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Barriers and drivers for energy-efficient homes in Greenland



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Barriers and drivers for energy-efficient homes in Greenland



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December 2015

Climate KIC Pathfinder – Barriers

Introduction

When you tell people that you are dealing with research and teaching in Arctic construction, the reaction is almost always the same:

It must be a question of building low-energy houses, particularly with more insulation. When it's so cold in the Arctic, there must be a great incentive to build energy-efficient.

Such was the attitude also in this project, and it is likely the reason why Greenland is included as a case study here.

The issue is, however, somewhat more complex than that.

The temperature is only a small part of it, and other climatic influences weigh substantially heavier and are more challenging - strong wind, rain(storm), snow, ice, sun, rapid changes in temperature, etc.

One must also realize that the framework conditions in Greenland are fundamentally different from most of the world, especially Europe, and therefore a comparison is not directly possible.

On the other hand, a different context can sharpen the analysis and especially the awareness of factors, that under other circumstances would be taken for granted.



Downtown Nuuk in a blizzard. There is no tradition for planning according to wind, snow and ice drifts in urban surroundings.

Generally, energy efficiency is not given a great priority in Greenlandic construction, although it is discussed, especially in the public administration.

There is a number of reasons to this, to mention the most important:

1. Market, ownership, and incentive.
2. Building life span and depreciation for energy investment
3. Economic barriers
4. Technical barriers
and not the least
5. Island operations

It is worth noticing , that an nZEB standard takes more and is more complicated to fulfil in Greenland. And even though heating and energy is a large post on most family budgets, oil prices are considerably lower in Greenland than in most of Europe.

Summary

- The framework conditions are very different in Greenland compared to most Western countries.

The main difference is, that in Greenland the government initiates, owns and funds almost all housing projects – and even private projects are dependent on public mortgage loans.

Therefore, there is a floating limit between legislation and requirements (=requirements from the building owner or in accordance with loans).

- The economic incentive to build low energy housing is limited. The end user pays for energy consumption, whereas the public pays the building costs.
There is no direct link between rent and building costs.

- The life span of buildings and especially building envelopes are in general low. Increased insulation is perhapsⁱ more expensive in Greenland due to e.g. transportation costs. It is not sure that it is cost-efficient.
- For a number of reasons, new knowledge, new methods and new products can be difficult to implement in Greenland.
- The market, the business and the networks are extremely small. Therefore individuals and enthusiasts are important as drivers.
- Energy efficient solutions are often copied from Denmark or Europe. Some of them has shown not to work as expected. There is a lack of knowledge and research on how these solutions work under Arctic conditions.
- Other factors than energy efficiency is given a higher priority in the construction process, also when it comes to a private building owner.
- Greenland is an island operated community. This is a condition that overrides almost everything, and implicates factors that are normally not thought of in a European context.

1. Market, ownership, and incentive

Construction price, financing, and the number of homes built per year?

To take the last subject first: About an average of 2-300 per year (approximately 70-80% of this is in Nuuk), with a peak around 2010-2012, and dropping since then.ⁱⁱ

The Greenlandic government has decided to give priority to refurbishment rather than to new construction in the years to come. There is a tremendous need for refurbishment, as there is no tradition for maintenance. Therefore most houses that are more than 20-30 years old, are in a rather bad shape.ⁱⁱⁱ The contradiction to this is the shortage of homes in Nuuk as well as other settlements with increasing activity.



Contrasts on Radoffeldet in Nuuk. Terraced houses built in the 1970's. To the left a block thoroughly renovated in 2013, to the right blocks that are still waiting on their turn.

The number of new homes are also influenced by the costs.

The costs of new construction has risen dramatically in Nuuk, due to other large projects (i.e. a new prison, a new courthouse, and the repair of building damages on the Nuuk Tower, the government office building from 2012).

It is estimated that a couple of hundred FTEs per year will be missing in the construction business in the coming years.^{iv} This also has an impact on the

construction sector in other parts of Greenland, as workers will move to Nuuk to get the more well-paid jobs. This will also increase the shortage of housing in the capital.

