FACTORS AFFECTING ENERGY CONSUMPTION OF BUILDINGS

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BACKGROUND

- Finland has committed to Kyoto climate convention and, therefore, we try to find all the ways to save energy.
- Construction of new buildings is one of these areas and, thus, the U-value requirements will be tighten remarkably from the beginning of 2010.
- The plan is that 2010 the typical insulation thickness e.g. in roofs is 500 mm, in walls 250 – 300 mm, in crawl spaces 250 – 300 mm and in slab-on-ground structures 200 mm. Windows with four glasses will also be used.
- We also try to calculate the real energy consumption of building as good as possible because we have started to categorize the buildings in different energy consumption classes.
- The problem is, that there are many uncertainties in these calculations and the real energy consumption of building can be clearly different than the calculated value.

INTRODUCTION

- Several studies on the energy consumption have been carried out at Department of Civil Engineering at Tampere University of Technology during the past 15 years.
- Many results show that calculational analysis of energy consumption does not in all cases give a sufficiently reliable overall picture.
- Development of energy regulations should not be based merely on calculational analyses.

THE DIFFERENCE BETWEEN CALCULATED AND MEASURED ENERGY CONSUMPTION

- Six test buildings
  - The floor area of each test building was 2.4 m x 2.4 m
  - The free floor to ceiling height 2.6 m.
  - The ceilings and floors of all buildings were of 200 mm polyurethane, and each had a single door facing the same direction and no windows.
  - Temperature, humidity, etc. were monitored constantly

- The exterior walls of the test houses were of the following types:
  1. Polyurethane (PUR) insulated wood-framed wall, calculated U-value 0.17 W/(m^{2}K)
  2. Insulated cavity brick wall, U=0.27 W/(m^{2}K)
  3. Insulated log wall, U=0.29 W/(m^{2}K)
  4. Plastered massive brick wall, U=0.86 W/(m^{2}K)
  5. Autoclaved aerated concrete (AAC) block wall, U=0.35 W/(m^{2}K)
  6. Massive log wall, U=0.6 W/(m^{2}K)

THE DIFFERENCE BETWEEN CALCULATED AND MEASURED ENERGY CONSUMPTION

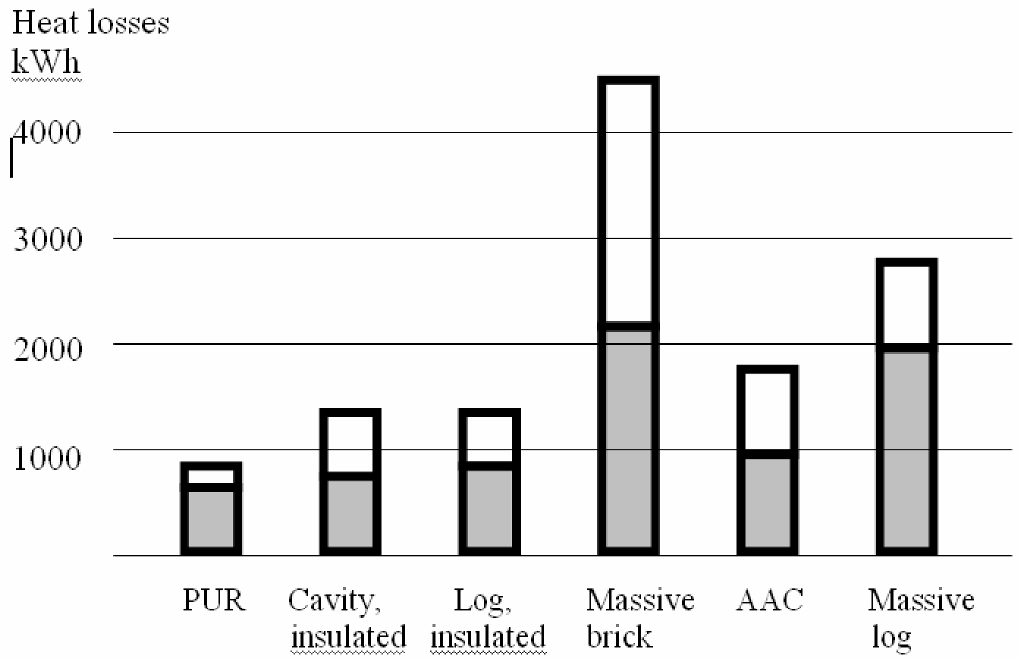

FIGURE 1
Transmission heat losses during the 1997–1998 heating season [Lindberg et al. 1998]

- The grey bottom part of the columns indicates measured energy consumption during the heating season. The total height of the columns represents the calculated energy consumption based on the U-values of the exterior walls.

THE DIFFERENCE BETWEEN CALCULATED AND MEASURED ENERGY CONSUMPTION

- There are three main reasons for the difference between measured and calculated energy consumption:

  (1) the material properties from which the U-values are calculated

  (2) the areas of the walls have been calculated by using the exterior surface lines of the walls

  (3) the solar radiation energy stored in the external part of the exterior walls.

