ZEBs - no fundamental progress over the last 25 years?

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Abstract

After the many ZEB /Zero Energy Building) attempts in the early nineties, the field stagnated. The new mantra became, better insulation. Nowadays ZEBs are being revisited as many *passive and low energy* building have been built and are apparently working well, although the debate on healthy or not indoor climate has increased as more and more „tight boxes“, all based on the same simple recipe; heavy insulation, heat recovery, new renewable energy - are being built.

The building profession now seem to be looking for more challenging tasks in the direction of ZEBs. This paper explores the development between 1985 and 2010 and shows own examples of ZEB designs for large buildings of 15-20 000 m^2 as well as making reference to other projects. The paper explores the reasons behind the slow development.

1. Introduction

Although mankind for thousands of years lived in autonomous shelters, modern times' attempts at developing technology-driven autonomy, nowadays named Zero Energy Building or Zero Emission Building, ZEB, was in some ways re-started around 1985. The pioneering attempts did meet with a range of obstacles. They were rarely technical, but bureaucratic and related to building regulations.

Today's interest for ZEBs do not seem to be documenting much progress since the mid-eighties but builds on the fact that bureaucratic obstacles are fewer and technological components more easily available and less costly now than a few decades ago. Still: Innovation seems to be lacking. Mostly insulation and heat recovery is applied.

In 1985 I [1] finally managed to do a ZEB design attempt that was buildable. The project was named Chanelle (Fig. 1,2) and constructed at the *Building for the Future Exhibition* in Stavanger, Norway. It opened in 1988. Architects like Danish Vandkunsten and Swedish Ralph Erskine participated. None of them did however try to do a sustainable design. Nobody else of the 100 built examples did either. Chanelle, on the other hand did try. As a result it attracted global attention and 50 000 visitors walked through the compact house within a few months. I still receive requests for tours, but after having worn out the occupants of the house, tours are now restricted. A few years after Chanelle was built, Fraunhofer Institute in Freiburg built their hydrogen fuelled ZEB attempt as part of a five-year research project started in 1992. It became the second ZEB attempt in Europe in modern times [2]. It was planned and erected in the period 1992 – 1995 and named Freiburg Self sufficient Solar House. It turned out in the views of many to be technologically overkill, so complicated that one needed to be an engineer to live there, but as a research platform it was most probably very useful.

2. Comparative Analysis

2.1. General Data

The two projects, hereafter named Chanelle and Freiburg, were immensely different.
Chanelle was compact and low cost, built for people on socially lower budget than the research object in Freiburg. Chanelle cost 180.000 Euro (1988) including the site cost of 60.000 Euro. So sheer construction costs including all the technical renewable energy systems were only 120.000 Euro.
The Freiburg figures on the other hand seemed to be held back but indications pointed towards an expenditure of 700.000 Euro.

With Chanelle, my point of departure was being an architect with a client that was supposed to live in the house. Fraunhofer coupled the project with research. What they achieved of useful data that can be used by architects in practice is unclear. I recently tried to organize a visit to the Fraunhofer house but was told it was now closed to visitors. What Freiburg must have achieved though is to inspire other designers and financing authorities to look into modern ZEB solutions. Rolf Disch [3] has later had great success with his solar plus houses in Freiburg, built recently. Although they only carry very traditional solutions, again based on the familiar recipe of heavy insulation and heat recovery coupled with solar energy, PV electric but also some thermal, at least they have been built and are in use.

2.2. “Chanelle”. Area efficiency and costs

Chanelle was compact and built to social housing bank standard in other words practicing *area efficiency* with its 121 BA or 137 m^2. The site cost was 60.000 Euro and to build the house took 120.000 Euro. It was an extremely compact house and questioned even then in 19888 the issue again being raised in 2010 as to the relevance of comparing energy efficiency in buildings through the figures of $kWh/m^2/year$. Such figures say nothing about the compactness, the area efficiency, of buildings. In many countries area built per person have doubled over the last decades. Housing in Norway is an example, rising from an average of approximately 25 m^2 per person to over 50 m^2. Even if energy need calculated by $kWh/m^2/year$ have halved in the period nothing is changed really since area used per person has doubled.

Fig 1. Chanelle. Europe’s first modern time’s ZEB? Designed 1985. Completed 1988 (RøstvikAS)

2.3. Insulation and solar thermal energy

Chanelle was well insulated compared to the standards of the time. The windows were all South facing (South West and South East) and made from 3 layers of low emission glass. The walls and roofs consisted of 20 cm glass wool insulation plus a solar air collector covering the external walls towards South West and South East, increasing the insulation further due to the two locked air gaps in the solar collector. As a result it probably had the effect of *40 cm insulated wall and roof.* In addition, the solar air collector created a *warmer climate* around the building, as well as supplying hot air to the *domestic hot water* tank and the *space heating* system as shown in Fig. 2. The solar heating system covered both South facing facades as well as both of the South facing roofs. A log fired „kakkelovn" (a Swedish compact model), provided 20 kW heat at its maximum. It had a huge mass and stored energy for up to 15 hours. The fire burnt fairly „clean" with an efficiency of almost 95 %.