The tender of the latest public residential project, 48 apartments in Nuuk, ended in a price on almost the double of the original budget. This was partly due to the overheated market, partly to increased energy requirements (that were not included in the initial budget).^v

The tender took place shortly before the interviews, and it is unknown whether this will result in a lowering of the energy standard of this block.

There has been other cases, where a ventilation system with heat recovery has been cut out of the project in order to balance the economy.

When it comes to financing, the state is the largest mortgage lender. There is not only public financing for publically owned homes (see the following paragraph), but also cooperative and private homes can have a significant part of their financing from public funding. These loans are offered with no interest and no repayments for period of time, going from 15 years to when the house is resold. The most favorable funding are offered to cooperative housing.

There are limits on these loans: to the total amount of funding each year, to the area of the single home, and to the building costs per m².

The aim is to make private ownership of homes more favorable compared to rental housing, and thereby reduce the public ownership.

Who build and own in Greenland?

From historic reasons, most residential building in Greenland had and still has public ownership. Though the authorities have tried to dispose of the ownership

through the “from tenant to owner” program, the public still plays the major role in housing ownership.^{vi}

Only the major settlements^{vii} have a market for real estate. This is the case in the capitol Nuuk, and to some extent in Sisimiut, Ilulissat and Qaqortoq. Outside these cities there is no functioning market. This is partly due to a low demand, and that the income is low, and the ability to pay therefore cannot cover the cost of a privately owned home. One cannot expect to get the investment back by selling. Another reason is the very high migration rate: approximately 40% of the Greenlandic population move every year^{viii}. Rental housing is easier to dispose of than private homes.

When it comes to new building, Nuuk has a small market for professional private building, mainly condominiums.

In general, new rental housing is build by Selvstyret. Municipalities only build housing for the elderly.

The gap between public rental housing and private homes is filled with cooperative housing, which is an increasing sector, partly due to the favorable funding.

For the small settlements (villages), Selvstyret has developed the Illorput (= our house in Greenlandic), an easy-to-build single-family house.

Which kind of homes are build?

Very few buildings in Greenland date back before 1950. Up till then, most Greenlanders lived in houses poorly built of peat or (scrap) wood. The health conditions were terrible and about 1/3 of all deaths were due to tuberculosis.

After WW II, there was a change of paradigm. The Danish government decided to provide better housing conditions for Greenland by building new homes for everybody.



*Housing in Sisimiut in the 1930's.
Photo: Sisimiut Museum*

The first generations of these homes were the small wooden houses which have become the spitting image of Greenlandic settlements. They were very well planned and designed by the Greenland Technical Organization (GTO). The materials were shipped in containers and Danish craftsmen came up in the summer to build the houses, as Greenlanders were not supposed to take part in the building process. They were to remain hunters and fishermen. (The first carpenter was educated in Greenland as late as in the beginning of the 70's).



GTO standard houses in the village of Kangaamiut, between Sisimiut and Maniitsoq. You can almost read the age of the house by looking at the windows in the gables. A small distance between the window and the roof leaves only little space for insulation = the oldest houses.

The Greenlanders thereby went from being responsible self-owners and self-builders to being tenants with no responsibility for their homes. This still has an impact on housing in Greenland, and thereby also on energy consumption.

Almost all residential buildings are standard houses, and has been since the 1940's. Only few are designed for the location where they are built.

Almost every decade has it's standard design for housing blocks. In the 70's, the typical residential buildings were long straight concrete blocks, looking like any other estate in Denmark, Germany or elsewhere. In the 80's and 90's, new types were developed, with a resemblance to the original colorful housing.



Blok P in Nuuk, once the largest building in Greenland, and Blokland in Albertslund, Denmark, built almost simultaneously in the 1960's; Blokland to house the workers of the nearby Coop main warehouse. Blok P was demolished in 2012, whereas the Blokland is facing a major refurbishment program. The budget for the Blokland masterplan is approximately 3/4-1 mill. DKR per apartment.



The new tower blocks in the Nuuk suburb Qinngorput (ongoing).



This estate in Sisimiut is one of the few designed for the spot it is built on.

In 2005, Selvstyret decided to develop a tower block as the new public housing concept, inspired by Icelandic construction. The first seven 8-storey blocks with 210 apartments were risen in Tuapannguit in Nuuk in 2007-11, and since then more of these blocks has been built in Nuuk (i.e. Qinnngorput) as well as in some of the larger towns. Some of them up to 10-storeys, some as “low high-rise” in 3 storeys.

