Does Greenland need a guideline on how to deal with moisture in the construction phase?

Hansen, Ernst Jan de Place

Published in:
Proceedings Artek Event 2012: Challenges for the Arctic Building Industry, Sisimiut, Greenland, 13-14 March 2012

Publication date:
2012

Document Version
Accepted author manuscript, peer reviewed version

Does Greenland need a guideline on how to deal with moisture in the construction phase?

Ernst Jan de Place Hansen

Danish Building Research Institute, Aalborg University. DK-2970 Hørsholm, Denmark
e-mail: ejp@.sbi.dk

Abstract

Damage to buildings seen in Denmark tends with some delay to turn up in Greenland. This makes it relevant to study buildings with moisture-related problems in Denmark and how they are dealt with in the Danish Building Regulations to prevent the problems from being copied in Greenland. As the requirements concerning moisture control are function-based, the construction client and the authorities are entrusted with interpreting requirements in a specific case, which caused the introduction of a guideline based on humidity risk classes. This paper presents the Danish requirements and guideline and gives examples of moisture-related problems in buildings in Greenland. Requirements and guidelines are needed in Greenland in order to deal with moisture in the construction phase, but as the conditions for constructing houses and the way that houses are used in Greenland are different from Denmark, an adaptation to the specific conditions in Greenland is needed.

1. Introduction

Damage to buildings seen in Denmark tends with some delay to turn up in Greenland. This makes it relevant to study actual problems with buildings in Denmark to prevent them from being copied in Greenland. This paper looks into moisture-related problems, as mould growth has been a growing problem in buildings in Denmark. In order to deal with this, the operating phase of a building was at first the main target, but recently focus shifted to the construction phase.

Moisture in buildings can result in unhealthy indoor climate. This has been known for long and many efforts have been made to avoid moisture in the operating phase. Moisture added to the building in the construction phase has been regarded as unavoidable and something that dries out during the first year after the completion of the building. In a number of cases in Denmark the completed building was however so wet - because of moisture added to the building in the construction phase - that part of the construction was attacked by mould growth even before the inhabitants started using the building.

As a result, the Danish Building Regulations (DBR) have since 2008 stipulated that building structures and materials should not, on moving in, have a moisture content that is liable to increase the risk of mould growth (Danish Enterprise and Construction Authority, 2008). The authorities have the possibility of requiring measurements or other types of documentation provided by a moisture specialist to verify compliance with the requirements.

In 2011, a guideline was introduced to help the client comply with the requirements and the intentions in DBR concerning dealing with moisture at each stage of the building process. This includes the categorisation of a specific building in a humidity risk class, as the risk of moisture damage is related both to the expected exposure to moisture during the construction phase and the building’s susceptibility to moisture.

How can this kind of guidelines and experience be implemented in the Greenlandic Building Regulations (GBR)? And are they relevant at all in a Greenlandic context?

As GBR will gradually approach DBR including the introduction of requirements for airtightness and increased insulation thickness, the importance of avoiding wet materials for construction in Greenland will increase. However, conditions for constructing buildings are different in Greenland. If guidelines and requirements regarding moisture in the construction phase are to be introduced in GBR, they must be adapted to these conditions.

The requirements, as they are introduced in DBR and the associated guideline, are presented in Sections 2 and 3 of this paper. Challenges related to moisture in the building stock in Greenland are presented in Section 4, followed by discussion and conclusions regarding the need for a guideline on how to deal with moisture in the construction phase in Greenland.

2. Moisture requirements in the Danish Building Regulations

Two important requirements concerning control of the moisture content in building structures and materials were added to DBR in 2008. The first one states that climate control measures essential to the proper construction of a building must be taken during planning, design, tendering and construction. This provision includes ensuring that neither wet moisture-sensitive materials nor materials and building elements that are affected by mould are incorporated during the construction period. The functional requirement may, for example, be complied with by:

a. Avoiding materials and constructional solutions that are unduly moisture-sensitive
b. Explicitly allocating time in the client's tendering plan and time schedule for all necessary drying out of building materials and structures
c. The client carrying out a cost-benefit analysis of the benefits of fully enclosing the building during construction and prescribing total enclosure if it is financially viable, or whether the tender documents specify particularly moisture-sensitive materials or constructional solutions
d. The client providing shared facilities for storage of moisture-sensitive materials.

The other requirement states that:

e. Building structures and materials should not, on moving in, have a moisture content that is liable to increase the risk of mould growth.

