1.2. THE STARTING POINT - ENERGY CONUNDRUM

It is difficult to compare current commercial buildings with those of 100 years ago because user requirements have changed. Yet, there is a category of multiple unit residential buildings (MURBs) that have the same function now as they had 100 years ago. The average energy use of MURBs in 1990 in North America (NA) was 315 kWh /m^2. Since 1990 energy use in MURBs has steadily declined, reaching 250 kWh /m^2 in 2002 (Finch et al., 2010). **Note, however, that this energy use is equivalent to that reached by commercial buildings in the 1920s**. So, the masonry buildings *without insulation*, built nearly one hundred years ago consumed as much energy as a shiny, glass-clad building constructed today. Yet, today we have so many measures to reduce energy consumption like thermal insulation, thermal mass, air barriers, high performance glazing systems etc.

1.2.1 Masonry buildings in the 1920s

The construction of a masonry building took a long time. As the load bearing function required thick masonry walls, such a building had a huge thermal capacity. The floors contained steel beams and masonry blocks. The walls were airtight because both exterior and interior plasters were lime based. Lime develops strength slowly, allowing self-healing of the cracks caused by settlement and movements of the walls. Excellent, heavy, and typically oil painted wood double hung windows were well integrated within the masonry walls. Window areas were small. From a building physics point of view the building was airtight, massive and well integrated. Due to inefficient and intermittent heating sources, the indoor temperature varied between periods of acceptable comfort and discomfort.

1.2.2 Building physics explains

Consider the performance aspects of the separation between exterior and interior environments. 1920 masonry walls with exterior and interior plaster layers had a high level of airtightness. Small windows do not introduce large radiative heat exchange. The large thermal mass of the structure combined with periodic heating reduced day/night temperature swings and thereby reduced the total need for energy.

All these advantages were eliminated by large and leaky windows and dramatically improved by mechanical control of indoor air temperature. When a thermostatically controlled heating system keeps the indoor air temperature constant within a fraction of a degree during the whole season, no benefit from thermal mass can be expected. For many office buildings it means the HVAC system must include both heating and cooling. Furthermore, when we do not have any moderating effect of thermal mass, we must design the HVAC for the peak loads. In short, the principle of energy efficiency is sacrificed when the demands of comfort are based on the wrong control mechanism. Furthermore, the heating load calculations are done based on the wall heat transmission characteristics and nominal room ventilation rates. In reality pressure differences created by local exhaust fans, corridor pressurization fans, stack and wind or even occupancy patterns produce air movements that vary widely across different zones of the building..

In effect, the holistic approach to design that was normal in 1920's is missing today. In 1920 one architect was able to deal with all trades constructing the building while today we have a number of experts each independently doing own part of the puzzle.

1.2.3 A fundamental lesson derived from the comparison of 1920 and 2002

There is a fundamental lesson derived from the comparison of 1920 and 2002 office buildings. **This is the effect of mass.** People in North America like to keep the thermostat almost at the same temperature for the whole heating or cooling periods. This approach is as counter-productive as keeping windows open for the whole day because it eliminates the contribution of thermal mass. Building physics tells us that people perceive thermal comfort based on a complex set of factors that include air temperature in the room, temperature of thermally radiative surfaces, the relative humidity of the air and air movement. So why do we single out the dry bulb air temperature and neglect the other variables of comfort?

In designing for environmental control, professionals integrate two very different conceptual processes. One involves specific testing and analysis; the other encompasses a broad qualitative assessment based on experience and judgment of what makes a building envelope function. On the analytical side is a complex array of tools, models and data which describe the material, structural and environmental factors relating to the building envelope. On the qualitative side there is a sense of how a particular building enclosure would function.

1.2.4 "Outcome-based pathways for achieving energy performance goals"

As we discuss later in this book, we do not have adequate analytical tools, our energy models do not include the effect of air and moisture flows, our hygrothermal models cannot predict interim effects of wetting and drying, our codes and standards are based on the prescriptive thinking of past buildings. Yet, we must be able to innovate and evaluate the performance of new approaches. In this context, the 2014 industrial initiative " that expands the *Moving Forward* report of the National Institute of Building Science submitted to the President of the United States in 2010 and was focused specifically on the actual energy used in the building states:

- "The building community needs a better baseline of actual building performance against which to measure progress. More importantly, the application and use of prescriptive criteria must be eliminated in favor of stated performance goals or expected outcomes (although, after setting those goals or outcomes, prescriptive guidance to achieve them can be developed).
- The industry group specifically is focused on outcome-based approach to address a number of challenges facing the building industry Code departments have limited resources available to enforce building codes (particularly energy codes, which are not usually seen as a life safety issue).
- Energy use is highly measurable, yet current code pathways anticipate results from designs; they do not assess actual building performance.
- Designers do not have the flexibility to use some of the latest technologies or practices to achieve energy efficiency requirements.
- Not all energy-saving strategies, such as building orientation, are effectively captured in codes.
- Energy efficiency goals increasingly rely on reductions in energy use at the systems level, but the IECC (int. energy conservation code) has primarily focused on a component approach. A growing percentage of energy uses associated with buildings are not currently covered within the existing code framework (i.e., plug loads). This evolution to outcome-based performance requirements recognizes that prescriptive and modeled design approaches are often not representative of the actual energy outcomes of buildings and that current codes fail to regulate some of the most significant energy end uses in buildings today".

While energy use can easily be measured and therefore the change was easy, yet the stress on measurable performance as opposed to using models is a significant development in the USA and in Europe (EPBD directive).

Summarizing this brief review we found that there is no problem on the innovation and creativity side of the technology. There is no problem with the society good will, in our codes and standards are postulating quite stringent requirements for energy efficiency and 'green' actions. So what is the problem? The definition of this problem was given many years ago by the communication guru Marshall McLuhan

Our Age of Anxiety is, in great part,
The result of trying to do today's jobs
With yesterday's tools

McLuhan was also the man who said:

Television is the medium that replaced the message.

Our universities today, do as they always have been doing, namely they enforce the philosophy of "*publish or perish*" with an assumption that *the more you are quoted in the first two years after* being published the more important must be your paper. With the overflow of reports and papers, however, being much quoted does not mean that much. After all, no-one quoted Einstein for many years. To add insult to injury most Universities find that using computer models is less expensive than making experiments. Later in this book we will show how stagnation was created in building physics by accepting simplifications in the models. The over-simplified model gave us a false impression that problems were solved. So, in closing this problem statement it is important to keep the following in mind.

Always beware of the predictions from a computer model that has not been verified by comparison with the experimental results

This message should particularly be remembered by all students and young engineers who were raised in digital environment. They may have difficulties with separation between life and fiction and are eager to accept a message from a computer model as a truth.

REFERENCES

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