



Conservation is the sustainable solution

Based on a SINTEF report on the the climate impact of conserving and reusing existing buildings



COVER PHOTO: The Grünerløkka Student House was originally a grain elevator built back in 1953. The Student Silo, which was completed in 2001, is comprised of 226 rooms and apartments of different sizes. The building was awarded an Architecture Prize by the City of Oslo for its transformation into student housing.

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About the report

In 2019, the Norwegian Directorate for Cultural Heritage (Riksantikvaren) commissioned SINTEF to survey the state of current knowledge concerning the rehabilitation and reuse of existing buildings. The researchers were to concentrate on lifecycle analyses; i.e. analyses which look at the climate impact of construction and the use of buildings over the course of their entire lifetime.

The project was completed in 2020 and its findings have been published in a full report entitled *Grønt er ikke bare en farge. Bærekraftige bygninger eksisterer allerede* (Green is Not Just A Colour: Sustainable Buildings Already Exist).

The report you are reading now presents a number of the main findings from the SINTEF study in a more

concise and accessible manner. The aim is to bring the primary conclusion of the SINTEF report to a broader audience: *Rehabilitating and reusing existing buildings entails lower greenhouse gas emissions than demolishing and rebuilding.*

For more comprehensive information about the research findings and the scientific sources which support this conclusion, please refer to the original SINTEF report. It contains a comprehensive list of sources, studies and published scientific works within this field.

In addition to the research findings, this report also contains a range of practical suggestions as to how existing buildings from different time periods can be restored and reused. Additional advice can also be found here: www.riksantikvaren.no/gode-rad-og-tiltak

Norwegian Directorate for Cultural Heritage (Riksantikvaren), May 2021

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Reusing buildings is good for the environment

The reuse of existing buildings can contribute towards reducing greenhouse gas emissions. This report presents research which documents this better than ever before.

Global climate change is the greatest challenge facing our world today, and construction accounts for a large proportion of the total greenhouse gas emissions produced.

Today's building stock has already taken its toll on the climate. Even if new buildings are made eco-friendly and energy-efficient, emissions from the demolition process, waste management, transport and the production of materials for the new building must all be factored into the project's climate accounting. Only then can we see the overall picture of costs and gains, both for the economy and for the climate. If we fail to look at all parts of the equation, we risk drawing seriously misguided conclusions when deciding between reuse or construction.

We have seen that several actors calculate emissions and draw up carbon accounts when upgrading existing buildings, but comparing these measurements is often difficult. The Norwegian Directorate for Cultural Heritage commissioned SINTEF to map out the state of current knowledge concerning how the rehabilitation and reuse of existing buildings affects the environment compared with demolition and new construction. This involved a systematic literature review of publications containing lifecycle analyses of existing buildings, both in Norway and internationally, as well as a quantitative analysis of 12 Norwegian and 11 international case studies. The end result is highly likely to be the broadest ever compilation of this type of international research to have been carried out thus far.

The study shows that it is almost always better to conserve and rehabilitate than to construct new buildings – especially given that we need to cut greenhouse emissions considerably over the next 10–30 years. Emissions from the actual construction phase are so great that it can take several decades for them to be offset through greater energy efficiency and lower rates of energy consumption. There are thus considerable climate gains to be won from the reuse of existing buildings. And that is before we even begin to mention some of the other benefits, such as the preservation of cultural-historical values and greater variety in our built environment.

As head of the Directorate for Cultural Heritage, I feel it is important to make clear that older buildings can be rehabilitated and upgraded. By taking this approach, our heritage can be used as a resource and our overall burden on the climate can be minimised. Upgrades, regular repairs and maintenance all serve to reduce greenhouse gas emissions from existing buildings and help to preserve their cultural-historical value. The palette of energy-saving measures is broad and should be used. Everything from residential dwellings to housing cooperatives and office buildings can be made more environmentally friendly. Even modest measures can make a difference. None of us can do everything, but all of us can do something. This holds true when it comes to our built heritage.

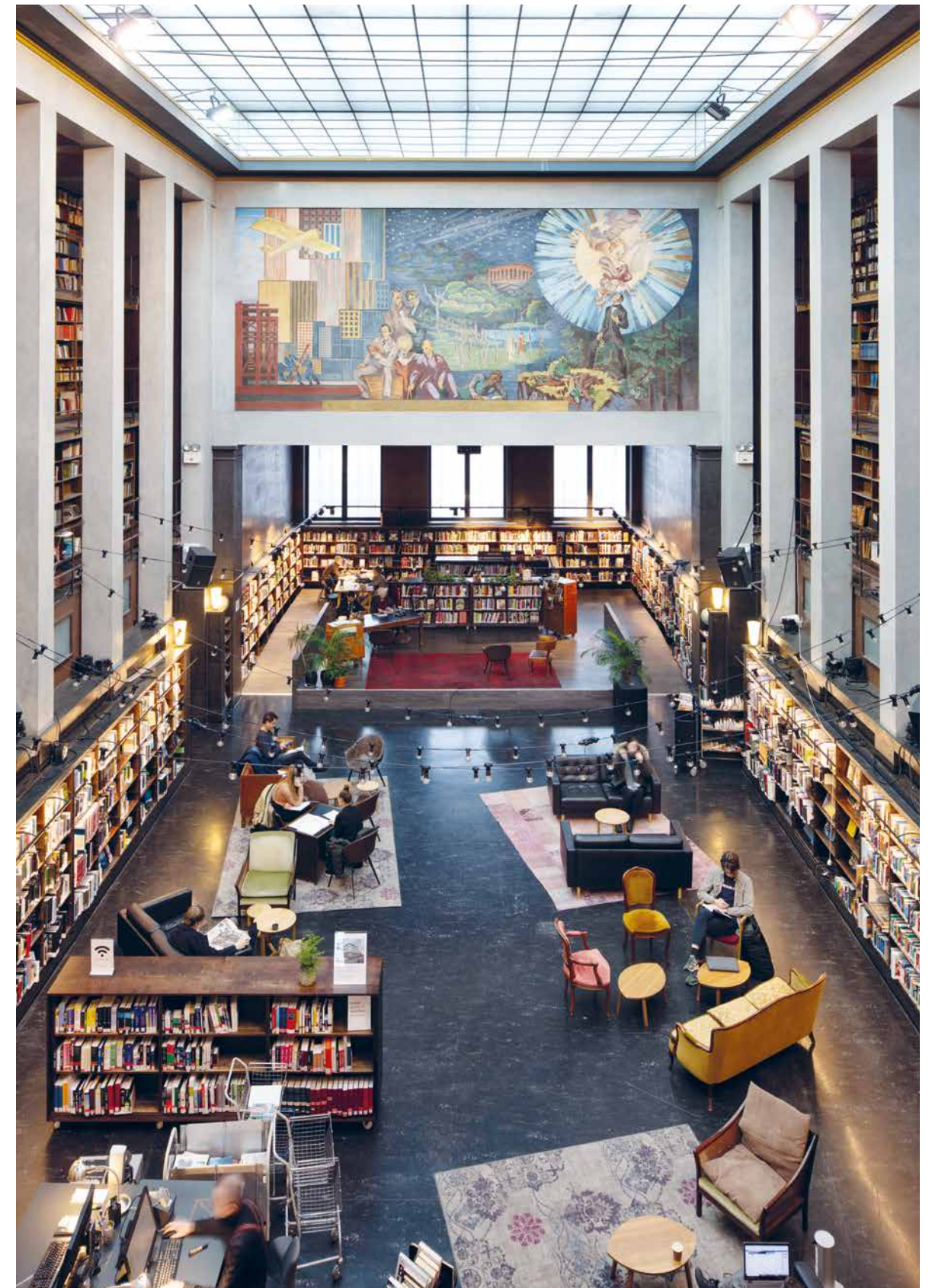
Those of us who work within the field of cultural heritage management possess expertise relating to transformation and reuse, and we are seeing more and more exciting projects that innovatively repurpose old buildings for new use. These projects ought to inspire both public and private property developers to reuse what we already have. Especially now that we know even more about the good reasons for doing so.