This requirement minimises the risk of moving into overly damp buildings and the risk of mould growth, in both new buildings and renovation projects.

2.1 Guideline for dealing with moisture in the construction phase

The DBR does not describe how it is documented that these requirements are complied with. To a great extent, the client and the authorities are entrusted with interpreting the requirements in a specific case. Therefore, a guideline for dealing with moisture in the construction phase was prepared for the Danish Enterprise and Construction Authority (Møller, 2010). For each step in the building process from the preliminary design phase to the 5-year inspection, the basic decisions are presented and it is suggested, what kind of documentation would be relevant.

In the building permission, the authorities have the possibility to require measurements or other types of documentation provided by a moisture specialist to verify compliance with the requirements. The documentation can be aimed at

– specific building components, e.g. prefabricated roof cassettes
– specific building processes, e.g. storage of materials on the building site
– the building process as a whole.

The client defines the competences of the moisture specialist and the amount of documentation that would be relevant. The moisture specialist does not have to be independent of the contractor. The tasks of a moisture specialist are described in

(Aagaard, Høite & Møller, 2011) and it is emphasised that the requirements in DBR are minimum requirements and that the construction client can benefit by going further. Therefore the construction client needs guidance to decide

– when it is relevant to consult a moisture specialist
– what kind of competences should be asked for
– how the competences of the specialist should be documented, and
– what kind of requirements can be made to the work of the moisture specialist in the different phases of the construction project.

A number of fundamental decisions on materials and design are taken very early in the building process. Many discontinuities and penetrations will for example increase the risk of moisture entering both during construction and afterwards in the operating phase.

Too many construction projects have been constructed without involving a moisture specialist, until a time when moisture-related damage are discovered and some kind of renovation becomes necessary. Therefore, depending on the type of construction project, it can be relevant to involve a moisture specialist from the very beginning of the planning, for instance if the client wants to use new materials or new solutions.

The authorities in Greenland have made a guideline for the construction client, mainly aimed at the directorates of the Home Rule, describing a construction project from the preliminary design phase to delivery of the completed building (Direktoratet for Boliger og Infrastruktur, 2005). It mentions only very briefly that the selected materials and building technology should minimise the safety- and health-related loads during the service life of the building. Guidelines on how to deal with moisture in the construction phase could therefore be a relevant supplement.

3. Humidity risk classes

The risk of moisture problems arising during the construction of a building primarily depends on

– how great the moisture exposure is during construction
– how susceptible the building is to moisture.

By combining these two properties, it can be assessed in which humidity risk class a building is during construction. Based on this, the actors in the building process can evaluate what measures it would be relevant to take. The classification is primarily meant as a help in assessing what requirements to measurements and documentation are needed. The Danish guideline (Møller, 2010) includes three humidity risk classes labelled 1, 2 and 3, as described in Table 1.

Table 1. Humidity risk classes as a function of exposure to moisture during construction and the susceptibility of the building to moisture.

The susceptibility of the building to moisture	Exposure to moisture during construction		
	Low	Medium	High
Low	class 1	class 2	class 2
Medium	class 1	class 2	class 3
High	class 2	class 3	class 3

Whether the exposure to moisture during construction is low, medium or high depends on

- how wet the construction and assembly processes are, e.g. in-situ concrete
- to which degree the construction and assembly processes take place without covering.

The susceptibility of a building to moisture is related to

– the ability of materials to absorb moisture
– the mould risk of a specific material
– the time available for drying.

The lesser the ability to absorb moisture, the lesser the mould risk. The longer the time available for drying, the lesser the susceptibility to moisture. It is highlighted that the combination of materials can be critical, e.g. the combination of moisture-sensitive materials like wood and plaster boards and materials with a high amount of moisture at construction like in-situ casted concrete.

The categorisation in humidity risk classes is only used as a guidance to evaluate the need for extra precautions against moisture. It is not a requirement to categorise a building or a part of a building in a specific humidity risk class before construction or to decide whether the risk class varies during construction. The evaluation is usually made by the client or his representative.

By introducing humidity risk classes, the consulting engineer can make it quite clear to the client that he is taking a risk. The engineer can also demonstrate how the risk can be reduced and where special precautions are necessary, including the use of a moisture specialist, as described in Table 2.

Table 2. Suggestions of how humidity risk classes can be utilised to determine the need for initiatives before and during construction. All initiatives must be documented.