The total heating system consisting of the described components was over dimensioned for this house, the idea being that one could open windows and *naturally ventilate* most of the year since the solar heat was free, once the heating systems were installed. This allowed for natural ventilation in a big way as opposed to the „tight box" type solutions that were later developed and made dependent on 80 % heat recovery technology. Chanelle tried to be the opposite of the „tight box" through the generosity of natural on-site energy. It counteracted the drive towards „tight boxes" and showed some innovative ideas of over dimensioned heating systems that were possible simply because the solar air based heating system was cheap to construct. It was based on a patent by author.

2.4. Solar and wind electricity

Chanelle was the first and largest solar PV electric building in Norway at the time, with its 2 kWp system. It was coupled with a roof mounted vertical axis wind turbine of 1.5 kWp. The electricity was stored in a large battery bank.

2.5. Waste and water handled on site

It was the intention of the Chanelle project to handle wastewater and sewage on site, through biological systems. This had been tried out elsewhere and worked well. Water supply was also proposed from a deep-water well and pump based on solar electricity.

In order to make the „value" of the solar and wind electricity make a considerable contribution, all electric appliances in the building were selected based on the best on the market energy performance. We found the most energy efficient refrigerator, washing machine coupled with solar heated water, light bulbs, TV and cookers. We found that even at that time very good products existed and they were using a fraction of the energy of the worst makes on the marked. Today selecting those is easy through the new A-G energy use marking system. At the time we had to search the product catalogues and ask the manufacturers to even get reliable data.

Fig 2. Chanelle. The design principles (RøstvikAS).

2.6. "Chanelle" lessons learnt

Bureaucratic obstacles in the Municipality of Stavanger resulted in a refusal to allow grid intertie for solar and wind power. The local energy utility Lyse and a Safety Directorate of the state was afraid that the huge Norwegian electricity network was going to get „disturbed" by the few kW from the natural solar PV energy resources at the house. Twenty years later, when Lyse had become more updated, the client and the architect once again tried to get the house connected to the grid and to sell surplus solar PV to Lyse and buy back in the winter. The obstacles were still many and after a year of struggle Lyse finally offered to buy the solar electricity at 0,01 Euro per kWh. As a contrast, the grid tie law in Germany started by offering German customers 0,5 Euro per kWh. Chanelle was simply located in the wrong country and the grid tie was never implemented.

The client was also refused to apply the grey water and waste cleaning system and the local on-site water supply. Instead they were forced to deliver the sewage and all into the municipality's system that at the time went unhandled straight into the North Sea.

The many bureaucratic obstacles de-motivated the client, the architect and other clients that might hence have tried to go for such autonomous solutions. The full story is described in the book The Sunshine Revolution" [4].

3. Improved designs. Four examples of large ZEBs

Over the last five years I have been lucky to collaborate with Architects Alexandros Tombazis & Associates' / Meletitiki in Athens. We have together participated in several international architectural competitions for huge commercial and cultural buildings. We have pushed the border by trying to develop close to autonomous ZEB designs for buildings of 15-20.000 m^2. Most such buildings today in the Norwegian climate need 250 –400 kWh/m^2/year to function. In all of these competitions the

competition programme has had strong texts asking participants to focus on sustainability. Some programmes even stated that sustainability/energy efficiency/renewable energy would be one of only five judgement criteria.
Below are some illustrations of four area-efficient compact buildings designed for international competitions in Norway. Through them, we have experienced that delivering ZEB does not give you any advantages in competitions. The jury does hardly have the competence to even consider such designs and they rarely are concerned with running costs of buildings. They seem hopelessly old fashioned. This attitude could now hopefully change:

Stavanger Concert Hall, Fig. 3, where we received Honorary mention for an energy efficient concert hall with solar PV hanging as stardust on strings in the air from a tower. The tower is also handling natural ventilation ducts fuelled by large sloping solar heating system along the spine of the tower to create natural up draught. The huge roof was grass covered so in many ways we proposed to give the site back to the public. The winner? A fossil fuelled natural gas glass box, shaped like two shoe boxes.

Fig 3. Stavanger Concert Hall (Tombazis & Associates/Røstvik AS).