This publication summarises some of the most important findings that researchers have made and contextualises them within the ongoing debate on climate politics and actions. It also puts forward some specific suggestions and recommendations as to what kinds of measures can be implemented on existing buildings and on their effect.



Hanna Geiran

HANNA GEIRAN, DIRECTOR OF THE
DIRECTORATE FOR CULTURAL HERITAGE



↑ **THE OSLO PUBLIC LIBRARY** was previously located in a grand building in the Hammersborg area of Oslo, directly behind the city's Government Quarter. In 2020, the library was moved to new premises in the Bjørvika neighbourhood and the old building was sold. The new owners plan to turn the former library into a multifunctional space for working, dining and photo art.

We have a job to do

Greenhouse gas emissions come from many sources, but the buildings we live and work in are one of the biggest. Emissions come from both the buildings themselves and from the way they are used. If we are to meet our climate targets, we need to change this.

The 2015 Paris Agreement is the first legally binding climate agreement that almost all countries have ratified. All Parties have committed to putting their best efforts towards cutting emissions. Despite international agreements and stated ambitions, actual emissions continue to increase.

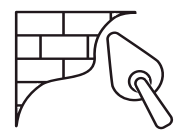
Emissions from buildings are considerable. Almost 40 percent of global greenhouse gas emissions come from buildings we live and work in. The European Commission points out that 75 percent of today's building stock in the EU

is inefficient and that by upgrading buildings we can reduce energy consumption by 5–6 percent. This would bring down greenhouse gas emissions in EU countries by around the same percentage.

At the same time, analyses into future needs for building space show that around 90 percent of the existing building stock will still be standing in 2050. It therefore makes sense for us to do something about how we maintain our buildings, however the energy efficiency and upgrades to existing buildings is still not a priority.

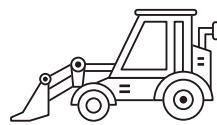
ENVIRONMENTAL IMPACT FROM THE CONSTRUCTION SECTOR

1.95 million tonnes of waste come from construction activity.
That is **25%** of total waste in Norway.



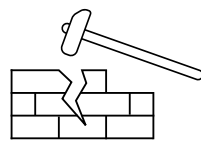
34%

waste from new constructions



41%

waste from demolitions

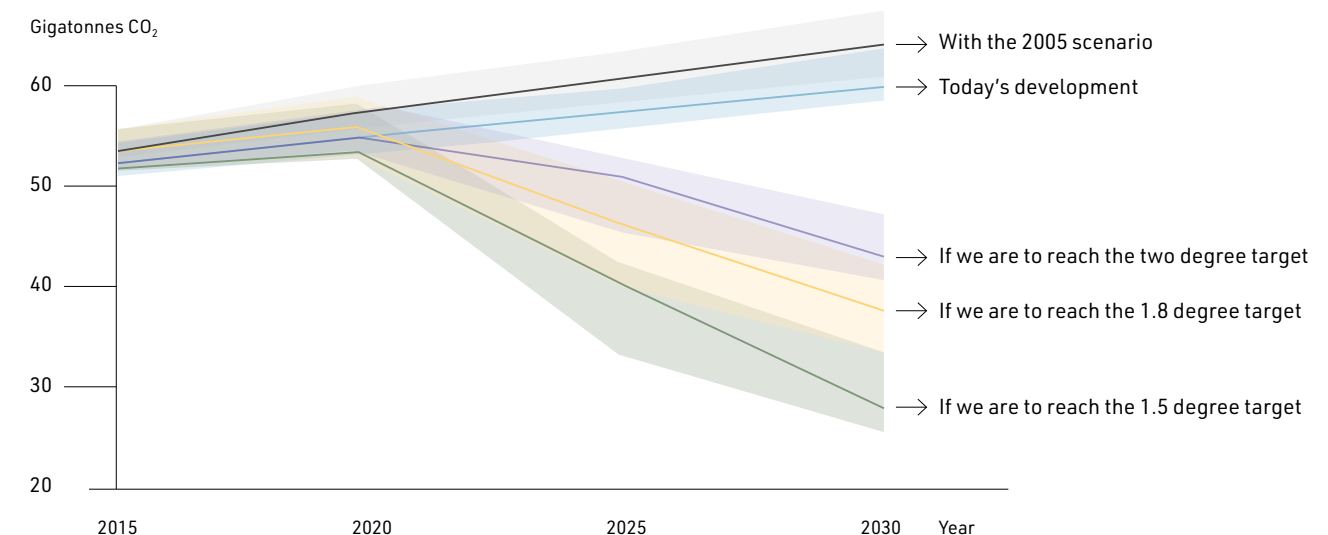


25%

waste from rehabilitation projects

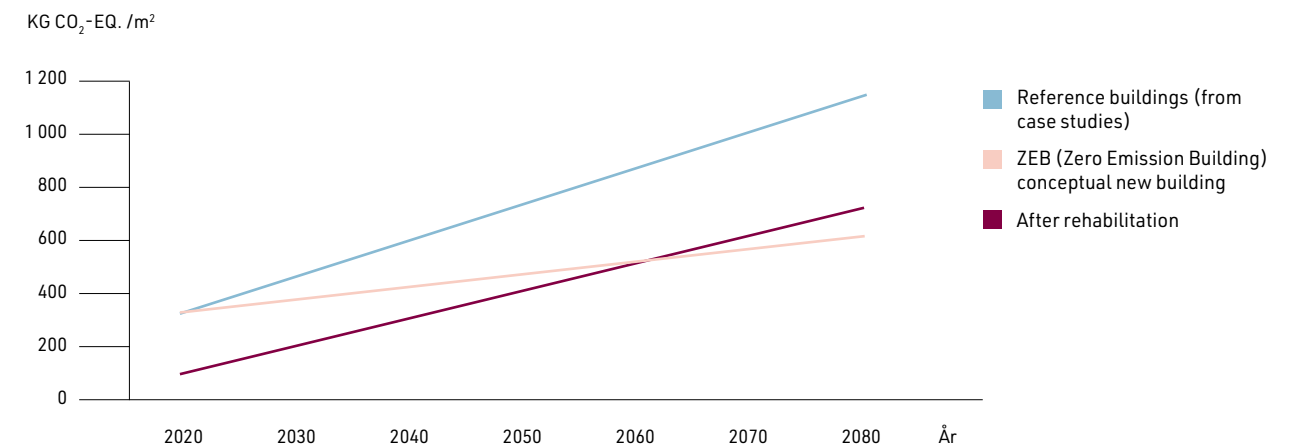
Source: Statistics Norway, 2021

FIGURE 1 / GLOBAL GREENHOUSE GAS EMISSIONS IN DIFFERENT SCENARIOS AND THE EMISSIONS GAP IN 2030.

