Optimization of an SOFC-based decentralized polygeneration system for providing energy services in an office-building in Tōkyō

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Goal and description

Define optimal configurations for an SOFC-based decentralized polygeneration (energy) system:

Providing:

heating, cooling and electricity services to a building

Minimizing:

Total costs

CO_2-emissions

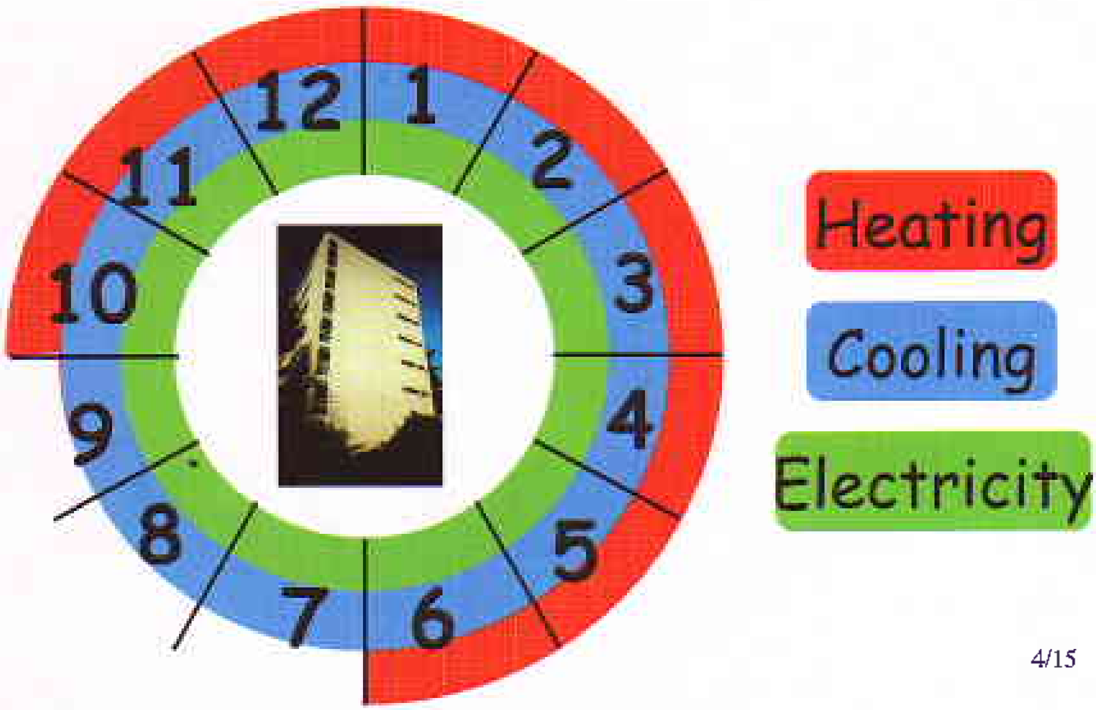
➡ Compare with the current situation.

