Energy-optimization of historic buildings: A challenge for preservation of cultural values of buildings? Results from a screening of energy-performance of Danish historic multi-story residential buildings

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Publication date:
2022

Citation for published version (APA):
Jensen, J. O., & Jensen, O. M. (2022). *Energy-optimization of historic buildings: A challenge for preservation of cultural values of buildings? Results from a screening of energy-performance of Danish historic multi-story residential buildings*. Paper presented at ENHR 2022, Barcelona, Spain.

Energy-optimization of historic buildings: A challenge for preservation of cultural values of buildings? Results from a screening of energy-performance of Danish historic multi-story residential buildings.

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Abstract

Energy-optimization of historic buildings is often seen as a thread against preservation of historic and cultural values of buildings. Critics have claimed that efficient energy retrofitting is difficult to carry out on historic buildings, as technical interventions such as external insulation of facades and roofs, energy-efficient windows, and PV panels will ruin the architectural value of the historic buildings. However very few studies have actually identified how energy optimization in practice takes place in historic buildings, and how historic buildings are performing energy-wise, compared to ordinary buildings. This paper presents the initial findings from a project that aims to map the energy performance of historic buildings, and to understand how preservation values of the buildings are taken care of in practice. It is based on combining the Danish database of the SAVE-registration system (Survey of Architectural Values in the Environment) and the database of EPC (Energy Performance Certificates). The main result of the analysis is that residential multi-story buildings with high preservation values are energy-preforming at least to the same level as traditional buildings. This is a somehow surprising result, and the paper explains some of the reasons behind this, and how energy-optimization takes place in practice. Another main result is that "deep renovations" which are often hailed as a desirable strategy for energy optimization, hardly ever takes place in practice. Instead, almost all buildings with high SAVE-values and high EPC-scores have used a step-by-step approach to energy optimization. The paper will discuss the results in the light of the ambitions for reducing CO2-levels in the existing building stock, and current policy interventions, e.g. the new EU-directive on energy efficiency of buildings.

Keywords: Historic buildings, SAVE, energy optimization, EPC, Denmark

Introduction

The challenge on how to energy optimize historic buildings without spoiling the architecture values of the buildings is a shared problem across European countries and cities and has been researched thoroughly in recent decades (Lucchi, 2022; Loli & Bertolin, 2018; Eriksson & Johansson, 2021). There is a large potential for energy optimization of historic buildings, as 35% of EU's buildings are more than 50 years old (Loli & Bertolin, 2018) and the building stock is characterized by a low energy performances and high energy consumption (Lucchi, 2022). Historic buildings are under thread, partly due to detoriation, partly due to convenient renovations instead of careful restoring (Loli & Bertolin, 2018). Therefore, there are plenty of reasons for developing more careful restauration approaches, combined with energy optimisation. The present energy crisis emphasizes the urgency for lowering the energy consumption in the entire existing building stock, including historic buildings, but at the same time stresses the dilemma on how to maintain the architectural and cultural values of the historic buildings.

The recently proposed revision of the EU building directive (Energy Performance of Buildings, European Commission, 2021) illustrates this dilemma. The directive aims to reduce CO2 emissions by at least 55% by 2030 and contribute to making the building stock CO2 neutral in 2050. The requirements are not just ambitions but tied to the EU's climate law. As something new, requirements are being set for existing buildings, as it is assumed that 15% of the worst properties must be raised by at least one step before 2030, for example from a G label to an F label. This has been criticized for being unambitious compared to requirements in an earlier draft that required an energy label of at least E for all residential properties by 2030. In spite of the potential challenges related to energy optimization og historic buildings (Webb, 2017), several studies find that significant energy reductions are possible in historic buildings, despite architectonic and historic restrictions (Rose & Thomsen, 2021; Zazzini & Capone, 2018; Tadeu et al, 2015; Ascione et al, 2011). In Denmark, there are a few examples of studies (e.g. Rose and Engelslund (2021), but systematic research and knowledge on energy optimization of historic buildings that goes beyond case studies of single buildings is generally rare, including the actual energy status of the historic building stock (with some exceptions, e.g. Fabbri et al, 2012). In general, the research in Scandinavian countries on energy optimization of historic buildings has been relatively limited compared to countries in southern Europe (Loli & Bertolin, 2018).