It is expected that tower blocks would be cheaper than for example terraced houses, and that a higher quantity of the same type also would result in lower prices.

However, pricing is rather un-transparent, inter alia, because the market is so small. Therefore, it is difficult to assess whether this type of housing really is cheaper, which the case with the tender on 48 apartments in Nuuk also shows.

Single family homes – private as well as cooperative - are almost always standard houses ordered from Danish manufacturers. They pack and ship everything needed for the house – materials, doors and windows, technical equipment etc. Most houses are build by local contractors.

Not all Danish companies are willing to ship to Greenland^{ix}. In fact only about 3-5 manufacturers are able to do it. There is a limited incentive for new companies to enter the Greenlandic market, as it takes know-how to export to Greenland and the quantities are small. The ability to operate in the specific market becomes more important than the quality of the product. Therefore, a demand for energy-efficient building will be given less priority.

There might be a tendency that in Nuuk more houses are individually designed by architects than in the rest of the country. There are only few architects outside Nuuk, and small projects cannot bear the costs of travelling.



A Panbo house kit for a single-family house, delivered on site in Sisimiut.

2. Building life span and depreciation for energy investment

As mentioned, very few homes in Greenland date back before 1950, and most buildings are less than 30 years old.

Wear and tear from many movings, especially in rental homes, has a impact on the building conditions; so has the weather, especially wind, sun, rain, snow and ice. As there is no tradition for repair work and maintenance in Greenland, the life span of buildings and building envelopes are considerably shorter than in for instance Denmark.^x

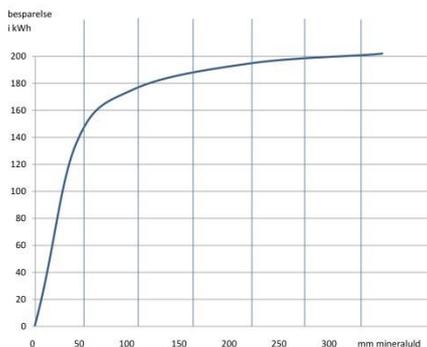


This residential block built in Sisimiut dates back to 1970's. Similar block was built in all major settlements along the West coast.

As maintenance is almost non-existing, these blocks are generally in a bad shape. Apartments that are too poor to be let out, are closed off with boards in front of the with plywood boards in front of the windows.

It is difficult to predict whether this will also be the case in the future. There are trends that point in the direction of an improved construction quality, but also tendencies pointing in the opposite direction.

Either way, this should be considered when assessing the depreciation for investments in energy efficiency. By “investments” means economic investments as well as the energy consumption for production and transportation of materials.



The curve for energy savings from insulation goes approximately like this.

The reduction in energy consumption achieved by increasing insulation on the top of the curve (i.e. from 200-250 to 250-300 mm) is limited.

It makes sense, if the building has a long life span and thereby a long time for depreciation – but perhaps not, if the building envelope has a life span of less than 30 years. Especially if there is a larger energy consumption for transportation of materials.^{xi}

Greenland has a large potential for renewable energy. Hydro power is the primary source for electricity, PV and solar heating could be a part of an overall energy strategy. So could more energy efficient construction, but it is not necessarily the element with the largest CO₂ reduction compared to the investment.

As most investments in Greenland are publicly funded, this also indicates that the government has more tools to deploy in terms of reducing CO₂ emissions (if it has the proper research to lean on).



The hydro power plant in Sisimiut is situated in the mountains, and only available by snowmobile or ATV – and not in the spring, when the snow is too soft for the first and too heavy for the second. So the staff hopes for the best and monitor the plant from a distance on computers. Hydropower supplies approximately 2/3 of total the energy consumption in Greenland.

