Optimization of insulation materials' thickness considering initial and running costs

Background

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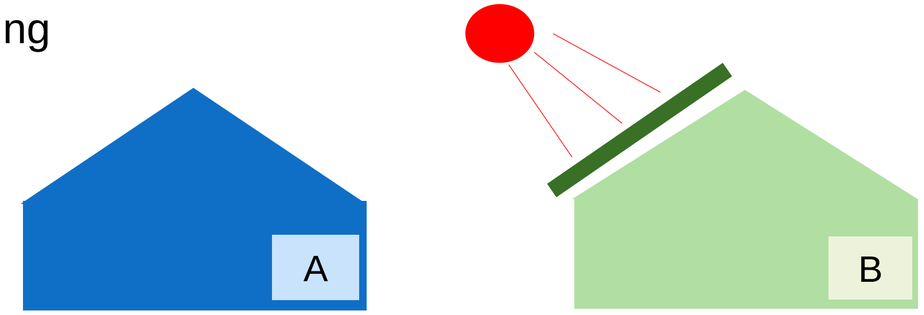
- ZEB(Zero Energy Building) has become increasingly popular and significant technology to accomplish energy saving



Ordinal house	Sustainable house
Low-level insulation	High-level insulation
Single glass window	Insulated window
Without PV panels	PV panels attached

Expensive
Expensive
Expensive

Affordable?

Expensive?

Decision-maker

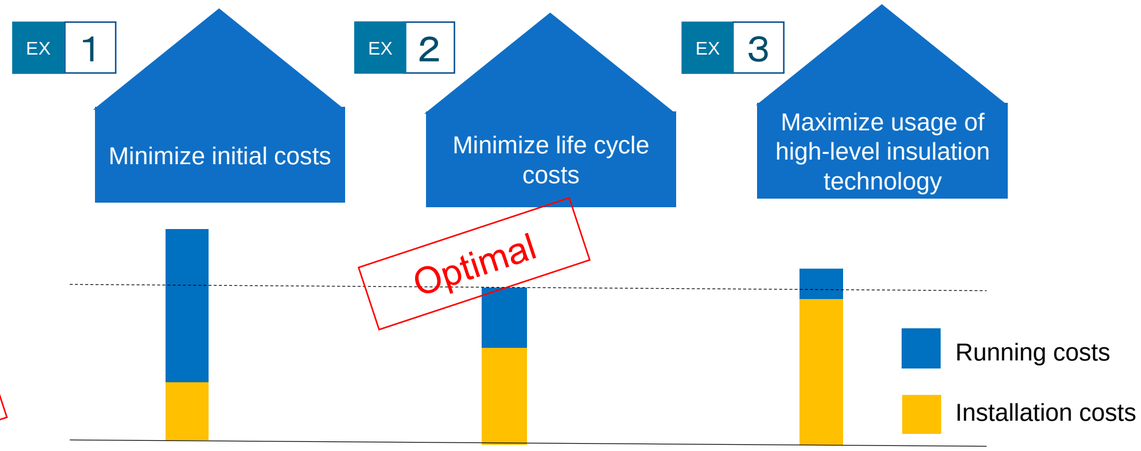
We should consider the tradeoff between installation costs and high-insulated building

Life cycle costs should be minimized

- High-level insulation causes the increase of installation costs.
- To make ZEB more common, a designer has to show the pareto-solution

How to minimize costs

- A building which has high-level insulation can reduce energy consumption and operating costs



- There are uncountable combinations to minimize the total costs. Hence, we utilized genetic algorithm to find a better solutions.

Insulation thickness	Window	Heat recovery
50mm	Single	Available
75mm	Multi	Non-available
100mm	Vacuum	
125mm		

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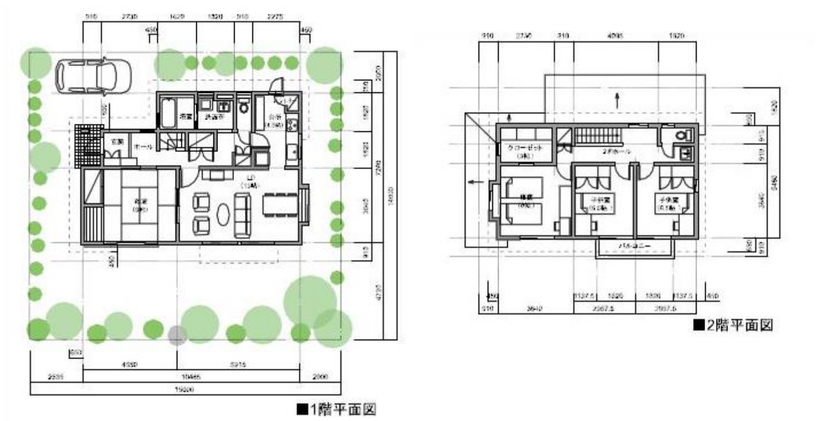
Simulation results

Building model: standard Japanese detached house



Calculation period: 50 years

Decision variables: thickness of insulation materials of wall, ceiling, and floor.

