International Journal of Economics, Business and Social Science Research

Volume: 03, Issue: 02 March - April 2025

ISSN 3048-8125

ON RETROFITTING OLD DWELLINGS: LOSE TIME ON EMPTY TALK OR START THE REAL WORK

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ABSTRACT

Scientists learn all the life until they retired, and then they fade out. The author, however, when retired, wants to rebel and publish his thesis, (like Martin Luther), to show another side of the coin. Today, he says, we are in the middle of the 4th industrial revolution, where dispersed energy sources combined with information technology enable buildings to have a new role. We now have a choice. If ventilation through dilution is not effective in removing the covid 19 virus (SARS-coV2) and the DOAS (dedicated outdoor air supply) with adequate filters are needed, one may either wait for the next 20 years when the natural progress in construction reaches this development level or to create a socio-economic wave to change the whole construction system. The latter we call a scientific revolution. The scientific revolution advocated below could improve life of people on three different levels.

Keywords: Retrofitting old dwellings, Building renovation, 4th Industrial Revolution, Dispersed energy sources, Information technology in construction.

Thesis 1: Each project can either be continued from the current state (observe that we act like ants, pulling in all directions to see who wins) or one can start planning it from the ultimate objective, to go back to the current time and know how to effectively organize the project. Still, most of the people follow politicians and work like ants without thinking about effectiveness of their work. If effectiveness is not considered, how can one introduce big changes into the socio-economic concepts?

Explanation: Since a long-time ago, we know that changes must be small to be easily acceptable and nowhere is it better seen than in construction. The first, ever built passive house was 1978 energy conservation house in Canada (Figure 1) was a large change and was not accepted by the builders.

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Figure 1. Saskatchewan Energy Conservation House, the concept proposed by the U. of Illinois, was designed and built as a demonstration of passive technology in 1978 (Regina, Saskatchewan). Inclined surfaces with evacuated solar pipes and heat recovery ventilators were used [1].

Technology in the 1978 demonstration house has almost been the same as today. Yet, builders improved the design to reduce the cost. They replaced a heating furnace with electric baseboard heating modifying the pattern of airflow and thereby changing the indoor environment. The elimination of chimneys caused sick buildings (not enough fresh ventilation air), and wet attics (increased humidity and condensation on top floors and attics). To avoid these problems, mechanical ventilation became mandated in 1985 in Canada.

While the first passive house was a breakthrough technology, our second example was a block of flats between four streets in Montreal built by a builder. This example demonstrates a new multi-stage construction process and discussed later in this technical note (Figure 2).

Figure 2. An affordable, low-rise, energy-efficient multi-unit residential building "Atelier Rosemount" in Montreal, rain retention basin in the bottom right (credit Nikkol Rot [2])

This multistage construction process was designed in the first stage and constructed with a self-financed scheme by the owners, leading to 92% reduction of energy use. Why was this process not followed in Canadian construction practice?

The only answer we can think about is that there was no market pull, no clear need for high level of energy conservation. The media are only talking about the need for renewable energy sources, people are waiting until a big invention like fusion to become panacea and the source of energy. Only a few people still keep common sense knowing that big savings are obtained by effort of many, each doing a small saving. One can only think about the adage "add insult to injury" because governments are typically throwing taxpayer money to push what they think are "green" products. In one European country, the government was giving grants to both sides of the chain, to local manufacturers of the obsolete type of heat pumps and to people buying their products, and they managed to increase the heat pump price by about 100%. The government has changed, and most people have started looking for solutions other than heat pumps. The effect of wrong government economic policy became opposite to their intentions.

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These two examples show that existence of good technology does not convince people and to introduce bigger socio-economic changes we will need to use another approach.

Thesis 2: There are two distinctly different categories of project directors: (1) administrators (appointed to take care of existing organization), and (2) leaders (either appointed or self-directed, who are capable to provide new directions). Except for the president of the United States, who is elected to do both functions, other people are either administrators or leaders. Einstein observed that our society cherishes administrators but does not pay adequate tribute to leaders. Why?