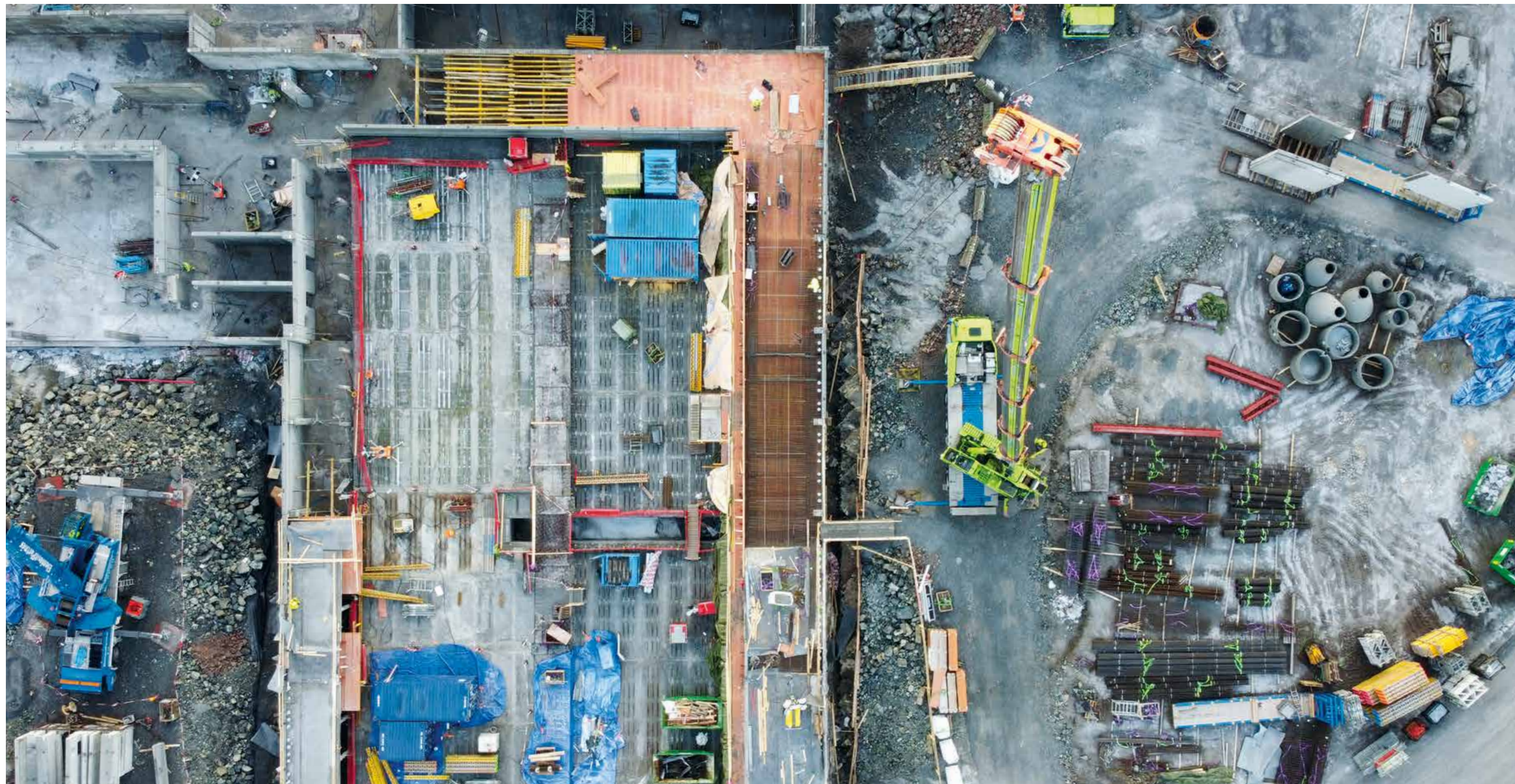


The figure shows how much we need to cut global emissions by over the next ten years if we are going to reach the climate targets of a maximum rise of 1.5 or two degrees Celsius. Under current policies, we are headed for an increase in emissions of up to 60 gigatonnes CO₂ by 2030. Source: UNEP 2019 (United Nations Environmental Programme)

FIGURE 2 / TOTAL GREENHOUSE GAS EMISSIONS OVER 60 YEARS



Accumulated greenhouse gas emissions over the next 60 years for each of the three scenarios in this analysis. All emissions connected to material consumption are allocated to the 2020 construction year while energy consumption in the operational phase is equally distributed over the next 60 years. Source: SINTEF 2020



EMISSIONS FROM BUILDINGS

Emissions from buildings are unevenly distributed over the course of a building's lifecycle. Some emissions come from the construction phase, some from use of the building and some from its demolition. When we build a new building, we release emissions through the production of construction materials such as cement, steel and glass; through the transport of materials to the construction site and through various activities undertaken directly at the building site. The rehabilitation of buildings also entails emissions, but these are generally much reduced compared with new

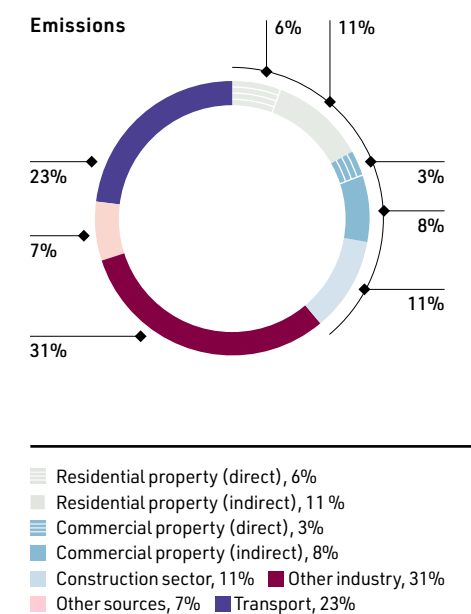
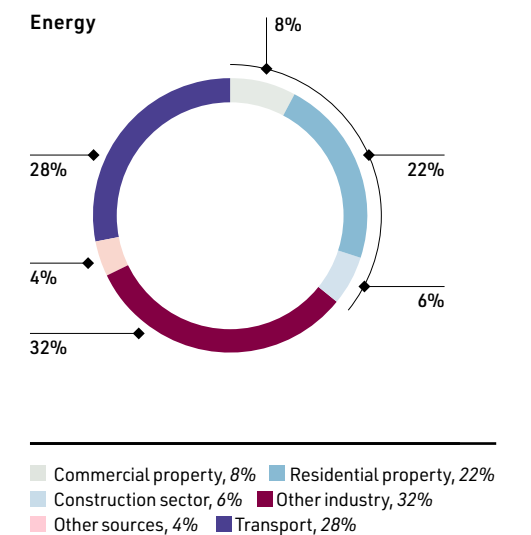
constructions. Emissions come primarily from the production of the new materials that we use in the renovation work and from their transport. Extensive rehabilitation projects can thus lead to a considerable increase in embodied emissions and in the worst case they can make a building less climate-friendly over its total lifetime. If we need to demolish an old building before we raise a new one, the demolition process will require the use of heavy machinery, and the materials will need to be removed. All this work and the materials used in the building are counted as part of its so-called 'embodied emissions'.