When the first version of the EU building directive was presented in November 2021, it caused some discussions in Denmark on how this will affect historic buildings. Experts and interest organizations on energy optimization of buildings have critizised the directive for not being ambitions enough, and for not including CO2-emissions for production of building materials (IDA, 2022; Dyck-Madsen et al, 2022). However, building and restauration professionals have raised concerns about the possible negative consequences the directive might have on historic buildings. This is illustrated by discussions and comments from a critical LinkedIn-track with comments, such as; "*..thousands of historic buildings that have not even been registered yet….will disappear behind external insulation*". The Directive explicit mentions that officially listed buildings are excepted from the requirements of the directive. However, the concerns raised in the LinkedIn thread clearly addresses the many buildings that are not officially listed, or even registered, and therefore are subject to the regulation of the Directive. Other comments followed a similar skepticism, not only for the Danish building heritage, but also for the European heritage buildings in general: "*It is an incredibly interesting development that can have devastating consequences. It can almost certainly cause greater destruction in southern and eastern Europe than here at home*". "*Imagine the 100s of adorable French and Italian villages that we all associate with southern Europe. Should we expect them wrapped in insulation with a coat of plaster on the outside? If that happens, southern Europe's attraction to tourism will disappear*".
Another comment stated: "*Much of the housing stock in Copenhagen and other larger cities built in the period approx. 1870 and up to 1920 are built in historicist styles, but some are also in pure Skønvirke [Danish building style], international Art Nouveau as well as some in "real" Art Deco......many of these are not protected. The EU's directive can therefore effectively threaten the original expression of many of the above-mentioned buildings because they are not (yet) protected and because there is no knowledge amongst the owners (who are often not the original builders) or the municipality about the building's decorative elements, facade covering, historical significance and stylistic uniqueness*".
And some even more pessimistic…."*These rules will destroy all our historic town centers*".

These quotes might on one hand be seen as just another social media storm on a controversial subject – but on the other hand, they also illustrate sincere worries about possible negative consequences on historic buildings following the demands on energy optimizations. We believe that these concerns are widely spread amongst professional and lay actors working with historic buildings – consultants, owners, users, interest organizations, authorities, municipalities and others.
However, the discussion also reflects a lack of knowledge about the actual status of energy optimization of historic buildings – what is the energy standard of the buildings, how far are they behind traditional buildings, how widespread are the good examples, and is there any hope for bringing them up to an acceptable level?

Aim and methodology

This paper represents a mid-term report from an ongoing research project on energy optimization of historic buildings in Denmark. The aim of the project is to identify and disseminate knowledge about successful energy renovation of historic buildings in order to ensure that owners of historic properties have access to relevant knowledge that on how to preserve the building heritage when carrying out energy optimization – and vice versa: How to identify suitable energy optimization solitons when renovating historic buildings. In contrast to many other studies in this field this study will focus on practical examples from real life amongst building owners, and not on single-case studies or dissemination of theoretical knowledge only. The study is based on a mixed methodology, with different research approaches: One part consists of register-based analysis on the connection between architectural values and energy performance in historic buildings. Another part consists of document studies of EPC-reports on historic buildings, to identify which energy optimization measures are being used in practice. A third part consists of interviews with key persons working with energy optimization of historic buildings, e.g. EPC consultants, architects, building operation managers, owners of buildings, municipal officers and planners. The study runs from 2021 to 2023 and is financed by the Landowners Investment Fund (Grundejernes Investeringsfond). This paper mainly concerns the first part of the paper, the register-based analysis on historic buildings and energy performance.

Registers on historic buildings

In Denmark, historic buildings are registered through the SAVE-methodology. The SAVE-methodology was introduced in Denmark in 1991. It is up to the 98 Danish municipalities to register the buildings in the municipality, and this is done with some variation. Since the 1991, 90 SAVE-atlasses have been published (Kulturarvsstyrelsen, 2011). All SAVE-registrations are stored in the Danish Agency for Culture and Palaces' SAVE-database for listed and historic buildings - in everyday speech FBB. The FBB database contains information on 9,000 listed buildings and 350,000 buildings that have had their conservation value assessed. The SAVE atlases operate with conservation values from 1 to 9, with 1 being the highest. The grades are given here within the categories: architectural value, cultural-historical value, environmental value, originality and construction technical condition within buildings with high, medium and low conservation value. Buildings with a SAVE value of 1 to 4 are considered to be "unconditionally worthy of preservation", while buildings in categories 5 to 6 are considered "even, but nice buildings, where typically unsuitable replacements and conversions detract from their character". There is some overlap between buildings with SAVE 1 value and listed buildings, that are defined by the Danish Agency for Culture and Palaces, and have legal status, in contrast to the SAVE-registrations. The buildings registered in FBB, is not a comprehensive figure, as the historic buildings also can be designated through e.g. local plan, municipal, in an older town planning statute, in a registered conservation declaration, or as listed buildings by the Danish Palaces and Culture Agency. These buildings do not necessarily appear in the FBB database (Høi, 2020). Since the municipal structural reform in 2007, the preparation of municipal atlases has however largely stopped. However, it is still a requirement that historic buildings and environments in towns and in the countryside are identified and mapped, and it is up to the single municipality to finance and prioritize this (Dahl et al, 2015)[1].