Algorithm to evaluate costs

Installation costs

Material
＋
Construction
＋
Maintenance

空調用熱負荷 計算値(kWh) ← 熱負荷シミュレーションによる

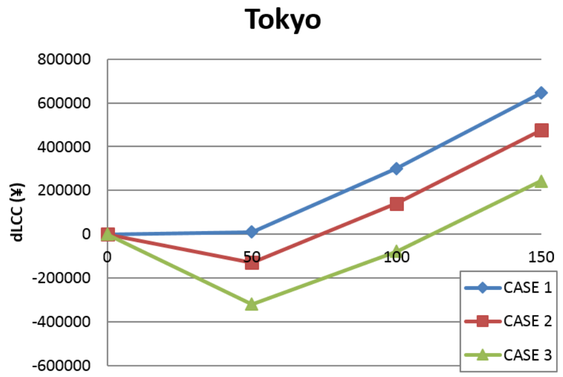
空調用年間 消費電力(kWh) ← 1/COP倍

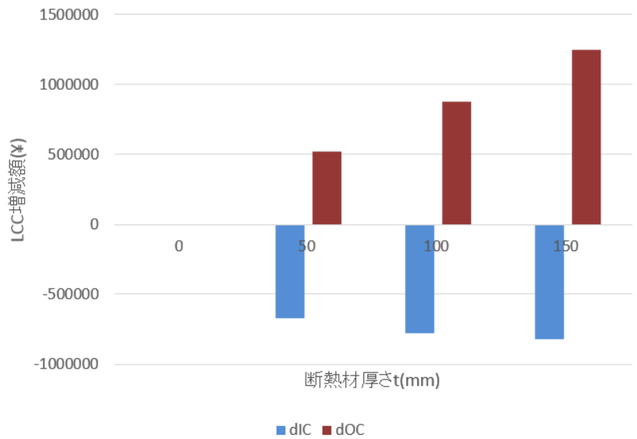
運用1年目の空調用エネルギーコスト(\) ← 電力量 料金換算

ライフサイクル エネルギーコスト(\) ← 運用年度ごとにエネルギー価格上昇を設定

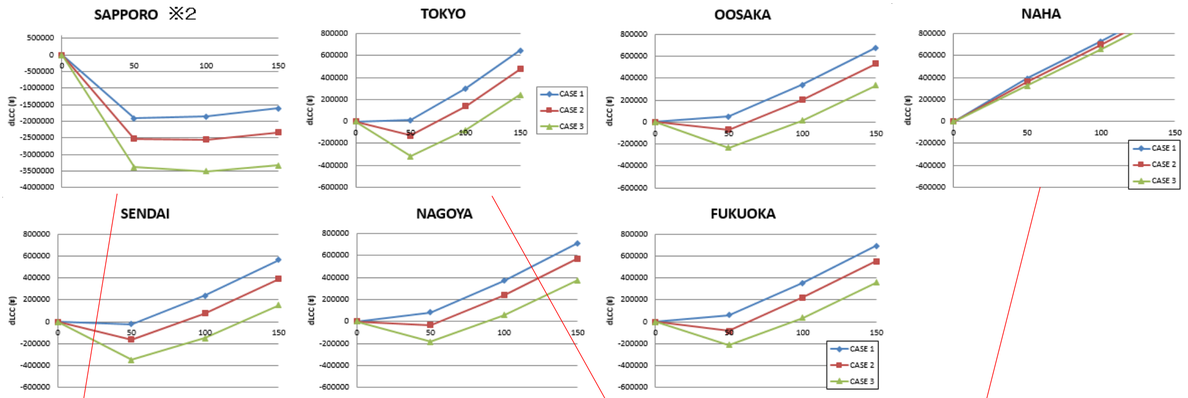
現在価値換算し、積算

Simulation results





- The best thickness was 50 mm of insulation materials



[Sapporo]
The life cycle costs could show the similar value when the thickness was 50-150 mm.

[Tokyo]
The best thickness depended on the inflation rate of energy price. When the rate more than 2%, the thickness should be 50 mm.

[Naha, Okinawa]
Insulation materials does not be valuable in the south part of Japan