Building description

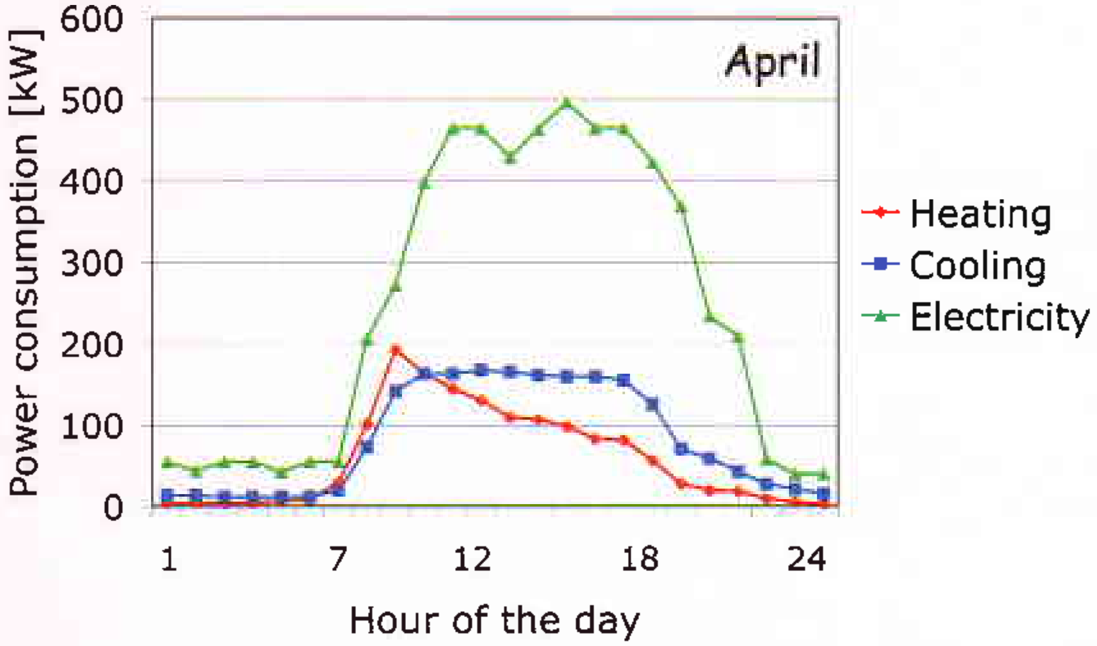
- 10 floors
- 20 offices per floor, 50m^2 per office-room
- 12 working-hours per day