Embodied emissions

'Embodied emissions' are the total emissions from all of the various different products and materials used in the production, maintenance and demolition of a building. These emissions are regarded as an inherent part of the building's materials. When a new building is constructed, embodied emissions are included as a part of the total carbon accounting. Existing buildings will have already produced greenhouse gas emissions when they were originally built. In the case of rehabilitation, only emissions linked to the new materials, their transport and the renovation work undertaken will be counted. If we compare demolition and building from scratch with reusing and rehabilitating, the embodied emissions linked to existing buildings will thus often be lower.

← **EMISSIONS** from construction come from both the energy and the resources used to produce the building materials, from transport of the building materials to the site and from machines which are used in the construction process. All of these emissions are said to be embodied within the building. This means they cannot be removed, no matter what measures you introduce or how you reuse the building at a later stage.

FIGURE 2 / GLOBAL ENERGY CONSUMPTION ASSOCIATED WITH BUILDING AND CONSTRUCTION COMPARED WITH OTHER SECTORS



Source: UNEP (2019c)

EMISSIONS FROM USE

Once a building is complete, greenhouse gas emissions for the rest of its lifecycle will come from lighting, heating, air conditioning and ventilation. Internationally, energy consumption linked to the heating and cooling of buildings is the largest source of emissions. This is due to the fact that many homes and commercial buildings are powered by fossil fuels such as coal and gas. In the case of Norway, emissions from heating and cooling are below the global average as such a large proportion of our energy comes from renewable sources.

→ **IN NORWAY**, most of the electricity that we use for heat, ventilation and light comes from renewable hydropower. This means that the use of buildings does not produce emissions to the same extent as in many other countries.

SHARE OF GREENHOUSE GAS EMISSIONS
IN NORWAY WHICH COMES FROM THE
CONSTRUCTION AND USE OF BUILDINGS

15,3%

The fact that Norway has lower emissions than the global average is due primarily to the fact that residential and commercial buildings in Norway are heated by electricity produced by hydropower.



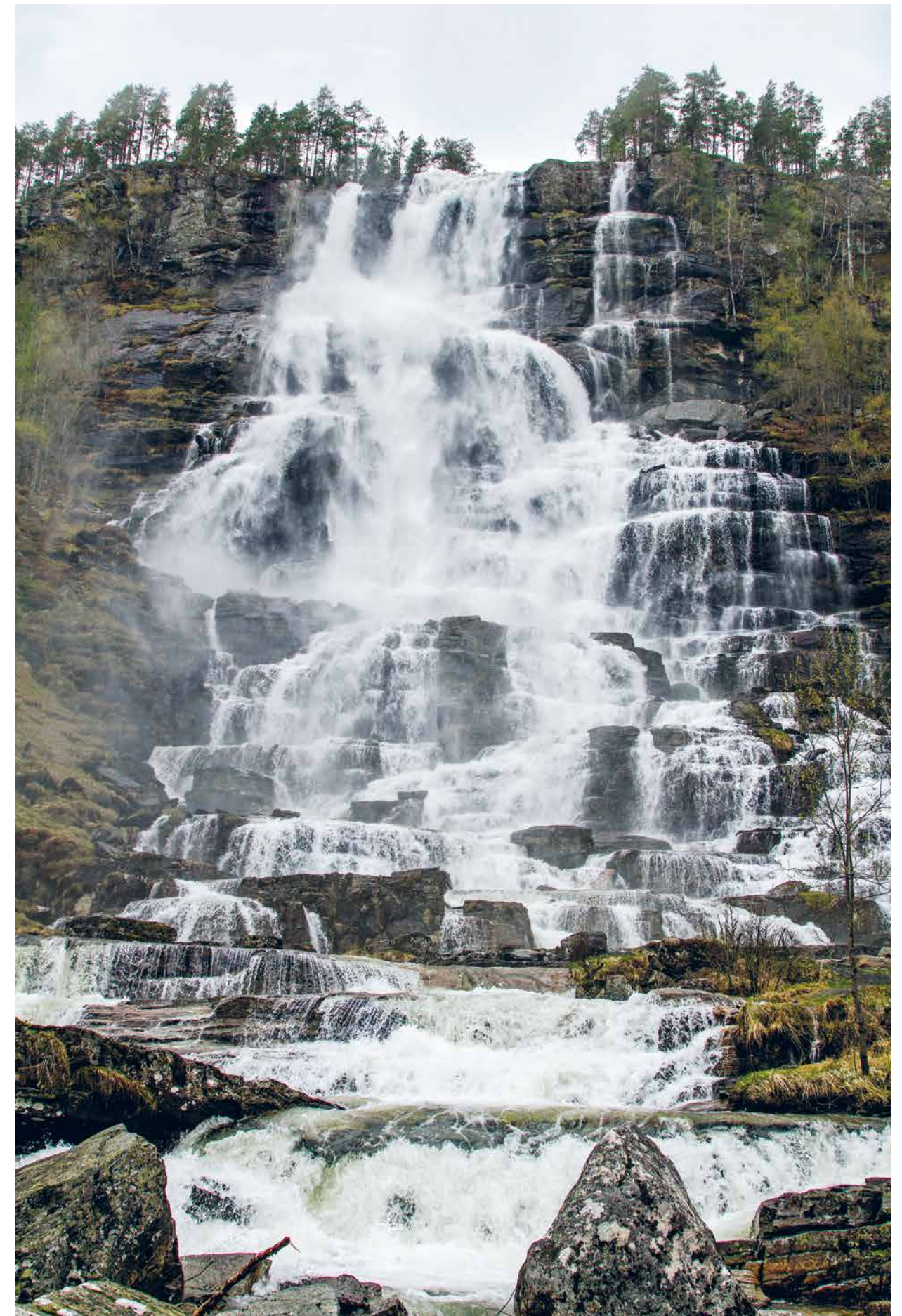
Stricter EU requirements

In 2018, the European Building Energy Directive was amended. The Directive places new and stricter demands on energy efficiency and tightens requirements for older and existing buildings to be powered by energy from renewable sources. Guidelines were drawn up for short-term goals to be met by 2030, medium-term goals to be met by 2040 and long-term goals to be met by 2050. The overall goal is to upgrade existing buildings in a cost-effective manner with a view to reducing greenhouse gas emissions by around 80–90 percent compared to 1990 levels.