	Risk class 1	Risk class 2	Risk class 3
Before construction	Comply with minimum requirements in DBR	Minimum requirements and: – Setting up a moisture strategy plan	Minimum requirements and: – Setting up a moisture strategy plan – Calculation or simulations if possible – Attach a moisture specialist
During construction	– Moisture measurements at critical times; as minimum before closing the building	– Continuous moisture measurements – Limited measurement program – Assess specific potential moisture problems	– Continuous moisture measurements – Expanded measurement programme – Attach a moisture specialist

4. Challenges related to moisture in the building stock in Greenland

In 2010, the number of dwellings totalled 23,112 (1.1.2010) in Greenland (Statistics Greenland, 2010). About 55 % of them are dwellings in single family or terraced houses, while 45 % are dwellings in multi-storey houses.

4.1 Single-family wooden houses

The development of residential houses in Greenland has resulted in practically all detached and semi-detached family houses being wood-framed structures with painted wooden cladding. These houses often have poor airtightness and many thermal bridges (Bjarløv and Vladykova, 2011). Poor air-tightness in combination with the dry outdoor air in Greenland could be helpful in ensuring the removal of construction moisture and preventing mould growth, but on other hand it could also lead warm humid air to areas in the building envelope where it can lead to moisture damage. Nor is a high and uncontrolled air change in accordance with the increasing focus on energy efficient houses.

4.2 Multi-storey houses

Many of the multi-storey houses in Greenland are copies of Danish multi-storey houses and are not suited for the arctic and often very windy Greenlandic climate, which in combination with poor execution and insufficient maintenance have resulted in houses with poor durability both of the constructions, the building envelope and installations, e.g. (Sanaartortitsiviit, 1990), (Hansen, Johansen & Jensen, 2004).

The dry outdoor air in Greenland should be a positive factor for avoiding moisture-related problems in houses. However, the higher concentration of residents, the higher generation of moisture from cooking and the widespread habit of drying clothes inside apartments in Greenland, compared with Danish traditions, and the fact that the cold climate limits the habit of opening windows to create a draught, means that copying the ventilation requirements in DBR is not sufficient to ensure a satisfying indoor air quality (Olsen, 2012).

Moreover, the inhabitants often block the ventilation ducts to reduce the energy loss and the discomfort from draught. Lack of ventilation and an insufficiently insulated building envelope with many thermal bridges will give rise to condensation problems with mould growth and a poor indoor climate as a result (Kragh, Reimann and Svendsen, 2005).

4.3 Challenges on the construction site

Although moisture-related problems in Greenlandic houses are in many cases related to the use made of them, it appeared that also the construction phase showed problems. Because of the extreme weather conditions, the duration of the activities on the construction site is much longer than in Denmark.

Facade elements are assembled on the construction site, directly exposed to the weather, and buildings are left with the wind barrier exposed to the weather for several months during the winter until the activities can proceed again in spring, which often results in damaged wind barriers (Barfoed, 2001). This means that the house contains a certain amount of construction moisture when it is finished. Traditionally this has been dealt with by ensuring that the outer part of the building envelope allows moisture to diffuse from the timber-frame construction to the outside, (Olsen, 2012).

In detached and semi-detached houses, it is common to place windows level with the outer wall, which makes them very exposed to the climate. Leaky joints often result in moisture-related problems. An outer wall based on a timber-frame construction in Greenland is much thinner than a concrete-based outer wall in Denmark, partially owing to a smaller insulation thickness, and this leaves very little room for a window board if the window is not placed close to the outside of the outer wall.

The fact that the amount of snow is much larger in Greenland than in Denmark also has to be taken into account, for instance when designing the joint between the roof and the outer wall (Barfoed, 2001).

4.4 Climatic conditions

Climate normals based on 30 years of observations by national meteorological institutes are shown in Figure 1. Normals for precipitation and average temperature for Copenhagen, Nuuk and Sisimiut are included. The temperature difference between Copenhagen and the two locations in Greenland is about 10 °C all year. The amount of precipitation per month in Copenhagen lies between Nuuk and Sisimiut, and the precipitation is higher in summer and autumn than in winter and spring. Therefore, protecting building materials and constructions from becoming wet is important on all locations, not only if the activities on the construction site are called off during winter, but in the summer as well.