www.unice.fr/LPCM/

Energy services required throughout the year

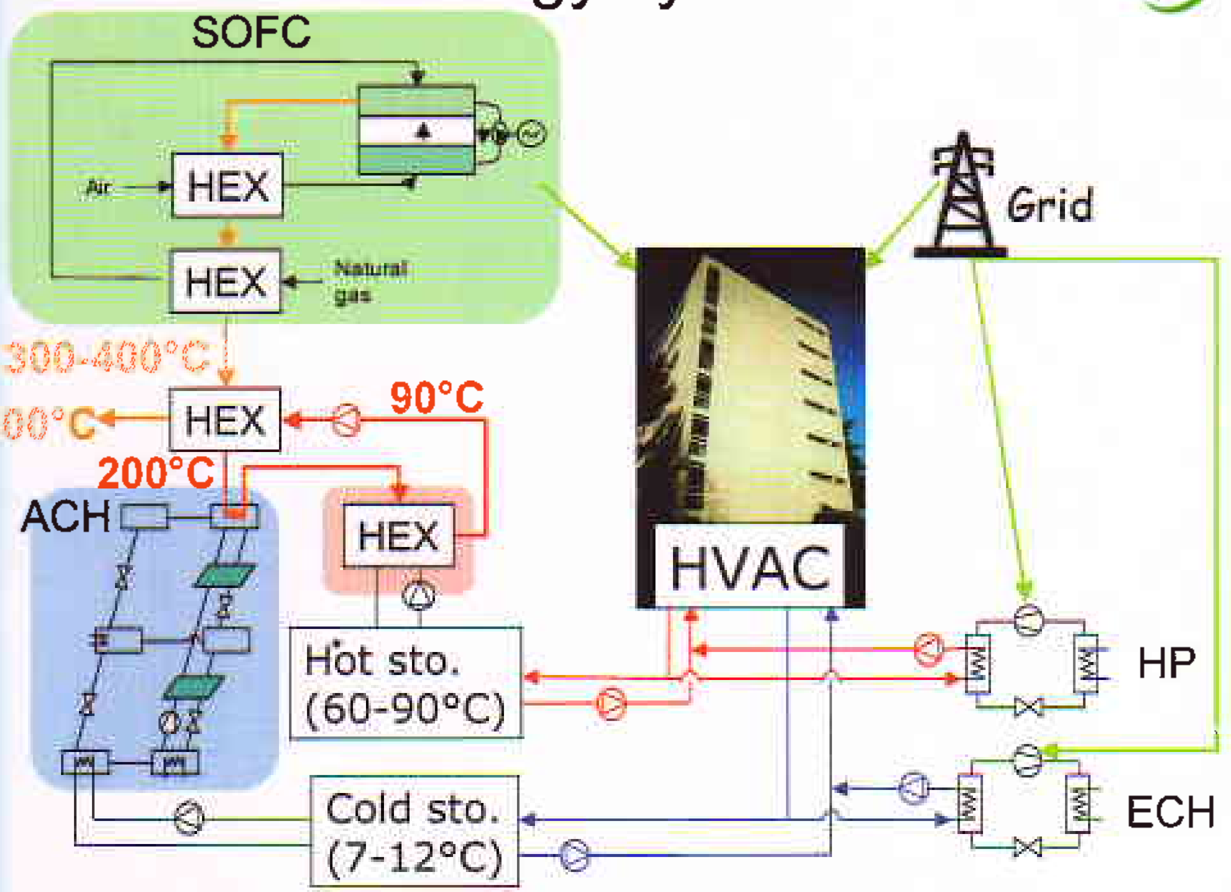


Daily consumption profiles

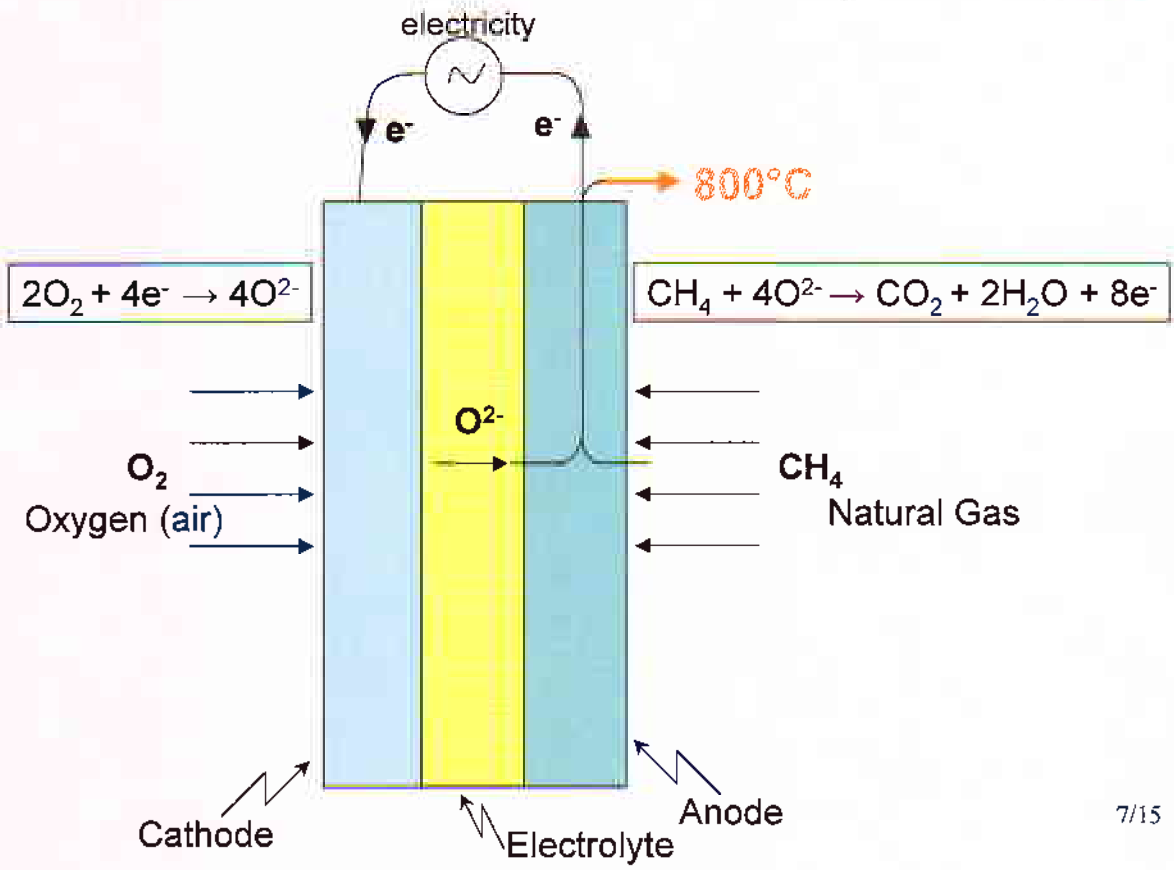


➡ One daily profile for each energy requirement per month

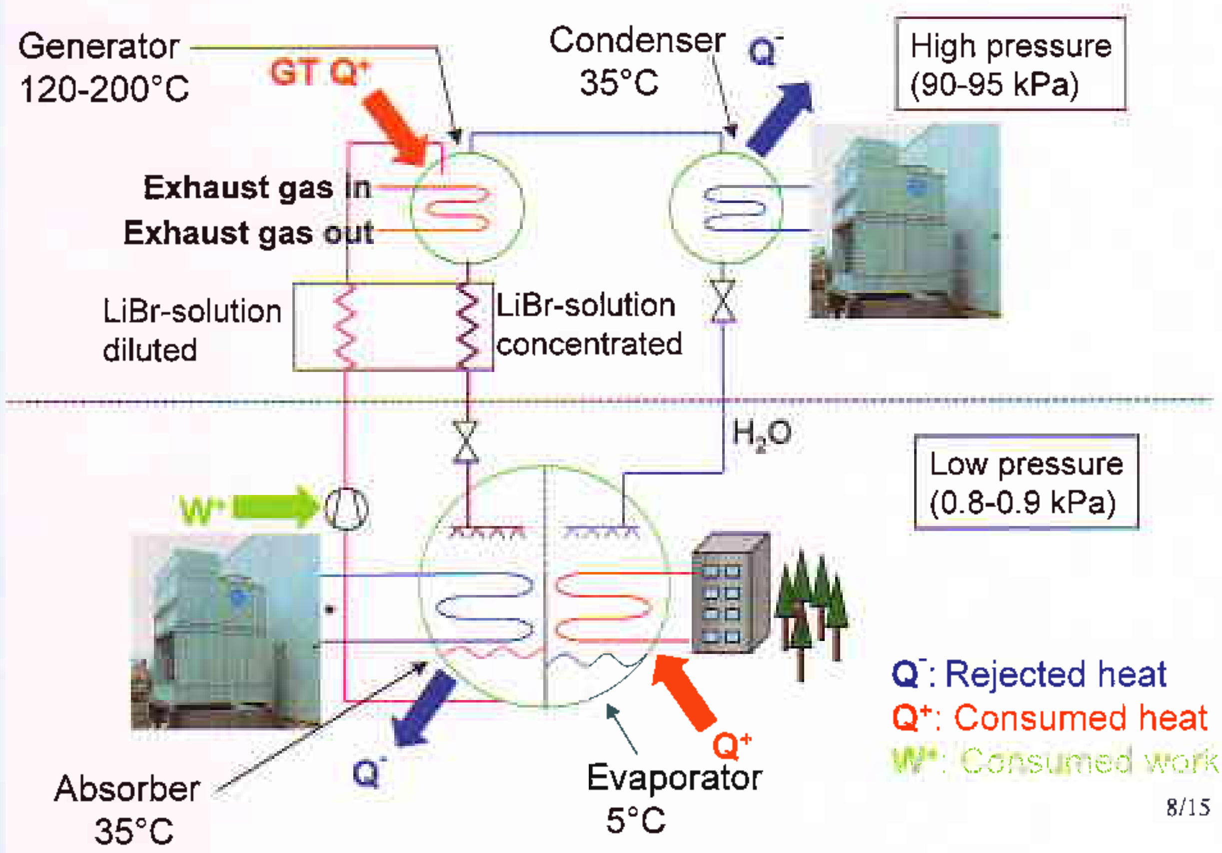
Energy system



Solid Oxide Fuel Cell (SOFC)



Absorption-chiller



Efficiency of the devices

SOFC:

$$\eta_{el} = \frac{el_{SOFC}}{Fuel \cdot LHV} = 46 - 53\%$$

η_{el}: Electrical efficiency of the SOFC [-]
el_SOFC: Electricity generated by the SOFC [kW]
Fuel: Fuel flow [mol/s]
LHV: Lower heating value [kJ]

Absorption-chiller:

$$COP = \frac{Cooling\_load}{Heat\_load} \cong 1.15$$

COP: Coefficient of performance [-]
Cooling_load: Cooling provided by the chiller [kJ]
Heat_load: Heat required by the chiller in the generator [kJ]

MO-NLP

Multi-objective optimization problem on two levels, investment and operational.

