Cost effective and environmental friendly energy renovation of commercial buildings from 1960s.

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Introduction:

This paper investigates different retrofit solutions simulated in a commercial building from the 1960s. All improvements were simulated in the IDA ICE software and the Global Warming Potential was calculated with the help of Eco Bat. During the investigation a cost-effective solution was indicated with the help of a life cycle cost calculation. Then the environmental impact of each proposal was estimated. This paper proves that it is possible to renovate the building reducing its energy consumption by using only the viable solutions.

Retrofits proposals were divided into envelope improvements and ventilation upgrades. The proposed renovation package to fulfil the Swedish building code requirements regarded only ventilation improvements, which comprised a ventilation system change from constant air volume to demand-controlled ventilation. The investigation covered two passive cooling methods suitable for retrofits. One of the most interesting conclusions was that the environmental impact level was strongly related to the quality of the energy source. For this reason, two different district heating systems were investigated: the typical Swedish district heating and a fully recyclable one. This work can be useful for those interested in commercial building retrofit and in renovation using cost-efficient methods.

Case study:

The whole investigation was based on the commercial building from 1967, located in Malmo, which has approximately 9 000 m^2 of floor area. It has an old and inefficient CAV ventilation system and a big glazing area. The specific energy use is about 180 kWh/ m^2 per year.

Envelope and ventilation improvements:

Referring to the monitored building, an addition of thermal insulation on the roof or external walls proved non-viable. Moreover, the surface of the external wall itself is very small, because a larger part of the façade consists of windows. Analogically, the highest heat transfer is through windows, which is logical for a building with a high window-to-wall ratio like in the case study. The change of the window-to-wall ratio was not taken into consideration because one of the priorities was to keep original appearance of the facade. That is why the only change to the windows considered for the simulation was one that did not affect the windows geometry. According to the LCC calculation, the windows change would save about 5 % of the total energy yearly, however, it would cost about SEK 5 680 000, which makes the investment unprofitable. There was no visible payback time within the next 40 years.

Regarding the ventilation improvements, the first thing was to change the operation schedule from 24 hours a day to 7am-5pm only on weekdays. It reduced the specific energy use from 195 kWh/ m^2 to 99 kWh/m^2. To reduce facility electricity use, new fans and AHU should be purchased. The old fans have high electricity consumption and the heat exchangers efficiency were between 0 - 60 %. Such investment would mean a change of the ventilation system from constant air volume to demand-controlled ventilation, i.e. VAV ventilation with CO_2 controllers within building zones. It decreased the facility electricity use from 21 kWh/ (m^2 year) for CAV with operation scheduled to 8 kWh/ (m^2 year). Investment in the DCV system was estimated at 1 810 000 SEK and saved about 30 % of the total energy demand mostly by smaller heating and facility electricity demand.

Passive cooling methods:

Two passive cooling methods were proposed to decrease the cooling demand. The first one was to control windows opening using indoor temperature and outdoor temperature sensors. Windows opening would be controlled by electric window actuators connected wirelessly with the temperature controlling panel. The actuators would open the windows when the set indoor temperature was exceeded and, at the same time, the outdoor temperature was below the indoor set temperature. The second successful working passive cooling methods was low E films. Such PET coatings installed on the glazing would reflect approximately 80 % of the infrared radiation, which prevents rooms overheating. Low E coatings are cheap, easy to install on the existing windows and they allow to across the visible light until 70 %.

Both passive cooling solutions, according to the simulation results and the LCC calculation, were feasible however the controlled windows opening system was slightly more expensive and complicated to install. However, it would occupy only every fourth windows on southeast and south facade. Other windows would still provide sufficient amount of natural light and good visual transmission. The low E coatings yielded similar results in the terms of cooling demand decreasing, but they could reduce the visual transmission, which could give unnatural image of the view from the window.

Life cycle assessment:

Environmental impact, expressed in Global Warming Potential, mostly depends on the energy use and its type. Because of high-energy use, environmental impact due to the potential material change e.g. new windows or additional insulation was marginal and was about 2 % - 4 % of the total GWP calculated for 60 years. The rest of the carbon emissions was produced from energy demand for district heating and electricity. Taking into consideration the average Swedish district heating, where energy source was 52 % recyclable, 40 % renewable and 8 % fossil-based, the Global Warming Potential was about 2 times higher than the GWP related to the same amount of energy provided by 100 % recyclable plant. The second alternative source was taken into account because of Malmö agreement with energy supplier, EON about fully- recyclable district heating by 2020.

Conclusion:

It is worthwhile to apply improvements which lead to a decrease in energy use. For this commercial building, the most efficient renovation package probably consists of ventilation improvements and free cooling. The new ventilation system DCV would be profitable from the economic and environmental point of view. Passive cooling methods can work very well in new buildings, but they can also be used efficiently in retrofits. This case study proved that the cost efficient solution, which led to a decrease in the energy use, had also the lowest environmental impact. In addition, from the environmental point of view the energy distributor is much more important that the energy use.