The FBB database contains information on 72,000 multi-story residential buildings, which corresponds to 73% of all the country's app. 100,000 multi-story residential buildings (www.statistikbanken.dk/BYGB12). The register is thus reasonably comprehensive when it comes to apartment buildings. In the FBB register, 19,734 multi-story residential buildings are noted for a high

[1] There are other systems for registration of historic values of buildings, focusing more on cultural environments (and not just individual buildings): SUIT (Sustainable development of Urban historical areas within Towns), ReSAVE is a superstructure on the SAVE system and focuses particularly on renovation issues, based on some of the same ideas as LCA programs (Life Cycle Assessment) (Kuben Management et al, 2011). Other methods include KIP (Culture history in Planning), SAK (Screening of Cultural Environments), the CultureEnvironment-Method, and DIVE (developed in Norway). These methods can supplement each other, but not substitute each other, so the use of method depends on the purpose of the mapping (Byplan Nyt 3, 2021). Finally, municipalities can use local plans to appoint historic buildings and environments.

conservation value (SAVE 1-4), corresponding to 20% of all multi-story residential buildings. The distribution of all SAVE-values is shown on figure 1 below.

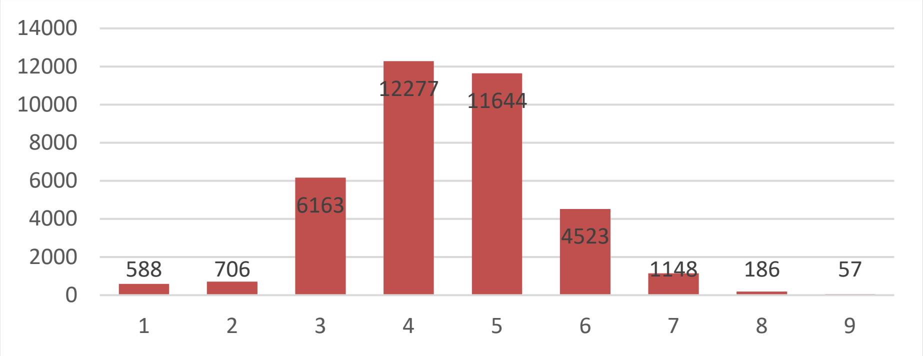


Figure 1. The number of residential multistory buildings with SAVE-values from 1 to 9. Source: FBB-database. The total is app. 72.000 buildings. Buildings with SAVE-values from 1 to 4 (are regarded as "unconditionally worthy of preservation".

For each individual property in the SAVE register, information about the property's energy label has been obtained from the Energy Performance Certificate Register (EPC register). The label grades the energy performance of the building from A+ to G, based on a technical assessment of the energy performance, carried out by professional and certified assessment companies. It is mandatory for a building to have an EPC label, either when it's sold or with 5 years intervals. The EPC register collects data from all EPC-labelled buildings, including historic buildings, with information on the current energy label, the potential EPC label (theoretically achieved by an affordable energy retrofit), the actual (measured) energy consumption, building ownership, year of construction, municipality affiliation, etc.). By combining the FBB database on SAVE-values and the EPC-register, a basis has thus been created for analyzing how multi-story residential buildings with a high conservation value perform in terms of energy compared to buildings with a low SAVE value[2].

Findings

Out of the almost 20,000 multi-story residential properties registered in the SAVE register, just over 13,000 properties have an energy label. Of these, 76% were completed in 2011 or later. (52% have an energy label that is valid up to and including 2021, while 48% of the properties have an energy label that is valid from 2022 onwards. The analysis includes both new and old labels, as the limit of 5 years does not reflect a deteriorated energy standard; but only determined administratively.
Figure 2 shows the distribution of the 13,000 properties with an EPC label for historic residential multi-story buildings, i.e. with SAVE values from 1 to 4. These are compared with all residential multi-story buildings. The analysis shows that 69% of the properties that have a high SAVE value (between 1 and 4) have an energy label of D or above. Furthermore, 19% of the properties have an energy label C, which is usually only achieved by newer properties. There are therefore relatively many buildings worthy of preservation that already have a good energy label today.

[2] A similar methodology was used by Fabbri et al (2012) to analyze the energy performance of the historic buildings on a town level.