The data in Figure 1 are based on observations from 1961-1990. Since then the climate has changed, and it is expected to change even further in the future. In Greenland the temperature is expected to increase with a few degrees in the southern part and up to 6-8°C in the northern part (Danish Meteorological Institute, 2006).

The southern part encompasses the part south of the 70th degree of latitude; i.e. south of Illulissat on the west coast and Ittoqqortoormiit on the east coast (see Figure 2) including most of the populated part of Greenland.

Calculations also show increases in the amount of precipitation of 20-30 % in the southern part, where the present amount of precipitation is comparable with Danish conditions, as shown in Figure 1, although the fraction of the precipitation that comes as snow is much higher in Greenland.

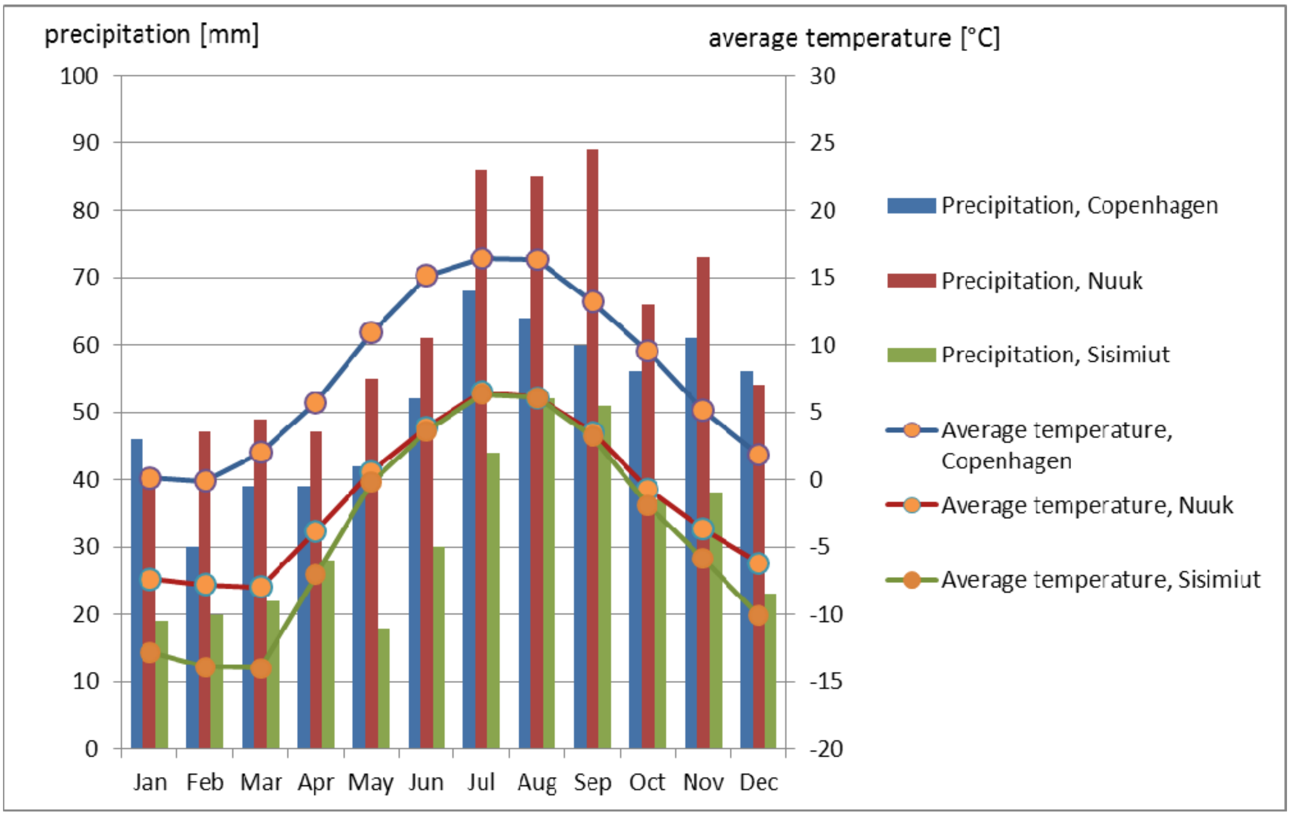

Figure 1. Precipitation and average temperature, Denmark, monthly values, climate normals 1961-1990. Source: www.dmi.dk.