Energy source is crucial

In Norway, 98 percent of electricity is produced from renewable power – primarily hydropower as well as solar and wind power. Because the EEA Agreement means that Norway is a part of the European energy market, and thus buys and sells electricity over international borders, our renewable energy production forms part of a joint carbon footprint for all trading countries. This average European energy mix, which is comprised of around 77 percent oil, gas and coal, 14 percent nuclear power and nine percent renewable energy, is used as the basis for drawing up carbon accounts in several lifecycle analyses.



Conservation and reuse are a win for the environment

SINTEF's review of international research shows that the rehabilitation of buildings can lead to a considerable reduction in greenhouse gas emissions. Demolishing an old building in order to erect a new one can lead to increased emissions for several decades, even if the new building is more energy efficient than the one it replaces.

On commission from the Norwegian Directorate for Cultural Heritage, SINTEF undertook to establish an holistic depiction of the impact that conserving and reusing buildings has on the climate.

The study used lifecycle analyses to investigate actual impact on the climate, as well as the disadvantages and the opportunities which lie in upgrading existing buildings. The studies refer both to existing buildings in general and more specifically to buildings with historical value, comparing their emissions with those from newer buildings.

The sub-goals of the commissioned assignment were to:

- identify the potential environmental benefits which lie in the upgrading and/or rehabilitation of existing building stock
- identify the overall performance levels of existing buildings and to compare these with the equivalent for new buildings

SINTEF has undertaken a systematic survey and review of lifecycle analyses for the rehabilitation and upgrading of existing buildings. The project studied and surveyed climate calculations on existing buildings from available national and international publications and project reports.



Data basis

SINTEF collected data in part through the use of keywords and search criteria in reputable research databases such as Web of Science, Engineering Village and Scopus. In addition, the researchers also undertook searches on literature and technical reports in order to involve more studies which were not covered by the research databases. They also undertook a close analysis of 12 Norwegian and 11 international projects (case studies) which used lifecycle analyses in connection with the rehabilitation of existing buildings.

↑ **POWERHOUSE KJØRBO** in Sandvika, outside of Oslo, is the first rehabilitated office building anywhere in the world to produce more energy than it consumes. The original foundation and load-bearing structure were retained in the rehabilitation process. Laminated glass panels from the original facade were reused on the inside while a new external facade was constructed with additional insulation and a cladding of charred wood. Ceilings and floors were further insulated and solar panels were installed on the roof. Heating is supplied by a heat pump and a geothermal well. Following the renovation, the building's energy needs were reduced by more than 86%.

Lifecycle analyses as a tool

Lifecycle analyses consider greenhouse gas emissions over the entire life of a building – from the moment ground is first broken through demolition. Such analyses thus produce a more holistic depiction as to how demolition and new construction would affect both the environment and society compared with rehabilitation and reuse. Having a complete account of all emissions over the lifetime of a building makes it easier to determine which buildings can and should be upgraded, what measures ought to be implemented and how this will affect the total emissions of the building.

The upgrading of our existing building stock is a suitable and important measure in meeting the 2050 climate targets.

DEMANDING COMPARISONS

Even if lifecycle analyses and emissions accounting are not exactly new concepts, few studies of this kind have thus far been carried out, either in Norway or internationally. Moreover, it is difficult to compare those studies that have been done. They relate to a wide variety of buildings – ranging from small homes to large office blocks – and the methods used vary. International standards do exist but there is nonetheless little harmony between choice of methods and background data. For example, should the emissions caused by the demolition of a building be attributed to the new building that is to be erected on the site of the demolished one? Or do they belong to the building that is to be demolished? How will total emissions be affected if the building is heated by fossil fuels rather than purely renewable sources of energy? Should the calculation be based on a national energy mix, a European energy mix or an international energy mix? How is local climate reflected in the calculations? How are emissions from material consumption calculated? These questions affect what factors are ultimately involved in the calculation.

Despite these variations in the lifecycle analyses, the researchers at SINTEF nonetheless found a selection of international studies that were sufficiently consistent that they could be used to state something about the front line of research today. The research points to the following:

OLDER BUILDINGS HAVE AN ADVANTAGE:

Several examples from the research studied by SINTEF documents that rehabilitation yields major climate benefits compared with demolishing and new constructions.

Existing buildings possess embodied emissions from when they were first constructed whether they are in use or not. Emissions from existing buildings come primarily from energy consumption and then from rehabilitation or demolition. A new, modern building may well be much more energy efficient and release less emissions in its use, but the climate cost of the construction phase (the embodied emissions) will take a heavy toll on the total emissions of the new building for many decades. Calculations show that it can

take up to 80 years before the climate accounts of a 'green' new build come out of the red, compared with an equivalent building which was already there. The reason for this is that such a large proportion of the emissions come from the actual construction phase.

A study from the US showed that emissions from a rehabilitated building can be anywhere from four to 46 percent lower than demolishing and building from scratch. A Canadian study also shows that relatively moderate measures are enough to make historical buildings climate-positive as they do not cause the same level of emissions as a new build. A crucial factor in the lifecycle analyses is the lifetime calculated for the various buildings. The longer the lifetime is expected to be, the more years you have across which to distribute embodied emissions from materials and constructions.

Both the international literature and the Norwegian examples show that reuse,

rehabilitation or upgrading of existing buildings constitute an efficient use of resources. These are measures which can reduce the carbon footprint of the construction sector. Although there are huge differences from one example to another, the emissions from a rehabilitated building will often be only half the emissions of an equivalent new build over the course of the building's lifetime. This means that the upgrading of our existing building stock is a suitable and important measure in meeting the 2050 climate targets. The high emissions associated with the construction of a new building today will – no matter how energy efficient the building may be – make it more difficult to reach the targets set both for 2030 and for 2050. It simply takes too long for lower energy consumption to offset the enormous emissions from the construction phase.



↑ **DEMOLISHING** an old building and replacing it with a new one will, in most cases, result in considerably higher greenhouse gas emissions compared to rehabilitating and reusing the old building.

→ **THE REFURBISHMENT OF OLD WINDOWS** and the use of sealing strips are simple measures that can benefit the climate.

MODEST ACTIONS ARE OFTEN GOOD ENOUGH

The survey shows that different upgrade projects yield highly disparate results, but that even modest actions can reduce the energy consumption of existing buildings considerably.

Increasing the thickness of insulation in walls and ceilings, installing heat pumps, LED lights and fixing draughty doors and windows are some typical examples of measures which can reduce the energy consumption of existing buildings.

Choosing local materials with a smaller carbon footprint (such as locally produced timber), the implementation of energy optimisation measures and the use of renewable energies are the most important measures for reducing emissions when upgrading existing buildings.

