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Methodology of Life Cycle Cost Optimization of energy retrofits

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Background

•The Swedish Building Regulation has decided that during a renovation in form of energy efficiency the measures which are planning to implement should not change the historic building's heritage culture values in a way that distorts the building from historical, enviromental and artistic point of view.

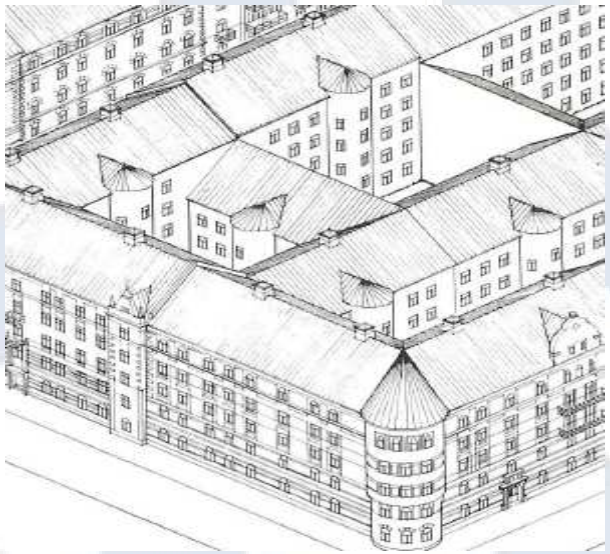
•The interest of implementing cost effective energy efficiency measures on historic building is increasing.

Aim

To describe the methodology which is called OPERA (Optimal Energy Retrofits Advisory) based on LCC method to optimize the energy use of buildings and energy efficienct measures while also considering the energy supply system.

Objective

- One Swedish multi-family building built in 1890 has been chosen.
- Building's external walls have different thicknesses at different floor.
- Location: Stockholm
- The building is connected to district heating.
- Natrual ventilation

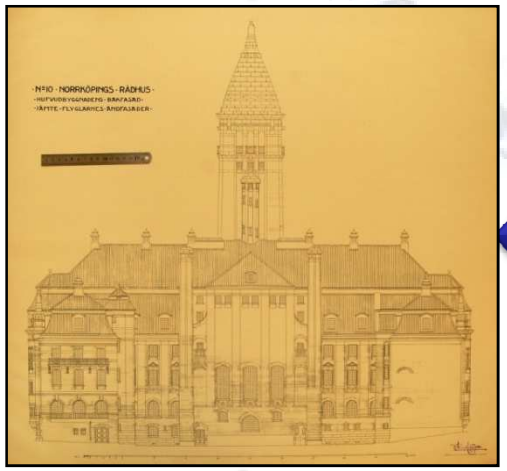


Energy efficient measures for buildings

-Hot water saving
-energy efficient lights
-Insulation of ventilation channel
-change to energy efficient heat source
-Installation of ventilation system
- etc.

2 Building service measures

1 Building construction measures



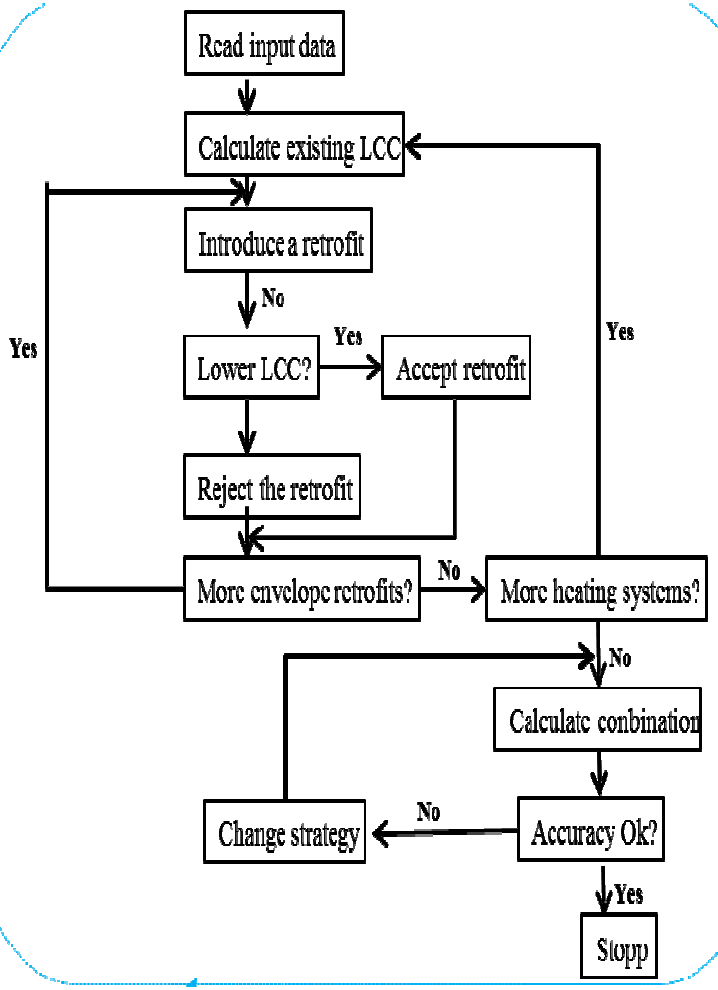
3 Controll and regulation measures

-Insulation of…
-Energy efficient windows installation.
-Sealing
- etc.