3. Economic, technical and logistic barriers

Legislation

The building code in Greenland is based on the Danish building code BR96 which has long been outdated in Denmark. A revision of legislation has been in the pipeline for some years, but for various reasons it has not been implemented yet. One can only guess to the reasons, but it seems obvious that the political priority has been elsewhere. As most construction is publicly funded, increased energy requirements would have an impact on the finances in the state and the

municipalities. And for the time being, the Greenlandic economy is in a bad shape. The financial crisis came to Greenland - or was acknowledged there - five years after it hit the rest of the world.^{xii}

At the same time, there is a shortage of housing in Nuuk as well as in other major settlements, and the need for refurbishment is tremendous. Therefore, there is no real inducement to implement costly energy requirements, as energy consumption is paid for by the end users.

Being the major construction owner, the government has the opportunity to ask for better standards in the individual projects - with the possibility of cutting it out again, if the economy is tight.^{xiii}

Indoor environment and low energy construction

Building airtight constructions have become normal standards in Greenland, whereas good ventilation systems with heat recovery have not.

This is partly due to economic reasons, partly to the fact that good and efficient ventilation systems are a rare phenomenon in Greenland. In general, the solutions are copied from Denmark, even though they often do not work in an Arctic context.^{xiv} Martin Kotol analyzed this problem in his PhD from 2014^{xv}. His study states, that it is possible to have well-functioning mechanical ventilation with good comfort and heat recovery also in an Arctic climate (on certain defined circumstances), but the results has not become common knowledge in the business.

There are less than a handful of ventilation engineers in Greenland, and a general lack of skills by the contractors. Installation and service of heat recovery systems can be a problem, at least outside Nuuk.

The building department in Selvstyret give a high priority to blower door tests on new buildings. However, air tight buildings need a sufficient ventilation system to ensure a good indoor climate. It is generally known that there is a close link between mold and inadequate ventilation.

Mould is a problem in Greenland – at least there is a lot of talk about it. It is a frequent subject in the news and in the public debate.^{xvi} It is well documented that mold has a harmful effect on health, and in the theory behind the cause of mold is likewise well known.^{xvii}

In view of this, one could have expected more emphasis to be put on the implementation of good ventilation solutions.



In 2014, this building in Sisimiut gave the best result in a blower door test in the “kingdom” (Greenland + Denmark).

Unfortunately, a ventilation system with heat recovery was not installed, probably due to economic reasons. There is exhaust ventilation the bathrooms, but the system is not working properly. The air inlet comes through wall vents, which are often blocked by the residents to reduce the drafts – which causes an even more heavy exhaust in the other apartments, and difficulties in opening the entrance doors.

Tightness is essential in low energy construction. The question is, however, whether the general European method for airtight construction – with an airtight plastic membrane in the building envelope – is the best way to do it in the Arctic. Here, the air in general is very dry, and the temperature conditions very different from Europe. It is not just a question of the cold weather in the winter, but also of the heat from the sun, that can cause local high temperatures in and around the building envelope. ^{xviii}

Mounting of an airtight membrane will be problematic in existing housing if adding extra insulation here.

As there is a total of 23.000 homes in Greenland and only 2-300 new ones are added per year, it is important to focus on the existing homes in order to reduce CO₂ emissions.



If the original Greenlandic houses shall be kept for the future, it is important to find ways of renovating them with better insulation and modern facilities.

Another problem occurs with the tightness: overheating.

The number of complaints on overheating is increasing, as a result of a trend with large window panes, in combination with less natural ventilation due to the tight constructions.

In a school in Ilulissat, the class rooms in the new wing cannot be used when the sun is shining in the summer^{xix}. In Sisimiut, the director of the cultural house Taseralik hopes for cloudy weather when having events in the building.



The Taseralik House of Culture in Sisimiut with large windows facing south – and overheating in the summer and cold drafts in the winter.

Even though the general outdoor temperature is rather low, there are more sunshine hours in the Arctic than in e.g. Denmark during the summer.

Local temperatures around a house can be pretty high. This is not always taken into account by the design of ventilation systems – an air inlet placed on a black roof facing south will not provide the cool air needed in overheated rooms^{xx}.

Architect Peter Barfoed, Tegnestuen Nuuk, points his finger on another problem: that highly insulated roofs tend to accumulate more ice, which can cause damages to the constructions, and by thaw to things and people near the house. Sliding ice can kill a man, and cause deformation of e.g. outdoor stairs.^{xxi}

On a moderately insulated roof, the snow will melt and the water will run off. With a better insulation, less snow will melt, and the water will freeze instead of running off. During the winter, this will build up a considerable layer of ice on the roof.