THE EFFECT OF THE THERMAL MASS OF THE EXTERNAL SECTIONS OF EXTERIOR WALLS ON ENERGY CONSUMPTION

- Measured March 13, 1998, southern façade of an insulated cavity brick wall
- The structure from the inside out is: 130 mm brick, 125 mm mineral wool, 30 mm wool sheathing, 20 mm ventilation gap, 85 mm clay brick.
- Energy stored in the mass near the exterior surface diminishes the need to offset heat loss through exterior walls.

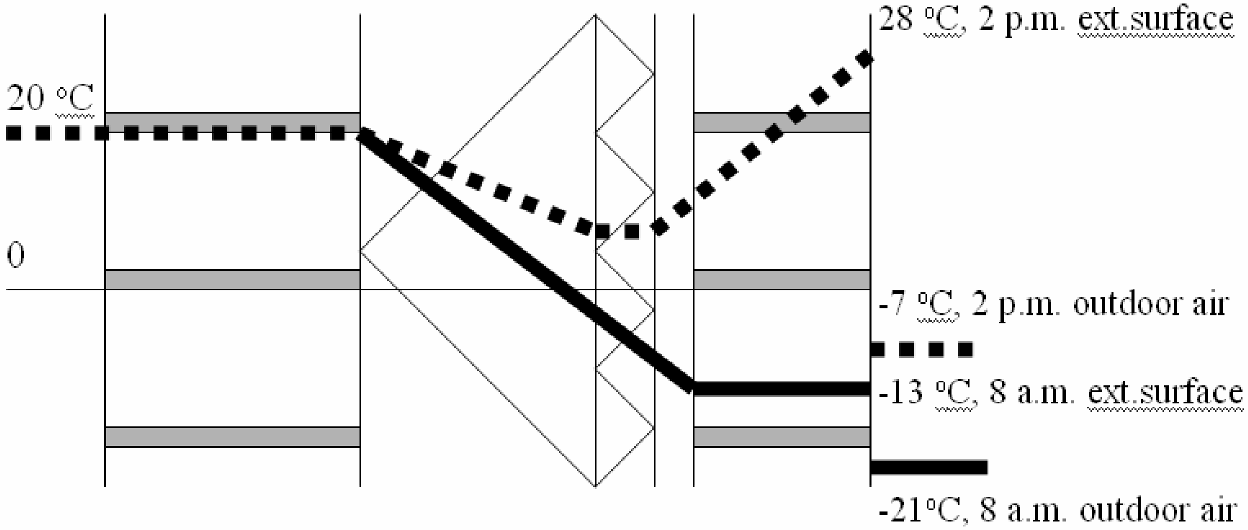

FIGURE 2
Temperature distribution of an insulated cavity brick wall [Lindberg et al. 1998]