Explanation: Sociology may discuss whether habits are the second nature of the human being, but for most people the key features of the administrator, namely the lack of risk and predictable actions are also their requirements. Leaders on the other hand, follow another adage: you cannot make scramble eggs without breaking the shells of the eggs. With other words, the new replaces the old though a disruption.

It is not a surprize that our conservative nature favours administrators.

Demonstration: In the later part of the building boom after World War II, two middle-sized countries (Sweden and Canada,) established national research institutes that led progress of residential buildings. Initially, both research centres addressed both theory and practice. Yet in both countries politicians started calling for research to be directed towards national industrial support. When the narrowly formulated objectives were enforced, the advanced research providing international leadership stopped, and these centres became administrators for the local industry, .i.e. following technology instead of leading it.

With Sweden and Canada gone from the scene, two new academic centres namely Belgum and Chechia both dealing with academic research only. None of these research groups deal directly with practical applications.

Thesis 3: About 100 years ago a scientific revolution (model T by Henry Ford), selected from the multitude hand-made automobiles one new concept for industrially produced vehicle. Today, there are many different car models, but the fundamental concept is the same. The second scientific revolution from Japan, (quality revolution), improved the quality of the manufacturing process. One may ask question, what should be done to create a similar concept of the universal, retrofitting technology enabling a dramatic the reduction of retrofitting cost.

Explanation: Torrie and Bak [3] stated that Canada, with residential area of 2.1 billion square meters and 65 million tons of carbon emissions per year, has no concept how to reach a low-carbon future. They compared the current calls for the reduction of carbon emissions to the time before the Model T was invented. At that time each vehicle was produced individually, much as today we do with housing. In today’s dollars, the price of a Ford was US$ 25,000, and throughout the year the company sold 19,000 cars. Ten years later, with acquired manufacturing experience on moving assembly, Model T cost was US$ 5,000, and Ford sold 941,000 vehicles.

Demonstration: Sixteen years ago, a few international scientists stated that hot and wet in summer and cold and wet in winter climate in Shanghai and Nanjing China requires new

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solution and the objective for work should be universal, climate-centered, interior retrofitting technology, permitting to upgrade only one dwelling at the time. Obviously, exterior retrofitting would be easier, but many buildings were already thermally upgraded to inferior standards and further work must be done from the interior. The work in China was interrupted when the principal investigator reached the age of 75 years, because the regulation did not allow him to work anymore. The work was continued in USA in collaboration with Poland.

Thesis 4: In 1980s a choice between solar engineering and passive measures was the question, today it is both of them plus adaptable indoor and active thermal storage. We call the integrated, retrofitting as **Passive and Thermo-Active Technology (PTAT)** and below we list the key components of this approach.

Explanation: Detailed description of PTAT is published elsewhere [4], below we only list the most important features in this approach:

• Alleviating economic conflict with the two-stage construction process

Investors must follow the requirements of codes and standards. Society, however, needs a higher investment level, zero carbon emission with near zero energy. The two-stage construction process alleviates this conflict. The second stage starts a few years later and completes actions for which there is already a design. For the two-stage solution to be successful, both stages must be designed together. The completed stage one is to secure funding for the second stage. The next section demonstrates a multistage construction project.

• Demonstration of multistage construction: Atelier Rosemont in Montreal, Canada

"Atelier Rosemount" in Montreal [3], included different dwellings, from inexpensive social to the top-priced ecological dwellings. Over the period from 2008 until 2018, stepwise upgraded buildings reached 92% of the cumulative reduction. The retrofitting included the following steps:

- High performance enclosure; common water loop; solar engineering = 36% reduction.
- Gray water, the passive measures of energy reduction gave 42%.
- Heat pump heating—all passive measures gave a 60% reduction.
- Domestic hot water with evacuated solar panels, a further 14%.
- Photovoltaic panels reduced the total energy to a total of 92% reduction.
- Water-sourced heat pump, WSHP-based, energy generating unit with thermal storage