Photos from the SANA hospital in Nuuk, taken in the February (left) and in May. The pictures show how a heavy layer of ice is built up under the snow during the winter. This layer can obtain a considerable thickness with very large icicles. The picture from May shows what can happen by the thaw, when such an icicle and block of ice break loose and fall on a staircase / ramp. Besides being a danger to the surroundings the massive ice means a risk of damage to the roof and deformation of the overhang.

Logistic challenges

All building materials – apart from stone and water for concrete – are imported to Greenland, and it all comes from Denmark. One could think that import of e.g. timber from Canada or Norway could be an advantage. In practice, it does not happen, mainly because there is no regular shipping traffic from other countries to Greenland.

The traffic goes from Aalborg to Nuuk, where the cargo is reloaded and shipped to other settlements in Greenland. In general there is a delivery time on 4-6 weeks, but the further north and east, the fewer ships a year. Qaanaaq in the north and the eastern town Tasiilaq only have 2-3 ships a year, in the summer.

Building materials are ordered per project. Only the larger towns have timber yards and hardware stores, with a limited selection of goods in stock, and at very high prices.

This makes it important to plan the project down to the last nail. As there are very few technical consultants outside Nuuk (and consultancy is expensive for small projects), this gives an advantage to standard houses, and especially to the few manufacturers who know the conditions in Greenland.

It obviously present challenges when trying to introduce and implement new products and solutions. A consultant mentioned that the Kujalleq Municipality (in the south) would not accept window panes with special coating, because they could not replace them when they broke.

It also opens the question of liability. Nobody wants to take liability for solutions and products they do not know and that are not commonly used.

On the other hand, the widespread use of standard houses will also make it easier to implement changes - if there is a common understanding in the business, and a will to do so in the state and the municipalities.

A political focus has been on producing local building materials. Therefore, the former government had an interest in introducing paper insulation, which was supposed to be possible to produce with small production facilities, as this would reduce the import of mineral wool. There was more focus on this matter than on reducing energy consumption. It is questionable whether paper insulation can be regarded as a sustainable substitution for mineral wool, especially in Greenland,^{xxii} and a local production has not been established yet.

There is a minor import of paper wool, but the most common insulation is glass wool. This is preferred to rock wool, as glass wool is more compressable and therefore cheaper in transportation.

6. Island operations^{xxiii}

The largest single challenge for the Arctic construction industry are without doubt the issue of island operations.

Greenland has 75 inhabited places, and none of them are connected by roads.

The smallest settlement has fewer than 50 residents, the second largest (Sisimiut) has 5,000. Settlements are spread over a coastline of nearly 3,000 km, with a detour to the eastern coast of 1.000 km.

Nuuk, with its 17,000 inhabitants, is an exception in this context. With its size and better shipping links the construction sector in Nuuk have completely different conditions than seen in the rest of the country. There is probably more equity between the construction sectors in Nuuk and Denmark, than there is between Nuuk and the rest of Greenland.



The village of Kangaamiut with 500 citizens has no roads, no airport and not even a harbour big enough for passenger and freight boats. Goods have to be sailed ashore on a barge with further transport on ATV. This is obviously a problem for shipping of building materials.

The costal boat Sarfaq Ittuk carries a small boat that will sail passengers to the pier.

This situation is similar for many other Greenlandic settlements – only that Kangaamiut has better trafic connections, since the costal boat passes twice a week most of the year.

Further north there is no boat in th winter time, due to too much ice.

Island operations have impacts on all aspects of construction.

Everything has to be imported, ranging from the materials to special skills. The larger ice-free towns regularly get deliveries per ship, while in the northern and eastern settlements shipping is limited to a few times a year. Often it is easier to import something from Denmark than it is to transport it across Greenland (excl. Nuuk).

This implicates that construction projects require thorough planning, because neither materials nor machinery is present in the local area (or at least only to a limited extend).

Single-family houses are delivered as kits from private firms, mostly in Denmark. The orders often go to the companies that are the best salesmen in Greenland. This does not necessarily imply that it is the products that perform best under Arctic conditions.