THE EFFECT OF THE THERMAL MASS OF THE ROOFS ON ENERGY CONSUMPTION

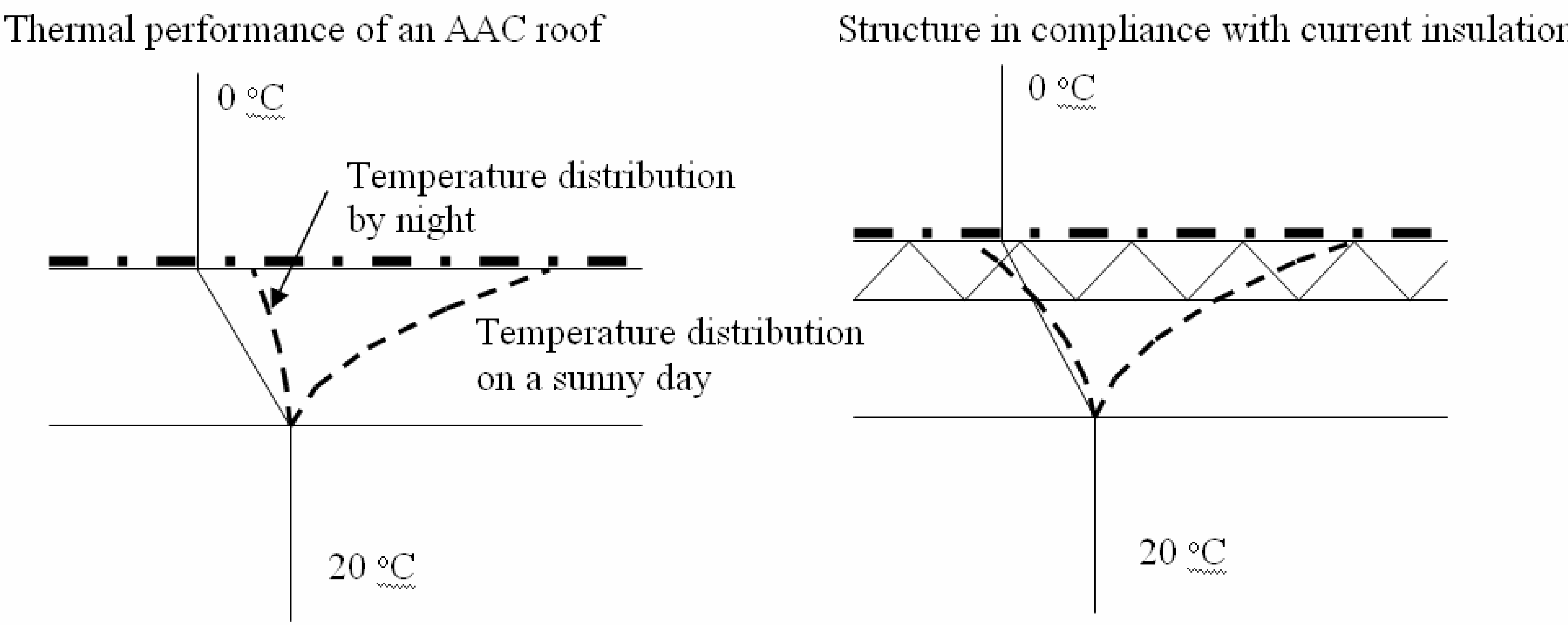

FIGURE 3
Thermal performance of an AAC roof at a certain moment

- This result can be interpreted, for example, so that the structure has a lower effective U-value than calculated. Presently, this effect cannot be taken into account.

CONNECTION BETWEEN INCREASED LIVING STANDARD AND NEED OF HEATING ENERGY

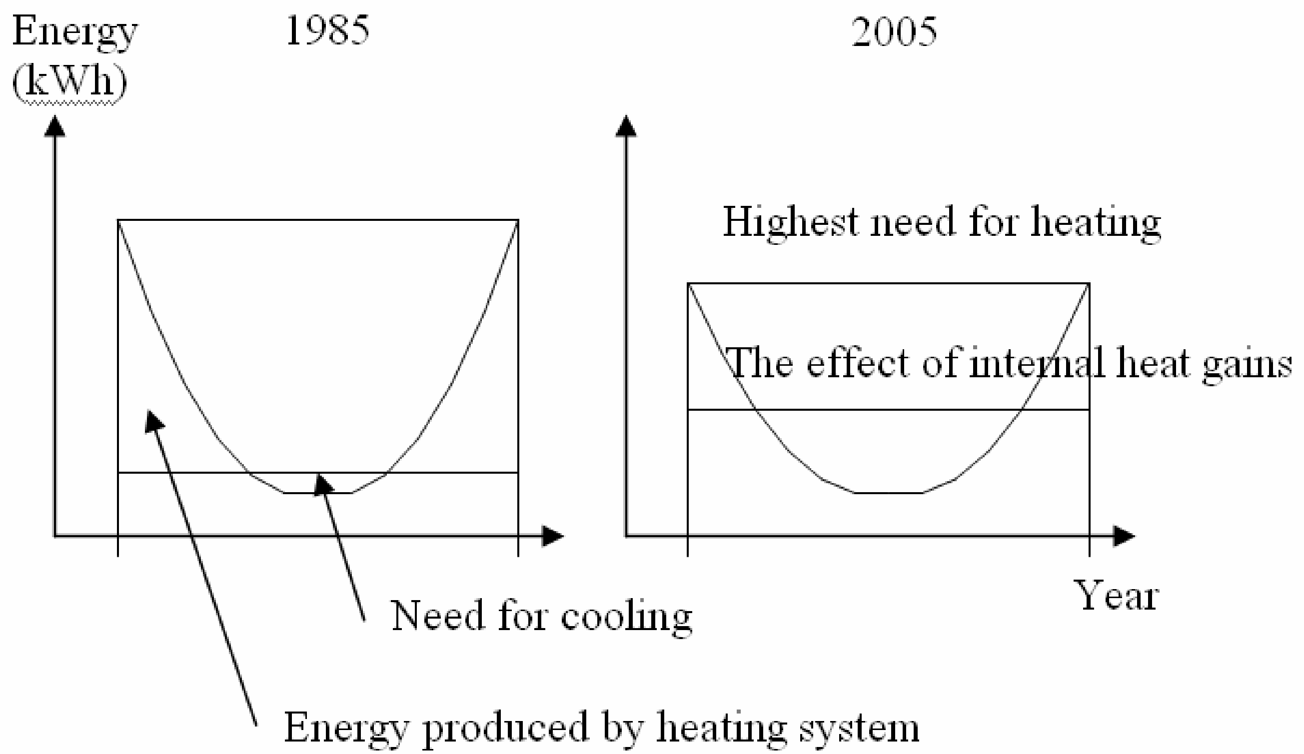

FIGURE 4
Annual use of energy for heating in different decades [Lindberg & Leivo 2005]

CONCLUSIONS

- We are not in full control of issues related to energy need. There are significant aspects related to the performance of buildings that should be taken into account when revising regulations.

- There are five important factors related to energy consumption of buildings that need to be considered:
  - heat loss by conduction through building envelope
  - energy used by ventilation systems
  - savings from ventilation air heat recovery
  - air tightness of building envelope
  - Impact of the occupants

The most effective overall means to reduce energy consumption, however, is to influence the occupants to save energy