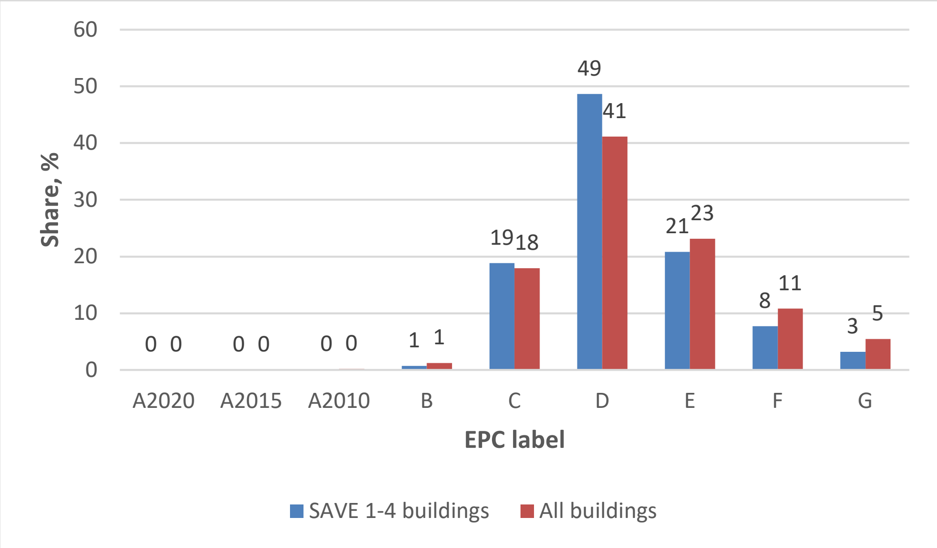


Figure 2. Distribution of EPC-labels for SAVE-1-4 residential multistory buildings built before 1950

An "good" EPC-label (A-C) implies a low energy consumption. From the EPC-register it has been analyzed that the actual heat consumption in buildings with energy label C is 123 kWh/m^2. This is around 15% less than properties with energy labels E and F, which have a consumption of around 142 kWh/m^2. See Table 1. Upgrading the properties that have an EPC label E, F and G to an EPC label C could result in a heat saving of around 15%.

Table 1. The actual (measured by the meter) heat consumption (kWh/m^2) in multi-story residential buildings, distributed on EPC labels.

EPC label	A2015	A2010	B	C	D	E	F	G
Actual heat consumption, kWh/m^2	21,1	79,7	103,1	122,9	131,9	141,9	142,1	129,5

Types of energy improvements

It can be questioned whether energy efficiency improvements are possible without large investments, and if this will destroy the architectural values of the historic buildings. Therefore, we have conducted a manual and visual survey of EPC-reports on historic buildings in various municipalities, to see which energy improvements were made, and how it has affected the visual and physical presence of the buildings. In interviews with EPC-consultants we have discussed those findings.
There are two main findings from this:

1. *For historic buildings (SAVE-value 1-4) it is possible to obtain an EPC-label C without any larger or profoundly visible or physical changes.*

Below is a list of measures typically taken to obtain an EPC -label on C or D:

Table 2. Types of energy improvements typically used to achieve EPC label C or D in historic buildings

Building components	Energy improvement measures to enable an EPC label C
1. Roofs and ceilings	• External insulation of a flat roof ("Copenhagen-roof") • Internal re-insulation of sloping walls. Blow-in of insulation granules in floor separation from living space • Post-insulation of non-insulated attic space, often in connection with roof replacement. • Post-insulation of vertical skunk walls. Often in connection with roof replacement.
2. Floor separations	• Subsequent insulation of floor separation against unheated basement. Either via blowing in insulate granulate or by mounting insulation batts between beams.
3. Windows	• Windows with 1-layer glass are replaced by windows with 2-layer energy glass • Internal front frame fitted with energy glass. In blind frames or as simple front frames • Internal front frame fitted with energy glass. In blind frames or as simple front frames. • Post-insulation of window niches. Blowing in of granules behind parapet panels
4. External walls	• External re-insulation of the facade facing the yard. Consider whether the insulation can go around the corner to reduce thermal bridges. • External re-insulation of the gable
5. Heating system	• Post-insulation of heating pipes and risers in unheated rooms. • Replacement of single-strand heating pipes with double strands. • Improve the cooling of the district heating boiler system.

None of these improvements affects the architectural presence in any profound way, if carried out carefully. Especially for window improvements (and typically new windows), there are much attention from the local authorities not to harm the architectural performance of the buildings, which often leads to fierce discussions with the owner and the architect on which specific solutions to choose. Also, external insulation of the façade in the yard (backside of the building) can be delicate, but this solution is relatively seldom. The buildings with EPC-labels C have not necessarily implemented all of these improvements, but only some of the measures, e.g. improvements of window and roof. In addition to the building's own energy efficiency, there are several other factors that influences which EPC label can be achieved:

- Buildings that are located side by side in a row of houses receive an indirect heat supplement by not emitting heat to the surroundings. They thus achieve a good EPC label more easily – compared to detached buildings
- Buildings that have a small surface area in relation to their total floor area have an advantage in terms of reducing heat loss. An analysis of the energy labels shows that buildings with energy label B, C or D have an average ratio between external wall and floor area of around 0.6, while buildings with energy label G have an average ratio between external walls and floor area of 0.95 (see figure 4).
- The heat supply is also important for the property's EPC label. In the EPC-calculations, properties with district heating are reduced by a factor of 0.8 in the calculation of heat consumption when compared to buildings that are supplied with gas, oil or other sources. Conversely, buildings with oil boilers have an increase in heat consumption by a factor of 1.2. Since 93% of the residential multi-story buildings with high preservation values (SAVE 1-4) are supplied with district heating, they gain an advantage in that way alone.