The extent to which existing buildings can be made more energy efficient varies. Several different studies within this category show that the effects are very uneven and depend both on building type and the extent of the upgrade. In the case of smaller and older buildings, an extensive upgrade will not necessarily be cost

effective or able to help reduce emissions. The materials used may leave a considerable carbon footprint which will not be offset by reduced energy consumption. In comparison, the comprehensive upgrading of a relatively new apartment building may pay off within just a few years. The researchers behind several of the studies point out that it is difficult to compare different rehabilitation scenarios because each example is unique and must be considered individually. The age of the building, material use, structures, conservation values and heritage protection level are all relevant factors. Energy requirements and efficiency measures should be adapted to the specific building in question. Naturally, results will also vary depending on the actual rehabilitation measures which are being considered.

Measures to reduce the energy consumption of buildings can be highly efficient. Even modest actions can considerably reduce the energy consumption of existing buildings.



Emissions from construction versus emissions from use

SINTEF has reviewed studies which compare greenhouse gas emissions in the construction phase with emissions from the operational phase, i.e. emissions from energy used for lighting, heating and ventilation. The international studies show that emissions largely depend on the energy source being used:

- A study of eight homes found that the reduction of greenhouse gas emissions was primarily tied to energy consumption, energy mix and efficiency in the electricity grid. The researchers also found that simple buildings with poor insulation were not worthy candidates for rehabilitation.
- A study from New Zealand shows that an extensive rehabilitation process will reduce energy consumption in the operational phase, but that any savings will be contingent upon the building having a long lifetime and its energy efficiency being maintained. The researchers emphasised that the type of energy used for heating (or cooling) would be of considerable importance. New Zealand has a large share of coal in its energy mix which means that improving energy efficiency is a measure that

can reduce greenhouse gas emissions considerably. The comprehensive upgrading of a building which gets its electricity from renewable sources is not necessarily an equally good idea. The construction work and material consumption may result in such large emissions that it will not be possible to offset them through reduced energy consumption in the operational phase.

- A case study on an office building in Brussels compared estimated emissions from rehabilitation with those of demolition and new construction. The results showed that rehabilitation would have almost cut both energy consumption and greenhouse gas emissions in half compared with building from scratch. The calculation factored in demolition of the existing building, future demolition of the new building, emissions from construction and embodied emissions from the construction materials used.

In other words, this is not an unambiguous answer to the question of whether rehabilitation is better for the environment compared with new construction. Emissions from material consumption in extensive rehabilitation projects can be so great that they are not offset by reduced energy consumption during the building's operational phase.

USAGE HAS AN EFFECT ON EMISSIONS

How buildings are used can be of great significance when calculating energy consumption and environmental impact. Buildings which are in use for large parts of the day or by many people simultaneously will have more usage hours and more people over which to distribute emissions. Emissions connected to use, or the building's operational phase, are particularly important to consider in countries where fossil fuels are primarily used for heating. In these cases, energy optimisation measures will rapidly help to lower greenhouse gas emissions. The same is not true of a country such as Norway, where heat is primarily produced using electricity from hydropower. In this case, changes to how the building is used will have only a modest impact on overall emissions. Extensive rehabilitation and energy optimisation may be effective towards cutting electricity costs, but this will not reduce emissions to the same extent.

In the United Kingdom, where the use of coal and gas in heating is pervasive, several studies have shown how emissions are distributed over the lifetime of a building. Several of these studies suggest that even extensive rehabilitation projects undertaken on older buildings can be justified in cases where there are many users and indoor temperature requirements are high. Some studies also conclude that new construction is the best option in certain cases when the greenhouse gas emissions produced from use of the building are considerable. Older buildings are often less space-efficient than new buildings. A new building for either residential or commercial use can have a more efficient floor plan and hence reduce emissions. Nevertheless, the rule of thumb is that the rehabilitation of old buildings is normally the best option. New

builds can be a close second in cases where heating comes from coal or gas. The worst option is to do nothing.

AN IMPORTANT TOOL

A lifecycle approach is central in order to be able to evaluate the sustainability of existing buildings more thoroughly and an important tool in identifying good upgrade measures. Lifecycle analyses can make it easier to assess which buildings are best suited for rehabilitation and where extensive rehabilitations or upgrades should be undertaken.

SINTEF's investigation shows that the majority of lifecycle analyses are undertaken on newer buildings. Fewer calculations are made on older buildings and scarcely any are undertaken in the case of buildings with historical value.

In addition, there is considerable uncertainty around studies that are undertaken on the basis of varying and incomplete methodologies.

In order to better understand the sustainability of existing buildings, SINTEF believes that lifecycle analyses should be carried out more often. Such analyses can tell us whether rehabilitation measures should be taken in order to strike the right balance between cultural and historical values and energy consumption and emissions. Lifecycle analyses should not focus exclusively on reducing emissions and bringing down energy consumption, but should also look at architectural, cultural-historical, aesthetic and experiential qualities and values. Examples from Historic England show that it is possible to conserve important historic buildings while simultaneously cutting environmental impact considerably.

SINTEF'S CONCLUSIONS

Based on the findings of this study, the authors have drawn three conclusions:

- ↓
1.

There is considerable untapped potential for environmental benefits within the existing building stock. Where possible, rehabilitation should be prioritised over demolition and the construction of new buildings in line with national and international climate targets.
2.

Environmentally friendly rehabilitation measures should not come at the expense of cultural and historical conservation values.
3.

Complete lifecycle analyses is an important tool in identifying and deciding on the best upgrade measures to take.

Two examples from Historic England

In the United Kingdom, a comparative study was undertaken into the environmental impact of rehabilitation versus demolition and new construction for two historical buildings. The first of the two buildings was a Victorian terrace house in classic red brick located in the East Midlands. The calculations show that in the case of rehabilitation, almost 98 percent of total emissions would come from the operational phase and only two percent from the building phase. On the other hand, in the event of demolition, 72 percent would stem from the operational phase and as much as 28 percent from construction. High emissions from the construction phase mean that the new building would need to be used for 60 years or more before its overall emissions would level off at the same value as in the case of rehabilitation.

The second example looked at the conversion of an old chapel in London into a residential dwelling.

For this project, it was estimated that greenhouse gas emissions from operation would correspond to 90% in the case of a redevelopment and 69% in the case of demolition and new construction. As in the other example, the new building would need to be in use for more than 60 years to exert an overall positive effect.

Both cases were also compared to their default positions – to do nothing at all. In the case of older, historic buildings this is revealed to be the worst option. The examples show that potential gains from the upgrading of old buildings are considerable enough that they can largely compete with those of new, more energy-efficient buildings.

All buildings can be made more climate-friendly

Everything from single family homes to housing cooperatives and office buildings can be made more environmentally friendly. Even modest actions can yield environmental gains. Lifecycle analyses is an important tool in assessing which measures ought to be implemented in each individual case.

The researchers at SINTEF have taken a closer look at 12 lifecycle studies undertaken on buildings in Norway. These include four residential buildings, five office buildings, one school, one university building and one nursing home. Emissions from the existing buildings, both before and after rehabilitation, were also compared with two newly constructed reference buildings – a detached home and an office building.

