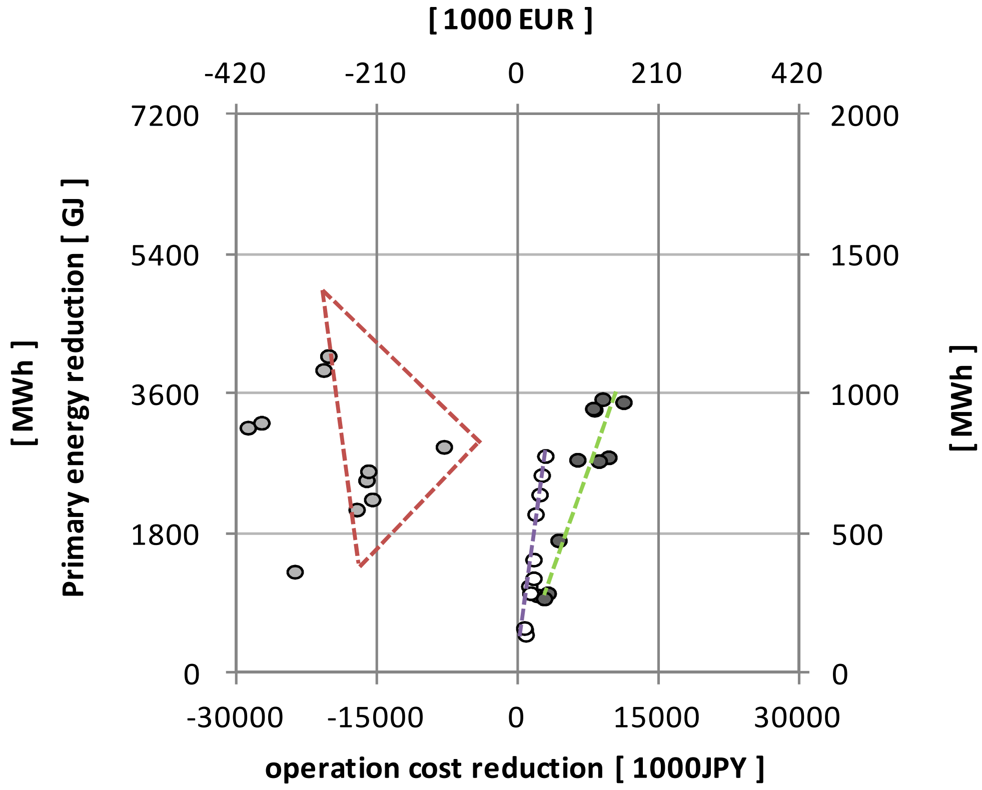
Operation cost reduction by energy sharing

if the electricity selling price were doubled in FIT,

Electricty selling price; 6 JPY/kWh



Electricty selling price; <u>12</u> JPY/kWh



Gas: 12.5 JPY/kWh

/m2

Conclusions

- **Primary energy consumption**
  - It can be reduced by sharing both electricity and heat.
  - Advantage of energy sharing depends on how the various types of buildings and CHP operational strategies are combined.
- **CO_2 reduction and Operation cost**
  - Energy sharing has the possibility to provide resiliency against economic and environmental changes by considering CHP operation modes and combinations of buildings.
- **Future research**
  - In the case of Japanese Feed-in Tariff, the market prices for buying/selling electricity differ according to the renewable energy compositions. Thus it should be considered into scenarios that involve other forms of renewable energy.
  - Energy market situations of different countries should also be studied.

Thank you for your attention!
and Question?

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genku.kayo@aalto.fi

Annual primary energy (Connected 3, 4 buildings)