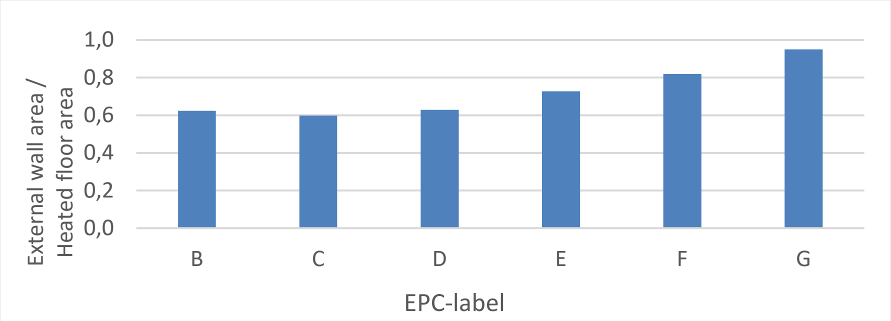


Figure 4. The relation between outer wall area and heated floor space in residential multi-story buildings, distributed on EPC-level. Buildings with less outer wall area, where the heat loss is high, have a better chance of achieving a "good" EPC-label.

2. *Deep renovations are rare. Most C-labels are achieved by using simple improvements step-wise over a longer period of time.*

At the start of the project, a search was launched for examples of comprehensive energy renovations of historic buildings, the so-called "deep renovations". Surveys were made amongst collections of good examples, lists of buildings suggested for the annual "Renovation prize", and contacts were made to consultants, conservation architects and municipalities to find such examples. However, it turned out that very few of such examples on deep energy renovation of historic buildings existed. Instead, browsing the EPC-reports on historic buildings with EPC-labels C, we found most buildings using relatively simple improvements (not including external insulation of the facades), and often not implemented at once, but over a period of years. Therefore, the preliminary conclusion is that a good energy label for most buildings is achieved by using relatively traditional solutions – such as post-insulation of the roof and the use of low-energy windows. In cases where external post-insulation has taken place, it has always been carried out on rear walls or gables that have already been plastered and where it does not spoil the overall impression of the building or spoil the streetscape. We also found, however, that the stepwise upgrading only accounted for C-labelled buildings, whereas historic buildings with an EPC-label B (of better) typically has gone through a larger transformation of the buildings, e.g., by supplying the older building with a newer add-on, or in other ways making large changes.

Three examples on energy optimization of historic residential buildings

To illustrate some the findings above, we will show three examples from the manual surveys on EPC-reports, on energy retrofitting of historic residential buildings.

Sommerstedgade 30-23 in Copenhagen is residential property in 5 stories, built in 1906, with a SAVE-value on 4. It has an EPC-label C, that has been achieved with simple improvements. With a renovation in 2013 old non-original windows have been replaced with coupled windows with a classic wooden frame and low-energy glazing. Single-glazed windows in stairwells are fitted with front windows. Window sills in kitchens, basement and ground deck as well as heating pipes on back stairs have been retrofitted. The EPC-label before the renovation was E and the energy consumption was 204 kWh/m^2. The actual present energy-consumption has not been found, but the calculated consumption in the EPC-label is 89 kWh/m^2.

Figure 5. Sommerstedgade, SAVE-value 4, EPC-label C.

Tårnborgvej 14 is building located at Frederiksberg, in the Copenhagen region. It is a multi-story property with 5 floors built by Frederiksberg Borgerforenings Stiftelse. The building dates from 1902. The building was renovated in 2018 with urban renewal support from Frederiksberg municipality. The renovation included a restauration of the facade to its original expression. At the same time, external insulation has been carried out on the back-facade facing the yard (see picture below). The gable to the north is retrofitted in the same way. The renovation included insulation of the roofs the floor separation. The window niches behind the radiators facing the facade are post-insulated. An old 1-wire heating system has been replaced with a 2-wire system. Mechanical ventilation with heat recovery has been established at the same time as well as new kitchens and bathrooms. The windows from 1980 have been retained, although they differ somewhat from the original windows. The building has a SAVE-value 4 and an EPC-label C (in 2020). The earlier EPC was an E. The building is supplied with district heating. The measured energy consumption was 114 kWh/m^2, after the renovation the consumption is 85 kWh/m^2.