Bjørvika Oslo, Europe's most energy efficient commercial building, Fig. 4. In order to participate one had to document designs under 80 kWh/m^2/year. We delivered a design with solar PV and solar thermal documenting the need for bought energy as low as 20 kWh/m^2/year. The building contained hotel, exhibitions, flats and offices. The winner, an A shaped glass box, was control calculated to 200.

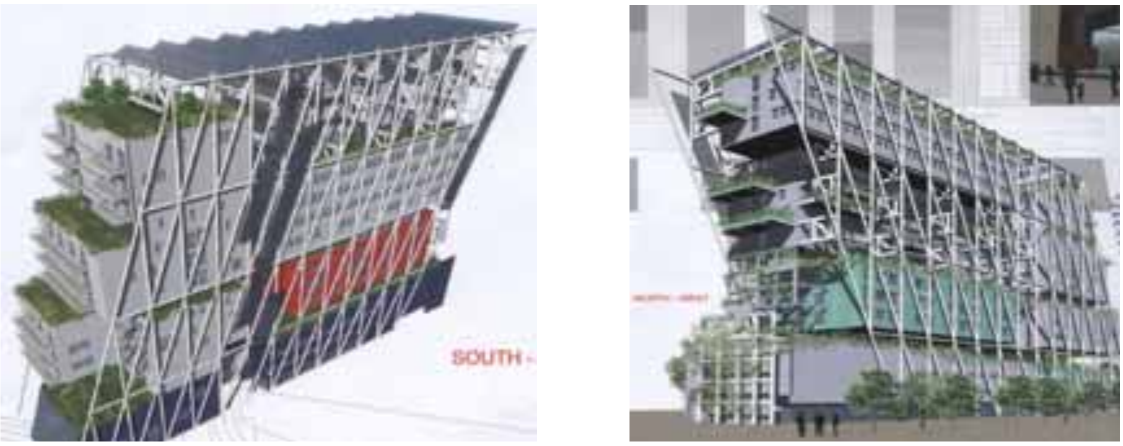

Fig 4. Bjørvika, Oslo. Europe's most energy efficient commercial building (Tombazis & Associates/Røstvik AS).

Kristiansand Concert Hall, Fig. 5. Again a ZEB energy efficient design with 5000 m^2 solar PV running a sea based heat pump among other items. The jury secretary later admitted that sustainability had not once been on the agenda in the jury meetings. The winner had no mention of energy efficiency.

Fig 5. Kristiansand Concert Hall (Tombazis & Associates/Røstvik AS).

National Art Museum in Oslo, Fig. 6. A design with a sculpture-garden on the roof. Overlooking the city. The southerly sides of the building facades were all covered by transparent solar PV running a sea based heat pump. The energy efficient design could run by as little as 50 $kWh/m^2/year$. The winner was a compact set of boxes with very little innovation as part of the design. It was a safe bet.

Fig. 6. National Art Museum, Oslo (Tombazis & Associates/Røstvik AS).

4. Twenty five years lost – now 2010

Since the Chanelle design I was heavily criticised by Norwegian colleagues that claimed it was wasteful to focus on ZEBs. Instead one should improve insulation standards by 10-15 % in all buildings. That would have a larger positive impact on the national energy consumption. This became the social democratic policy in Norway and architects and engineers loyally backed the socialist government's new mantra. I tried to do both insulation and autonomy, but the political national message won and all my ZEB attempts were from then on grounded, in spite of the positive results of Chanelle, which had been innovation driven.

As a result of the ”insulation only” state policy in Norway this innovation was stopped. Much to my surprise Norwegian state financed research institutes like SINTEF/NTNU led the way in criticizing my work. They seemingly were behaving like a prolongation of the state's messengers, recommending a few centimeter raised insulation standards only. From then on, no more ZEB projects came into my office. The rush had stopped. The socialist government had set a policy and the loyal state financed researchers obediently followed suit. I had been stamped a "rebel" to the state's recommendations. Work in my office dried up and from then on I had to survive by trying to design ZEB villages in the third world, consulting nations that looked for ZEB solutions on a national scale and participating in international architectural competitions designing ZEB solutions, This became my life for decades.

I have been very hesitant at whether to publish this story. Had it not been for he fact that now, 25 years later, in Norway, the National Norwegian Research Council (NFR) have finally decided that ZEB buildings are very interesting to the national planning, after all. *25 years is hence lost.* They now go for ZEBs in a big way and have decided to grant one state dependent well established research institute/university group hardly with no experience in the field 15 million Euro to look into the matter. The lucky one has set up a ZEB centre of excellence, including educating students in the field. To my surprise the lucky one which millions now is raining on is SINTEF/NTNU, the very institutions that criticised and through that undermined my ZEB attempts 25 years ago.