-Change of radiator valve.
-Time and demand controlled heating /ventilation system / lighting.
-Cleaning of heating/ ventilation system.
-Etc.

4 Energy supply

Optimal Energy Retrofit Advisory (OPERA)

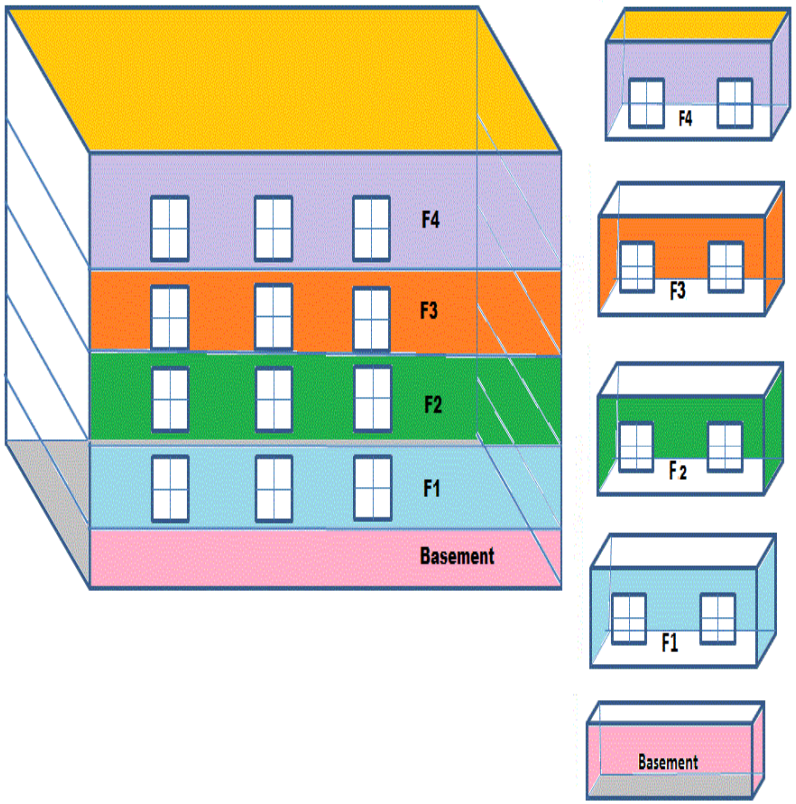


- Energy efficient measures (EEMs):
  - Attic floor insul.
  - Ground floor insul.
  - External wall insul. From inside or outside
  - Window exchange
  - Weather stripping

  &Heating system upgrade (WB, HP, DH)

- The lowest LCC is the optimal soultion of the building.
- To find solutions **before** the building gets to the optimal solution:
- To find solutions **after** the building gets to the optimal point..

How to handle the objective?



1. Separate the building.
2. Calculate the LCC for each floor for each heating system.
3. Add all the LCC of each floor for each heating sytem. The lowest LCC is the optimal solution.
4. To investigate other cases other than the optimal case.
5. Sensitivity analysis base on the optimal solution.

Result

	Before retrofits	
LCC_0 MEuro	0.5 0	
E_0 MWh	131.1	
	After retrofits	
	No limitation	**50% E_0 reduce**
WB		
LCC MSEK	0.40(-18.0%)	0.41 (-16.3%)
E MWh	84.7 (-45.4%)	76.3 (-50.8%)
PWB kW	40.9	38.8
HP (Optimal)		
LCC MSEK	0.34 (-28.5%)	0.38 (22.7%)
E MWh	92.2 (-40.5%)	75.4 (-51.4%)
PHP kW	13.4	11.5
DH		
LCC MSEK	0.41 (-16.1%)	0.43 (-13.5%)
E MWh	89.5 (-42.2%)	75.7 (-51.1%)
PDH kW	34.3	31.5

Optimal case: measures

- Basement: External wall insul. 12cm inside;
- 1st 2nd 3rd floor: external wall insul. 14cm inside + sealing windows;
- 4th floor: attic floor insulation 24cm + external wall insulation 14cm inside + sealing windows;

50% Energy reduce measure:

- Basement: Floor insul. 40cm + External wall insul. 34 cm inside;
- 1st 2nd 3rd floor: External wall insul. 14cm inside + Sealing windows + Window exchange U=2.7 to U=1.1;
- 4th floor: Attic floor insul. 24 cm + External wall insul. 14cm inside + sealing windows

Conclusions

- The retrofit cost is lowest by using heat pump and implementing the appropriate measures both in the optimal case and when reduce the building's energy use by 50%.
- E_0 reduce by 20%?
- In secitivity analysis: energy prises, insulation prises, window changing
- To which level can we reduce the building's energy use without destroy building's historic value?

Thank you for your attention!