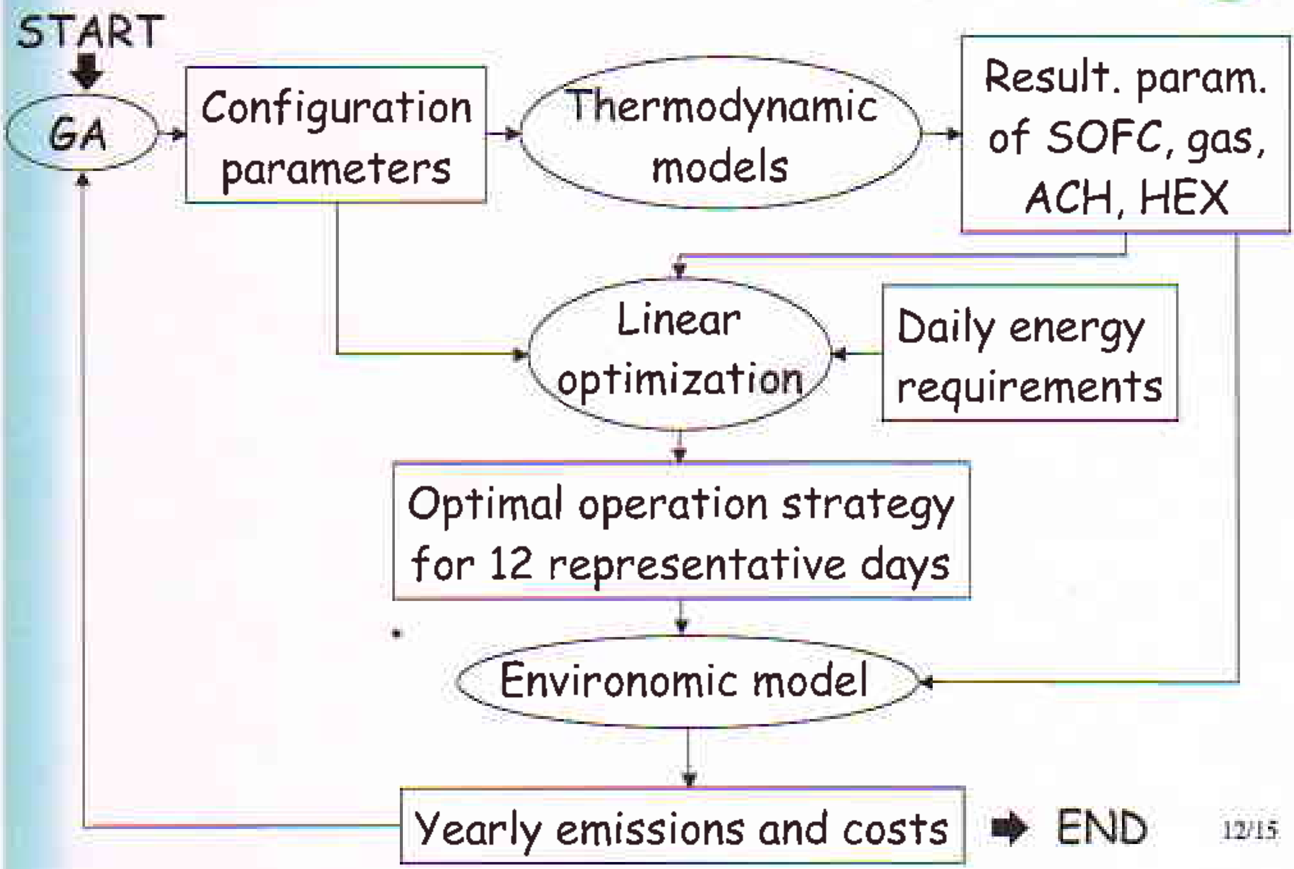
Min: Costs, CO_2-emissions
Subject to: Thermodynamic models
Electricity balance
SOFC part-load ≥ 0.3 * SOFC size

Decision variables

1. Multi-objective genetic algorithm:
   Configuration parameters: sizes and operating conditions: SOFC
   Absorption-chiller (ACH)
   Heat-exchanger (HEX)
   Storage devices

2. Linear optimization algorithm:
   Optimal operation of: SOFC
   Absorption-chiller
   Storage tanks
   Use backup-devices.