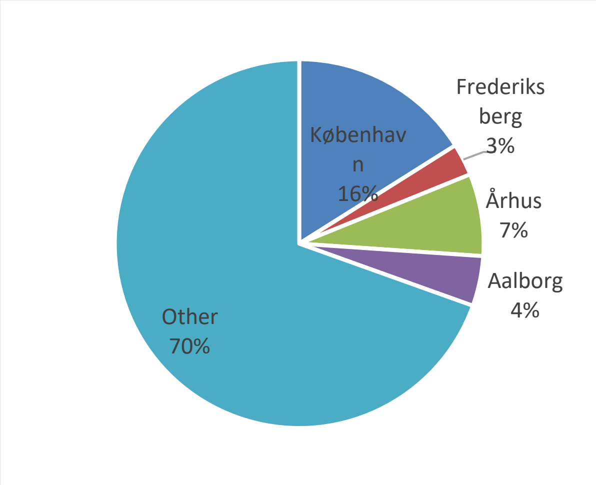
Figure 6. Tårnborgvej, SAVE-value 4, EPC label C. Left: The front facade, restored to its original look. Right: The rear façade, externally insulated.

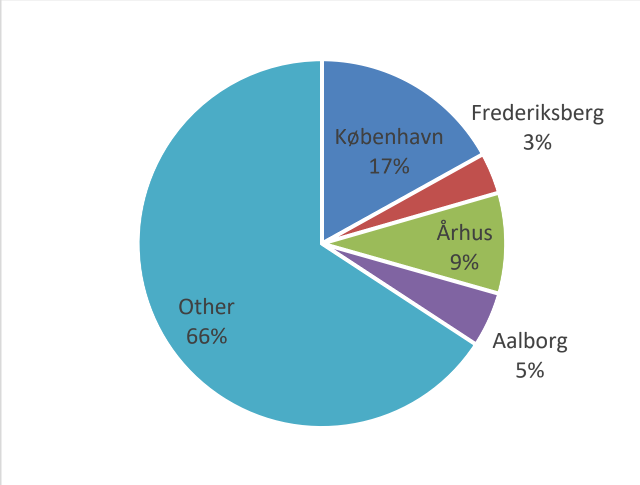
Mejlgade 74 is a residential building in Aarhus that has been renovated, close to transformation, as an extra three floors have been added on top of the old building, obviously in a completely different style. The ground floor, which until the renovation was a shop front, has been restored to its original appearance and converted into an office. It lies in the middle of a row of more or less historic buildings. It is a multi-story building, formerly in 3 floors, now 5 floors with a used attic. The building, which was built in 1891, is today subdivided into owner-occupied flats. The superstructure, which in its appearance differs significantly from the rest of the building, is from 2019. With the superstructure, three new floors have been added, which comply with the building regulations' requirements for insulation. The extension and rear facade are clad in the material tombak (brass alloy). The rear facade has been re-insulated on the outside with facade panels of the same type as the new superstructure. The new windows in the facade are fitted with low-energy glazing. The building has a SAVE-value 2 and an EPC-label C. There building has not earlier had an EPC-level. The present energy consumption is 98 kWh/m^2. An estimate of the former energy consumption is 250 kWh/m^2

Figure 7. Mejlgade. SAVE-value 2, EPC-label C. Right: The present building with three new floors added. Right: The original building before the renovation.

Energy optimization of historic buildings in a spatial context

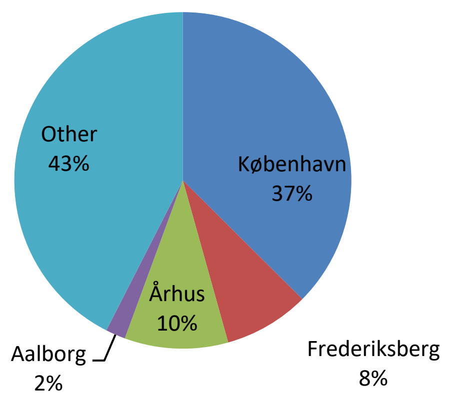
Although the overall picture shows that the historic buildings are performing well in terms of energy optimization, there is an uneven distribution between the country's municipalities. The analysis shows that there are large differences between the Danish municipalities on how the historic and energy-optimized buildings are distributed. A breakdown by municipality shows that of the almost 100,000 apartment buildings in the country, 30% are located in the municipalities of Copenhagen, Frederiksberg, Ålborg and Aarhus (figure 3a). The share of SAVE-registered residential properties is distributed in roughly the same way (figure 3b). In contrast, the proportion of SAVE-registered buildings with a high conservation value is overrepresented in Copenhagen and Frederiksberg municipalities (20% of all SAVE buildings, but 43% of all SAVE 1-4 buildings), and underrepresented in "other municipalities" (66% of all SAVE properties, but 43% of all SAVE 1-4 buildings) (Figure 3c). This difference is even more accentuated when looking at the share of properties having both a high SAVE-value and a good EPC label; here, both Copenhagen, Frederiksberg, Århus and Ålborg are overrepresented (34% of all SAVE properties, but 86% of SAVE 1-4 properties with energy label A-C), and other municipalities are underrepresented (66% of all SAVE properties, but 34% of SAVE 1-4 buildings with energy label A-C (figure 3d).