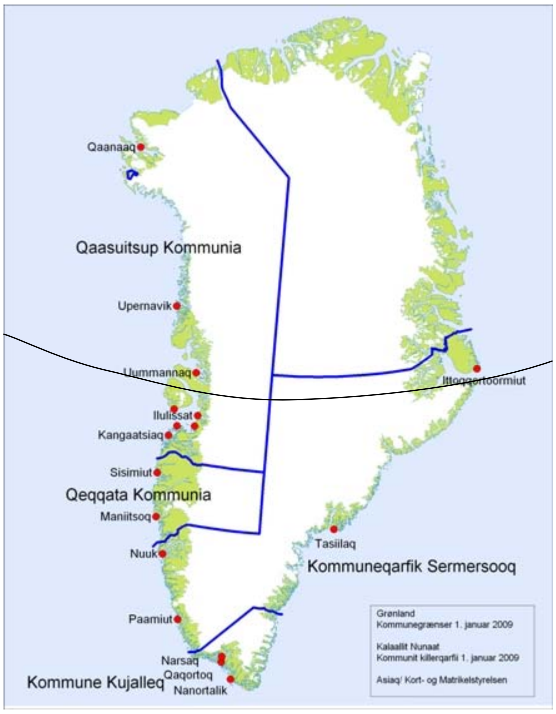

Figure 2: Map of Greenland. The 70th degree of latitude is added. Source: Asiaq/Kort- og Matrikelstyrelsen.

5. Discussion

For many years the requirements for insulation has been relatively moderate compared with the harsh Greenlandic climate. This is due to the expensive costs of transporting insulation materials to Greenland, the relatively low energy prices and traditions in construction (Bygge- og anlægsstyrelsen, 1982). With the tightening of requirements for energy consumption in GBR, including requirements for airtightness, and with the expected effects of the climate change, the importance of moisture control in the construction phase should be highlighted. As in Denmark, it is no longer enough to focus on the operating phase in order to avoid mould growth.

DBR includes five recommendations concerning climate control measures, presented as a)-e) in Section 2. Recommendation a) to choose less moisture-sensitive materials and constructional solutions is already being introduced in Greenland, cf. the increasing use of fibre-cement based materials for wind barrier and cladding instead of plasterboards and painted wood (Anon, 2011). The use of windows with a wood-aluminium frame is also becoming more common, e.g. (Barfoed, 2001).

With proper planning, it should be possible to deal with recommendations b) and d) concerning storage of moisture-sensitive materials and the allocation time for drying out building materials and structures, although the extreme weather conditions can be a challenge.

Recommendation c) prescribes total enclosure of the building during construction thereby protecting the building materials and building components from becoming wet, for instance if it is necessary to use moisture-sensitive materials for wind barriers etc. This is more problematic in Greenland because of the windy climate and the costs related to scaffolding owing to the topography. Instead of using total enclosure, a solution with temporary constructions that can withstand the winter, could be considered.

DBR also contains a requirement concerning the moisture content in the building on moving in (labelled e in Section 2). In order to document the moisture content, the necessary requirements for a measurement programme is drafted in the guideline (Møller, 2010). The guideline makes use of humidity risk classes in order to rank different building materials. The classes are defined in such a way that they should be operational in Greenland as well.

The guideline does not contain specific descriptions of measurement programmes, only some principles based on the choice of building materials and building technology. The authorities in Greenland should consider whether it is necessary to describe measurement programmes in more detail in order to facilitate their use.

For several years, it has been common to base revisions of GBR on experience with new requirements in DBR. The experience in Denmark with the function-based requirements introduced in 2008 concerning moisture control has yet to be made. But at least it is shown that interpretation and guidelines are needed. As the challenges in the building stock in Greenland outlined in Section 4 show, it is necessary to focus on moisture control in the construction phase and some kind of requirements or guidelines are needed also in Greenland.

However, as the example with the ventilation requirements shows, adaptation to the specific conditions concerning climate and building technology in Greenland are necessary. It is also important to remember that introduction of new requirements cannot stand alone. Moisture specialists need to be educated, and the efforts to simplify the building technique in order to end up with buildings where the risk of moisture-related problems is as little as possible should be continued.

6. Conclusions and further implications

The building sectors in Greenland and Denmark face some challenges on dealing with moisture in the construction phase in order to minimise mould growth and ensure a healthy indoor climate.

Function-based requirements were introduced in the Danish Building Regulations, based on a guideline defining humidity risk classes, a measurement programme and possibly a moisture specialist.