In order to draw conclusions on how rehabilitation affects greenhouse gas emissions, energy consumption after rehabilitation is compared with that of an equivalent, newly constructed building (a reference building) which has been built in line with standard

specifications and requirements. Where possible, energy use before rehabilitation has also been included as part of the basis for comparison. The results are then compared with similar studies from other countries.

The Norwegian examples are taken from various academic sources such as the Future Built Programme, the Cities of the Future Project (Framtidens Byer) and the Norwegian Zero Emissions Buildings Research Centre (ZEB Centre). In addition, the Directorate for Cultural Heritage has put forth two of the examples. The calculations assume that the buildings will have a lifetime of 60 years. Greenhouse gas emissions are measured as the number of CO₂ equivalents per square metre per year (CO₂eq/m²/yr).



The twelve Norwegian buildings

Villa Dammen, detached home in Moss

Ulsholtsveien, apartment building in Oslo

Stjernehuset Cooperative, apartment blocks in Kristiansand

Vestlia Cooperative, apartment blocks in Trondheim

Rådhuskvartalet, office building in Kristiansand

Powerhouse Kjørbo, office building in Sandvika

Grensesvingen 7, office building in Oslo

Bergen City Hall, office building in Bergen

Økernhemmet, nursing home in Oslo

Stasjonsfjellet School, school building in Oslo

NHH Norwegian School of Economics, university building in Bergen

Statens Hus, Building B, office building in Vadsø



↑ **VESTLIA COOPERATIVE** in Trondheim was built in the 1970s. The TOBB Housing Association wanted to investigate their opportunities to improve the energy efficiency of older apartment blocks and so they engaged SINTEF to develop two different scenarios for a possible upgrading. The simpler of the two scenarios primarily involved the additional insulation of ceilings and walls, as well as a better ventilation system. The more extensive proposal – which was for a nearly zero emission building (nZEB) – would have involved more insulation in ceilings and walls, new triple-glazed windows, balanced ventilation and more. The calculations showed that the more extensive upgrading would mean higher emissions in the first year but that this would be offset after 13 and ½ years with a Norwegian energy mix and after only two and a half years with a European energy mix.

UNEQUAL DISTRIBUTION OF EMISSIONS

The review of the 12 examples from Norway shows that the biggest emission cuts from rehabilitation compared with new construction come from reduced material consumption. The explanation for this is that rehabilitation normally requires less material compared with building from scratch. There is also a difference between a limited and more extensive rehabilitation. A rehabilitation project involving little use of new materials will often result in lower emissions than a more ambitious rehabilitation. An extensive upgrade can lead to a sharp increase in embodied emissions. These can sometimes be so high that reduced emissions in the operational phase will not be sufficient in order to compensate from the emissions released during the rehabilitation process.

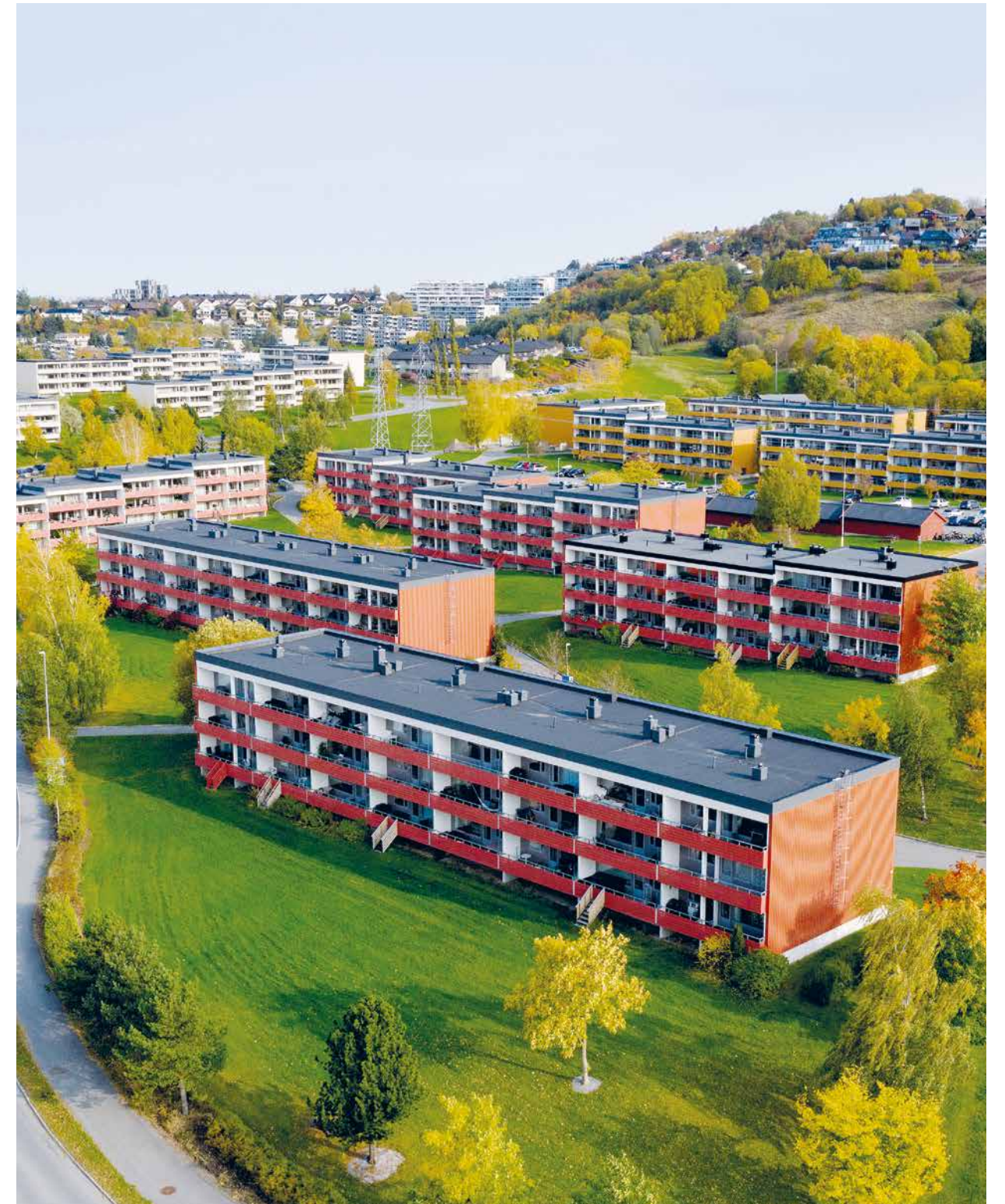
Emissions from the rehabilitated buildings were compared with those of the reference buildings. These are new buildings where no extra efforts have been made to reduce material use or to include particularly environmentally friendly materials. Today, however, we have the know-how to build virtually zero emissions buildings – i.e.

buildings with considerably reduced total lifetime emissions. SINTEF therefore also compared the rehabilitation projects with such a building, a hypothetical zero emissions building (ZEB).