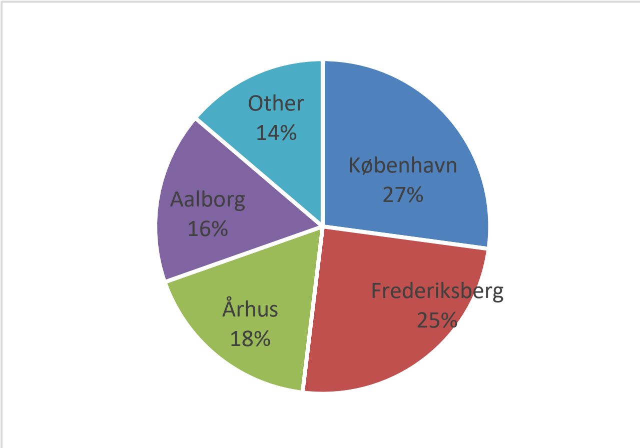




Figur 3a. Distribution of multi-story buildings on municipalities (n = 99.916).

Figur 3b. Distribution of SAVE-buildings on municipalities (n = 72.079).





Figur 3c. Distribution of SAVE 1-4 buildings on municipalities (n = 19.735).

Figur 3d. Distribution of EPC-level A-C amongst SAVE 1-4 buildings (n = 2.611).

The group of "other" municipalities are lagging behind in energy-optimizing of historic buildings, even though this does not necessarily require large investments. Detailed studies in different municipalities has not been carried out yet, but some of the interviews made with municipalities and consultants clearly shows the importance of the local approach to building culture, both amongst the local authorities and the local citizens. In the case of Frederiksberg Municipality, it is obvious that the municipality has a high concern for its historic buildings and at the same time high ambitions for a greener municipality, which also means high energy standards in the renovations. This is reflected in the staff working with historic planning which is large and highly qualified. An EPC-consultant says that there is a huge difference between Frederiksberg and Copenhagen, although they are two neighboring municipalities: At Frederiksberg, there is a ”village”-feeling with a high level of local awareness on history and building culture, both amongst the local authorities (the municipality) and amongst the local population (especially building owners). In Copenhagen, owners and residents obviously shows less interest in building culture, so here it is the municipality that takes care of these issues (interviews with EPC-consultant). It is obvious, that competences in the municipal administration is not enough to make things happen in real life; the awareness amongst building owners on the historic values of their buildings is probably the most important. Interviews with owners in “other municipalities” about retrofitting of historic buildings shows examples on lower awareness, for instance about the use of materials and types of windows. This might be a result of lower real estate prices and lower rents in such municipalities, compared to the larger cities (Copenhagen, Frederiksberg, Aarhus, Aalborg), and less frequent renovations. The data shows that the share of historic buildings in "other municipalities" is almost as high as in the larger cities, but the share of EPC-labels "C" is significantly lower, which indicates a lower level of energy optimization.

Although the municipality of Frederiksberg does a lot to protect its historic buildings and at the same time optimize them, they still experience the classic conflicts between conservation and energy efficiency: According to interview with an architect on the building department, there is clearly a division between the building department (with 75% architects) and the "energy department" (mainly engineers with a technical focus) who are following different legislation, rationales and interests, and not having a high level of communication. The officer explains: "*Well, it's not optimal.... because, over there we have some environmental people who are in a totally different department and their core task is to make the city sustainable, and we are in this one, and works with preservation, and we don't talk together*" (Officer, Frederiksberg Municipality).

Conclusions and perspectives

The preliminary conclusion from this study indicates that the historic residential buildings are performing surprisingly well compared to the building stock in general. And that this has not caused any large damage regarding the buildings' architectural expression or cultural values, at least what we have been able to detect. On the contrary, some historic buildings have benefitted architecturally from the renovations, as they have been restored back to a more original status, e.g. by restoring the façade, changing windows to a more original style etc.