As GBR is going to be revised in the next couple of years, it is recommended to introduce requirements and guidelines on moisture control in the construction phase, based on the experience gained in Denmark and adapted to the conditions in Greenland. As a possible benefit, the introduction of such requirements could be a driver for developing a simpler and more robust building technology that considers the use of a local work force.

References

Aagaard, N.-J., Høite, K. and Møller, E. B. (2011): Krav til fugtteknisk dokumentation samt fugtsagkyndiges kompetencer og virke

[Requirements for moisture analysis documentation and the competences and work of the moisture specialist], Prepared by the Danish Building Research Institute for the Danish Enterprise and Construction Authority, Copenhagen. Located 20111216 at: http://www.ebst.dk/file/180041/Fugtsagkyndiges_kompetencer.pdf

Anon. (2011): Isbjørne-hi til studerende [Polar bear hibernation for students], BYG-TEK, Vol. 27, No.7, p.10.

Barfoed, P. (2001): Nuuk/Godthåb – en arktisk hovedstad [Nuuk – an arctic capital]. Presentation at Go'vær og uvær – og dejlig koldt [Good weather and bad weather – and pleasantly cold]. Husbankkonference, Tromsø, 24-25. april 2001. Located 20120105 at: http://www.tenu.dk/dbase/downloads/Tegnestue_presentation.pdf

Bjarløv, S.P. and Vladykova, P. (2011): The potential and need for energy saving in standard family detached and semi-detached wooden houses in arctic Greenland, Building and Environment, Vol. 46, pp. 1525-1536.

Bygge- og anlægsstyrelsen (1982): Grønlands Bygningsreglement 1982 [Building Regulations of Greenland 1982]. Grønlands Hjemmestyre, Nuuk.

Danish Enterprise and Construction Authority (2008): Bekendtgørelse om offentliggørelse af bygningsreglement 2008, BEK nr. 45 af 30/01/2008 [Ministerial Order on publication of the Building Regulations 2008], Copenhagen.

Danish Meteorological Institute (2006): Klimaændringer i Grønland [Climate changes in Greenland], Copenhagen. Located 20111216 at: http://www.dmi.dk/dmi/index/klima/virkninger_af_klimaaendringer/klimaaendringer_i_groenland.htm

Direktoratet for boliger og infrastruktur (2005): Bygherrevejledning. Forskrifter og generelle retningslinjer for hjemmestyrets byggevirksomhed [Guideline for the construction client. Instructions and general guidelines for the construction activities of the Home Rule]. Grønlands hjemmestyre, Nuuk.

Hansen, C.R., Johansen, H.M. and Jensen, G.D. (2004). Fugtmåling i lavenergihuset, Sisimiut [Moisture measurements in the low-energy house in Sisimiut]. Report 04-03, Centre for Arctic Technology, BYG-DTU, Technical University of Denmark, Lyngby. Located 20120105 at: http://www.artek.byg.dtu.dk/upload/centre/artek/filer/list_student_repports_all.pdf

Kragh, J., Reimann, G. and Svendsen, S. (2005): Mekanisk ventilation med varmegenvinding i arktisk klima [Mechanical ventilation with heat recovery in an arctic climate], Report R-196, BYG-DTU, Technical University of Denmark, Lyngby.

Møller, E.B. (ed.) (2010): Vejledning om håndtering af fugt i byggeriet [Guideline on handling of moisture in construction], Prepared by the Danish Building Research Institute for the Danish Enterprise and Construction Authority, Copenhagen. Located 20111216 at: http://www.ebst.dk/bygningsreglementet.dk/vejledninger/0/40

Olsen, I.L. (2012): Skimmelsvamp i grønlandske boliger [Mould in Greenlandic dwellings], B.Sc.-Thesis, Centre for Arctic Technology, BYG-DTU, Technical University of Denmark, Lyngby.

Sanaartortitsivitt (1990): Behovsanalyse for renovering 1990 – eksempler på skader [Analysis of the need for renovation 1990 – examples on damage on buildings]. Grønlands Bygningsvæsen, Nuuk. Located 20120105 at: http://www.byginfo.gl/Portals/0/pdf/bygerfa/behovsanalyse_eksempler.pdf

Statistics Greenland (2010): Boligbestanden efter tid, distrikt, bosted og type (tabel BODBE2) [The population of dwellings divided after year, area and type], Nuuk. Located 20111216 at: http://www.stat.gl