Water source heat pumps (WSHP) became indispensable because they have the highest energy multiplication effect. WSHP is used with two buffer tanks (thermal storage): Domestic Hot Water (DHW) tank, and one from which heat is extracted, cold water tank (CWT). This tank functions as a lower terminal of the heat pump. We use two concepts for thermal storage: short-term storage with 4 -18-hour thermal capacity to equalize daily loads, and long-term storage, with weekly (168 hours) equalization of thermal loads. The energy generating unit may have one or two heat pumps where a WSHP is the main. A water pump circulates water to the space heat-exchanges in floors, exterior or interior walls or ceilings of the dwelling.

• Monitoring and modeling for evaluation (MAPE) and steering the building automatics

Monitoring data can be used to optimize mechanical devices and improve the synergy of subsystems. Particularly successful are simple and precise artificial neural network models [5, 6]. They can be used for steering the building automatics. Furthermore, most of the mid-rises and high-rises use the corridor air pressure correction for the stack effect, which is different on each floor and varies with the seasons. Those differences have a significant effect on indoor air quality. Adding air pressure differences makes a small difference in monitoring cost but a large difference in analysis capability, particularly when a variable rate of air exchange is included in the building design.

• A new type of district climatic network

Return water from building one is used in building two for the lower terminal of the heat pump. This system can be used for two buildings (historic buildings) or the whole region of buildings. District climatic network addresses also preconditioning of air and reduces the difference between designing one building or the whole settlement and thereby opens a new trade-off capability.

• Optional:adding the water recycling and/or hybrid, variable rate, mechanical ventilation

For details see elsewhere [4].

Thesis 5 When using PTAT as defined in thesis 4 and economic value of the building, there are no differences between designing new building or retrofitting existing building or cluster of buildings because the concept of the building cluster for 2 buildings or 200 is the same.

Explanation. The value of the property or dwelling does not depend on administrative labels and using them only creates confusion. Furthermore, the use of wrong economic measures such as return on investment of one specific function of the building leads to misleading results. One should not mix technical and economic criteria with administrative labels.

On the other hand, the climatic district network that includes heating, cooling, and ventilation system eliminates the difference between a single building and a district of the city. As PTAT technology includes thermal storage and water tanks may be located underground, the climatic district system may either be a part of the building or the energy distributing system. Observe that designing a cluster of buildings, either new or retrofitted, may permit using water tanks in ground and lower the investment cost while improving technical solution.

Thesis 6: Even the best technology without a deep social engagement will not lead to the spread of the new technology. To introduce a real progress to retrofitting of the existing dwelling we must link it to a transcendental issue of climate change. Such a solution offers a win-win-win to occupants, society and economy.

Explanation: Builders do what the buyer wants them to do, and if the buyer's only vision is the low purchase price and not even the low cost of purchase and exploitation, he/ she will get a low-functional, relatively inexpensive property. For a buyer to consider a higher mortgage cost two things must be fulfilled; (1) his long-term expenses must be lowered, (2) his/her

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ISSN 3048-8125

contribution to the high motivation social goals must also be satisfied during the same process. Thus, evaluation that includes cost of specified period of maintenance and repairs (e.g., 15 years of operation) in addition to the purchase price and it is less expensive than the traditional one, while providing zero emission and low heating cost appears to be a good combination.

A scientific revolution like that of Henry Ford in car manufacturing is needed in the retrofitting existing buildings to provide win-win-win for society, the economy, and the building's occupants. Society wins with slowing climate change, the economy with plenty of local jobs, and occupants with affordable, good indoor environments [7,8]. Our experience from North American national public-private projects which in a span of few years changed the public perception of buildings, implies the need to institute similar programs for retrofitting with the view to slow climate change.

Action needed: We have an advanced Polish Government laboratory willing to develop materials covered by the US patent and interest of some EU universities to become members of te team. We need a developer/ builder company in Poland or elsewhere in the EU to be able to establish a public-private consortium demonstrating that affordable and universal retrofitting may slow climate change.

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