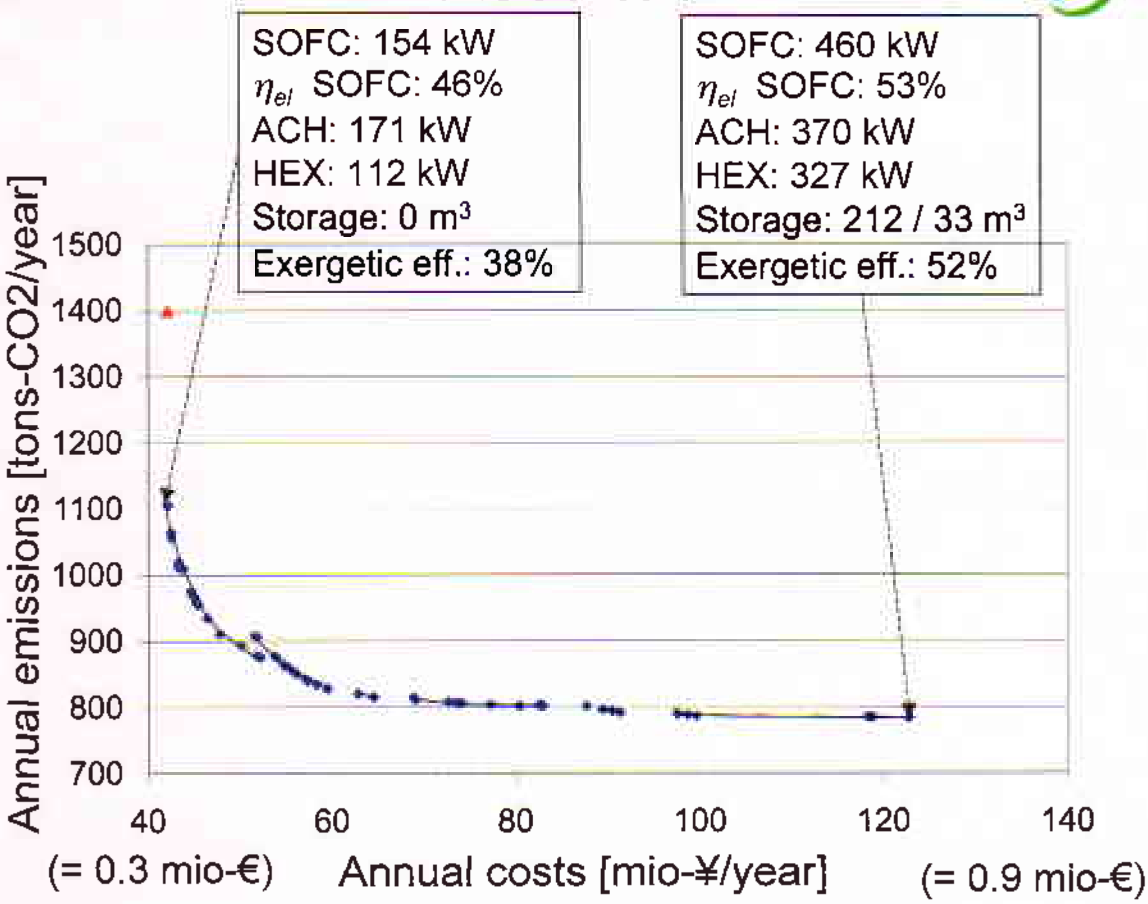
Resolution strategy



Assumptions

- All devices (except storage) perfectly insulated,
- The losses of the storage devices are maximum 10% at full charge,
- The temperature of the stocks is the same at the beginning and the end of the day,
- All the efficiencies and COP (coefficient of performance) are constant, regardless of the part load fraction,
- The values for costs and emissions are valid for Tōkyō.

Results



Conclusions

Output of the optimization problem
- Minus 40% CO2-emissions by double the costs

Methodology
- Modular tool easy to adapt (other technologies, other regions, other buildings,…)

Pareto curve