From a strictly technical perspective, it could probably be beneficial to import houses developed for other parts of the Arctic, but the logistics would be a challenge.

There are craftsmen in most settlements, but the number and specializations are naturally adapted to the local market. In smaller towns they are generalists who can handle various repairs, even if they have not had received formal training. They are often skilled to cope with the various situations that arise in an Arctic island operations community, which is almost a specialization in itself.

However, they are not always updated and trained on the newest construction techniques and products. It may complicate implementation of new methods.

Naturally, the larger towns and cities have larger construction companies, but here too there are limits to the capacity, and skills are developed in relation to "the general market", repairs and small construction projects.

By the construction of larger buildings, it will often be necessary to retrieve the labor and skills from outside (Denmark).

In 2015, Greenland's construction industry is strained by a number of major construction projects. The Danish government (in charge of the judiciary) have chosen simultaneously to build new courthouses in Nuuk, Sisimiut, Ilulissat and Qaqortoq, and a new large prison is being build in Nuuk.

On the brand new 10- storey administration building of Selvstyret, the exterior as well as the interior cladding of the facades had to be replaced, as the original boards could not withstand the pressure from wind and rain.



*Selvstyret's high rise office building, before and after replacing the cladding, due to insufficient windproofness, moisture in the construction and mold.
The building was finished in 2012, the renovation took place in 2013 and 2015.*

This means an overheating of the construction sector in Greenland. Director Michael Mørch, Orbicon consulting engineers (ex-chairman of the consultant's committee in GE, the Greenland Business Association) estimates that in the coming years, a couple of hundred FTEs per year are missing in the construction industry, primarily in Nuuk.

A recent tender for public housing in Nuuk ended in a price almost twice the budget. Approximately half the cost overrun due to market pressure, the other half partly due to energy requirements.

There are only two ways to manage a construction boom. The workers, who reside in Greenland, will have to work more, and it will be necessary to call in foreign labor. Both increase the risk of construction defects.

A construction boom also means an increased demand for engineers. Larger building projects are naturally designed and managed by professional consultants, but often this is done in Denmark, in collaboration with local companies.

There are very few consultants outside Nuuk. There are a total of maybe 10 to 15 engineering consultants north of Nuuk, but also in Nuuk, the industry has a limited size.

In cases of a construction boom a larger share of the planning as well as supervisory work will be performed by technicians with limited experience in the Arctic. This also increases the risk of errors.

Almost all major construction projects in Greenland have public ownership. This should enable better coordination and overall planning of the major projects, implicating economic as well as quality benefits.

Knowledge of new products and methods are often shared through networking. Because the professional networks in a country like Greenland are small, it may be coincidental, which information is spread. It is often dependent on the specific persons and enthusiasts.

Therefore, this report should end with a success story for the energy efficient homes:

Arctic engineers Rasmus and Themonia Kruse-Nielsen (from the Masanti engineering office) built their own home in Sisimiut.

They bought a Scanwo standard house with more insulation than the usual type, and with the help from Artek's PhD Martin Kotol they have installed a ventilation system with heat recovery. It has now worked without problems for two years.

The house has large windows facing south, and the rooms might be overheated in the summer. This is solved by simply opening the windows.



The house of Rasmus and Themona in Sisimiut – a standard house with extra insulation and a heat recovery system.

Perhaps by inspiration from Rasmus and Themona, Torben Olsen - construction manager at Permagreen (contractor) - designed for himself a super-low-energy house, with high insulation, PV and heat pumps. Unfortunately he was not able to get at site close to the water (which was a necessity for the heat pumps), and therefore had to give up this project. But he did not give up energy efficiency.

In 2015-16 Permagreen is building 8 homes as cooperative housing. These houses have ventilation with heat recovery and more insulation than the common standard. They are log houses, produced by Scanwo, and insulated with 240 mm in the outer wall, 290 mm in floors and 290 mm in the roof. In a Danish context, this is not a high insulation standard – but it is a great improvement in Greenland.

This was not the result of requirements from the building owner or the authorities, but it came through because Torben and his colleague gave it priority, and managed to do it without exceeding the budget.