The expected result at SINTEF/NTNU will be several well financed PhDs and built examples. In addition the project have links to a number of industry partners mainly with products to sell. The value of their services and goods are set to a sum even higher than the state support via the Norwegian Research Council. All in all, the project will use almost 40 million Euro over the next 5 years.
The question is: What will they invent? Is this state-subsidised, limited group of industry actors coupled with a university up North in the coldest part of Europe, a relevant place to start?
They think so. They also think that they will be able to develop architectural high quality ZEBs since they have entered into a collaboration with the Norwegian architects Snøhetta, a company that have not really until now shown interest or talent in pushing the border of energy efficicnt buildings towards ZEB level. But they are famous. Their white Opera building in Oslo has travelled the world's glossy architectural magazines, but is it a building for our time? Its energy need is so high that it is a subject in the board meetings at the Opera. At one time they had to close all lights at night to lower the energy bill. The energy need is now probably over 200 kWh/m^2/year. But no architects risk to get unpopular and be stamped jealous by criticising Snøhetta's lack of environmental conscientiousness.

There is a long way go towards autonomy and ZEBs in Norway.
Architectural debate hardly exist, only praise.
The smug profession is a silent one.

5. Technology advances, need for innovation and ethics

There are several key barriers to the widespread application of ZEB designs. As far as my experience and studies show, none of them are technology-related. The technology and know-how is more or less in place and costs will fall in due time through replication and mass production. The architects that enter the autonomy field now walk straight to a set table, as opposed to the pioneers from decades ago that had to fight the silly resistance of the short term thinkers.

Barrier number one in bringing ZEBs to the market has been lack of interest from clients. They seemed unwilling to cover the extra costs. They also seemed unaware of the potential at saving running costs and bringing that into their maintenance running cost calculation through the life span of the building. As long as the client initiating the building process very often is not the one using the building, but instead renting it out, the incentives to bring down running costs seem to be lacking. It is hoped, however, that the energy marking system classifying buildings' energy need by kWh/m^2/year (A-G) might help drive the market towards more ZEB or close to ZEB designs.

Barrier number two occurs clearly during architectural competitions. The composition of the jury normally decides everything. Many architects considering participating in competitions first study the attitudes of the jury members to find out if they are receptive or not to their ideas. Mostly, one finds that juries as not manned with people with sustainability competence. On the contrary, they are mostly manned with architects that have made names through obedience and through having a clear focus on form, materials and colours. Studies of jury composition documents this.

One example is the above mentioned International architectural competitions in Bjørvika, Norway, mentioned above. While the programme clearly stated that submissions had to be calculated to be below 80 kWh/m^2/year, the jury selected a Danish winner that before the decision was finally made was control calculated to need over 200 kWh/m^2/year. The head of the jury was Dutch Architect Winy Maas from MVRDV [5]. Another jury member was Norwegian Architect Anne G Lien of ENOVA [6], the Norwegian state's body to reduce energy need in buildings and elsewhere. It seems a mystery how such a clear competition programme could result in such an evasive decision. Participants used a lot of time and money on their entries. Legally, what the jury did in this and similar instances could probably be tried in courts. Above all this is an ethical challenge that must be addressed preferably by the UIA, the International Union of Architects.

After heavy pressure from angry competition participant, the Norwegian league of Architects, NAL, initiated a debate meeting. Many articles were produced in the journal Arkiteknytt [7]. The full day meeting took place and anybody could air their views. Many of the competition participants did so. NAL naturally invited especially Winy Maas as head of the jury. He refrained from turning up.

6. Conclusions and recommendations

Timing is everything. Society must be prepared for fundamental change, if not it is very hard to move beyond demonstration projects. It is surprising though how many decades it took before autonomy and ZEB concepts picked up on the interest scale even among researchers, never mind architects. This really also raises the question if architects and researchers generally have become so dependent on public financing of projects that they have not been willing to pursue projects along the autonomy and ZEB avenue unless society and the research funding establishments were ready and inviting?

References

[1] Harald N. Røstvik, Architect MNAL. www.sunlab.no

[2] www.scienzattiva.eu/files/risposte/00e-ISE-Brochure-The-Solar-**House**1.pdf

[3] Rolf Disch, Freiburg plus houses. www.rolfdisch.de

[4] Harald N. Røstvik, The Sunshine Revolution. Sun Lab Publishers. ISBN 82-91052-03-4.

[5] Winy Maas of MVRDV, Netherlands. www.mvrdv.nl

[6] Anne G. Lien of ENOVA, Norway. www.enova.no.

[7] Arkitektnytt, Norwegian Journal of Architecture. www.arkitektnytt.no

For the Bjørvika competition debate at Arkitektnytt use search words like Bjørvika Europas Røstvik.