Seen in this perspective, the concerns about the damages that might hit the historic buildings, as a result of new requirements on energy optimization, as expressed by members of the professional community on building restauration, seems less likely. The analysis and the examples have shown that it is possible to improve the buildings to a relatively high EPC label ("C") without ruining the architectural and historic values. Moreover, the research also indicates that those improvements are relatively simple and can be carried out at relatively low extra costs.

The register-based analysis shows that there are spatial inequalities to which degrees historic buildings are being improved energy-wise. This might be due to differences in local building cultures, and knowledge as well as resources on energy-optimization and building culture. In some regions or municipalities the challenges might look different. A general challenge is that a large share of the historic buildings are not registered yet (but also with large variations from municipality to municipality) which makes it easy to overlook the historic buildings in local regulation policies.

Formulating policies for energy retrofitting of historic residential buildings raise a question of governance, and to which extent authorities are able to motivate owners and influence the results. Discussions on this subject often implicitly assumes that there are governance arrangements that enables strategies to be formulated, prioritizations of buildings to be retrofitted, measures to be taken in the retrofitting, procedures to be followed etc. However, most historic buildings are a part of the housing market, are privately owned, and few options for interventions, e.g. support programs, exists. Moreover, in an era of new public management regimes, public interventions are more sparse and market-driven. As an example, national programs for urban regeneration In Denmark have in recent years been shrinking, and at the same time gradually been moved from the larger cities, towards smaller towns in the periphery of the country. Some of the larger cities, such as Copenhagen and Frederiksberg, have maintained an urban regeneration program, but only based on municipal funding (whereas the subsidies in former regeneration programs included a combination of national and municipal funding). Thus, the practices of retrofitting historic buildings is increasingly a result of structural conditions, motivations, knowledge and competences that are shared by the public part (the municipality), the building owner, the retrofitting practitioners, consultants and producers of building solutions. There is a strong need to understand how these practices can be improved in the near future.

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References

Byplan Nyt 3 (2021) *Overblik: Kortlægning af bevaringsværdier og kulturmiljøer*. Dansk Byplanlaboratorium, p. 35.

Dahl, T. et al (2015) Vejledning til kommunal sagsbehandling af byggesager med energitiltag i bevaringsværdige bygninger [*Guidelines for municipal case management of construction cases with energy optimization in historic buildings*] Gate 21.

Dyck-Madsen, S.; Damsø Pedersen, C. and Jarby, C (2022) *EU-Kommissionens udspil til revision af Bygningsdirektivet af 15.12.2021. Kommentarer*. CONCITO og Rådet for Grøn omstilling.

Eriksson, P, & Johansson, T. (2021) Towards differentiated strategies for Heritage-Designated Multifamily Building Stocks. *Heritage* 2021, 4, 4318-4334

European Commission (2021) *Proposal for a Directive of the European Parliament and of The Council on the energy performance of buildings (recast)*. Brussels, 15.12.2021 COM (2021) 802 final 2021/0426 (COD)

Fabbri, K. et al. (2012) Heritage buildings and energy performance: Mapping with GIS tools, *Energy and Buildings 48* (2012) 137–145.

Høi, A (2020) *Tendenser i kommunernes arbejde med de bevaringsværdige bygninger. En spørgeskemaundersøgelse blandt medlemmerne af "Det Kommunale Netværk"*. Realdania

IDA (Ingeniørforeningen i Danmark) (2022) *IDA: Forslag til bygningsdirektiv er uambitiøst og løser ikke klimaudfordringerne*. Altinget, 4. marts 2022.

Kuben Management A/S, Kunstakademiets Arkitektskole, Esbensen Rådgivende Ingeniører Dansk Arkitektur Center (2011) *Arkitektur & energirenovering i det murede etagebyggeri fra 1920 til 1960*. Dansk Arkitekturcenter.

Kulturarvsstyrelsen (2011) *SAVE – Kortlægning og registrering af bymiljøers og bygningers bevaringsværdi*. Kulturministeriet.

Loli, A. & Bertolin, C., 2018. *Towards Zero-Emission Refurbishment of Historic Buildings: A Literature Review. Buildings*, 8, 22.

Lucchi, E. (editorial) (2022) Energy Efficiency of Historic Buildings. *Buildings 2022, 12, 200.* https://doi.org/10.3390/buildings12020200

Rose, J. & Thomsen, K.E (2021) Comprehensive energy renovation of Two Danish Heritage Buildings within IEA SHC Task 59. *Heritage, 2021*, 4, 2746-2762.

Webb, A.L. (2017) Energy retrofits in historic and traditional buildings: A review of problems and methods, *Renewable and Sustainable Energy Reviews*, Volume 77, 2017, Pages 748-759. ISSN 1364-0321, https://doi.org/10.1016/j.rser.2017.01.145.