These examples show that in spite of legislation, politics, logistics, economy etc., people (and companies) can change the way things are done, and hopefully they will push the standards for the future.

■



Notes

This report is based on interviews in Sisimiut, Nuuk and Ilulissat in May and August 2015 with consultants, contractors and municipality employees, combined with in situ registration and information collected on previous travels to Greenland from 2010-15.

ⁱ Not all the interviewed consultants and contractors agree on that. The major part find energy efficient construction more expensive and not always cost-efficient.

ⁱⁱ Unfortunately, the data on housing and building are not very precise, as Statistics Greenland has not made statistics on this since 2010 (probably because it is difficult to collect the information in an island operated community).

The figures are based on a combination of information from Statistics Greenland, from interviews with the consultants in Greenland, from the housing company INI, from the department of housing in Selvstyret, and from questioning the Danish producers of wooden houses ("how many houses have they sold to Greenland during the last couple of years").

ⁱⁱⁱ Tove Lading: Report on housing, AMAP 2015

^{iv} Michael Mørch, director Orbicon Greenland, head of the building committee in the Business Greenland association.

^v Information from consultants in Nuuk.

^{vi} 60% of all homes have public ownership, 40% are community housing, private homes and homes owned by companies, either for rental or for their own employees. [Statistics Greenland 2010]

^{vii} The four largest cities in Greenland are:

Nuuk 17.000 inhabitants, Sisimiut 5.600, Ilulissat 4.500, Qaqortoq 3.200 [Statistics Greenland 2015]

^{viii} Hendriksen, Kåre, 2013, "Grønlands bygder – økonomi og udviklingsdynamik"

^{ix} The Danish producers of wooden houses (from a list from Teknologisk Institut) have been questioned on their export to Greenland. Only two companies (Scanwo and Panbo) had sold houses to Greenland during the past 2-3 years.

^x How much shorter is difficult to estimate, as there is no specific measurement for the life span of buildings. But it is obvious, that the "acceptable building standards" are on a much lower level in Greenland than in Denmark.

^{xi} There is no available information, documentation, or calculations on this matter.

^{xii} Jesper Johannesen in February 2013, at that time director of INI Byggeteknik, when asked about the impact from the financial crisis: "There is no financial crisis in Greenland. It doesn't exist."

There were two reasons to this: First that block grant from the Danish government remained the same in spite of the crisis, and this was approximately half the GDP in Greenland. Second, that it was a general expectation in Greenland that mining industry - oil or minerals - would make the country rich within a few years.

^{xiii} This was the case with the tender with 48 apartments, held in Nuuk in the autumn 2015. A higher energy standard was required, but the price was considerably higher than the budget (50-100%). More consultants have referred to this case when asked about energy standards and costs.

^{xiv} It has not been sufficiently documented, whether there is more moisture in Greenlandic homes than in e.g. Denmark. Some of the reasons why Danish ventilation solutions do no work are obvious, and one can guess to others:

- Simple ventilation solutions (open windows, slit valves, etc.) are uncomfortable at low outdoor temperatures and strong winds. It is well known that people block fresh air valves.
- People take more moisture in from the outside (snowy and wet outerwear and boots).
- A cultural pattern where a larger part of the social life takes part in the homes (kaffemik).
- A food culture, where meat is often cooked (boiled in water) for a long time.

^{xv} Martin Kotol: "Energy use and indoor environment in new and existing dwellings in Arctic climate", DTU 2014.

^{xvi} There is no research on the exact extent of the problem and whether mold is more prevalent in Greenland than in e.g. Denmark.

^{xvii} The causation in relation to a possible larger dissemination in Greenland has not been researched thoroughly. Danish explanatory models are used, e.g. in anti-mold guides for residents [www.ini.gl].

^{xviii} There is apparently no available research on this subject.

^{xix} Planchef Hanne Holm Andersen, Ilulissat, Qaasuitsup Kommunia.

^{xx} Culture house Taseralik, Sisimiut.

^{xxi} Serious deformation of stairs and ramps by ice was seen at the Sana Hospital in Nuuk in 2015.

^{xxii} Tove Lading: "Papiruld i Grønland", memo, 2013

^{xxiii} Tove Lading: Report on housing, AMAP 2015

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