This comparison shows that a zero emissions building will have considerably lower greenhouse gas emissions than both a standard new construction (reference building) and a rehabilitated building when it is in use. On the other hand, emissions linked to materials are considerably higher for the concept building than the two other options – partly due to the inclusion of more insulation and solar panels. Total emissions over a lifetime of 60 years are thus lowest for an ambitious new-build project, however the difference between this and rehabilitation is not considerable.

In practice, it takes almost 40 years for a ZEB to catch up with the rehabilitated building. This is important to keep in mind as the biggest emission cuts in Norway – and in the rest of the world – must be made before 2050. If we are to achieve our emissions targets, it is not a good strategy to replace existing buildings with new ones, even if they produce fewer emissions when in use.

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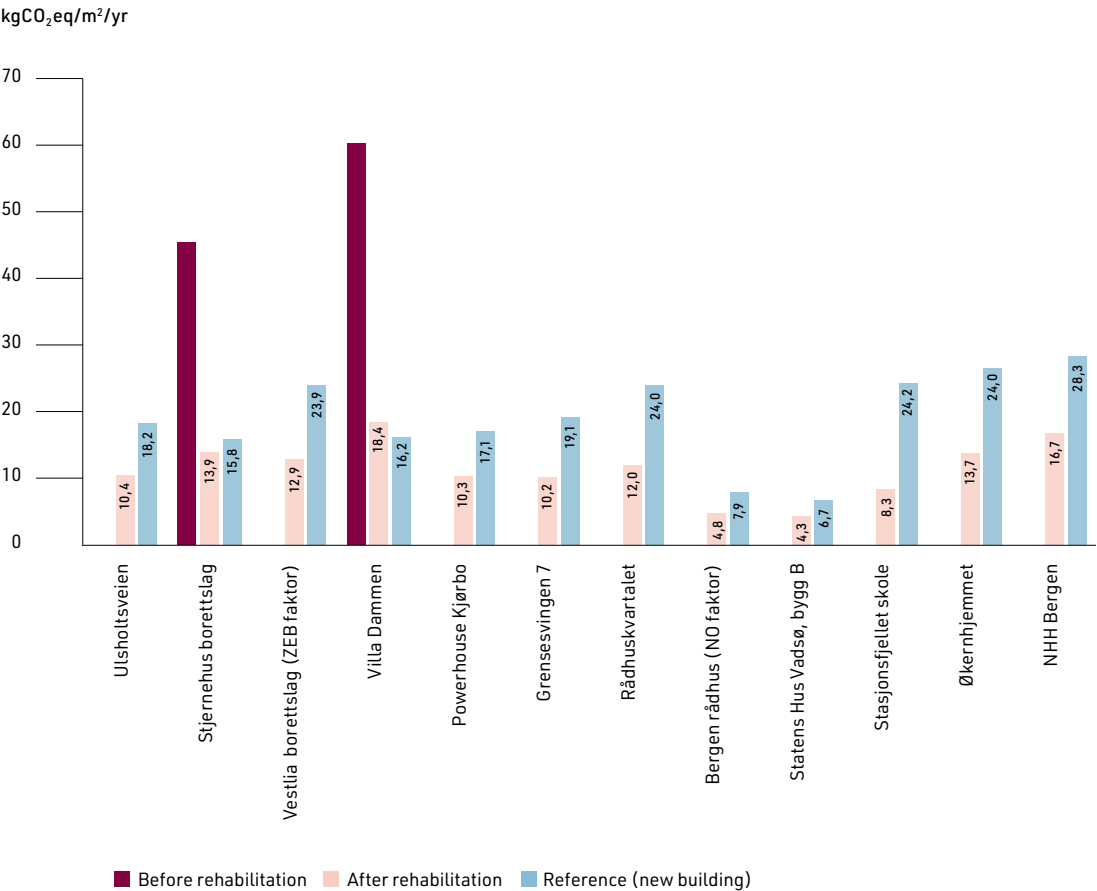
↑ **THE REHABILITATION** of older buildings can be both financially profitable and good for the environment. In many cases, a simple rehabilitation is best. Extensive rehabilitation increases material use and thus the building's carbon footprint.

According to SINTEF, data on greenhouse gas emissions prior to rehabilitation is often lacking. Out of the 12 examples from Norway, such data was only available for two of the buildings. This lack of comparable data makes it difficult to know what level of ambitions are right for a specific building. Hence SINTEF recommends that analyses into different upgrade scenarios be conducted to a greater extent than is currently the case, and that these should in turn be based on a lifecycle analysis. Such an analysis can provide a good indication as to how extensive the rehabilitation measures should be in specific cases. An overall footprint which yields positive results over a 60-year period may

not necessarily provide the emissions cuts needed within the 30 years between now and 2050.

Out of the 12 examples, it is only the Stjernehus Cooperative and Villa Dammen which calculated emissions prior to rehabilitation. Across the board, rehabilitation resulted in fewer emissions than an equivalent new construction (reference building) with just one exception: the rehabilitation of Villa Dammen has resulted in somewhat higher emissions than an equivalent new build. However, the rehabilitation leads to a reduction of greenhouse gas emissions by more than two thirds – from over 60 to 18 kilograms of CO2 per square metre.

FIGURE 6 / BELOW SHOWS THE TOTAL GREENHOUSE GAS EMISSIONS FROM ALL OF THE TWELVE EXAMPLES



↑ **VILLA DAMMEN** is a privately-owned single-family home of historical value, dating back to 1935. The owners wanted to make the house environmentally friendly and energy efficient while also conserving the original style and distinctiveness of the home. Some of the measures undertaken include weatherproofing doors and windows, the replacement of an oil boiler with a wood-burning stove and the installation of a heat recovery unit for grey water. The rehabilitation led to considerable reductions in estimated emissions, particularly due to the boiler being replaced.



↑ **IN ADDITION** to a positive climate impact, the rehabilitation of older buildings also often helps to retain valuable cultural-historical values – as is the case for Grünerløkka in Oslo (pictured) – which speak to the social and economic conditions of a certain locality throughout its history.

Rehabilitation on the building's terms

Older buildings can be rehabilitated and upgraded to reduce their environmental impact without impairing their cultural and historical value. Even in the case of buildings with historical value, it is possible to undertake effective measures that will reduce energy costs.

As a general rule, upgrading typically involves both demolition and the replacement of materials. From a resource and environmental perspective, it is preferable to use materials and building components over long periods. The construction industry accounts for the greatest share of raw material consumption in our society and it also produces the most waste. The best approach is to reuse buildings without undertaking overly extensive remodelling processes. A relatively gentle and restrained rehabilitation will generally be compatible with good resource and environment management. When improving energy efficiency, it is important to consider adding components or materials rather than replacing them.

AVOID DAMAGE

Older buildings require more energy than newer ones when in use. This is primarily due to inadequate insulation and heat escaping through ceilings, walls, doors and windows. Energy-conserving measures often involve changing conditions within the buildings which relate to humidity and temperature. It is therefore important to possess thorough knowledge as to how the building is constructed and how it was originally intended to function. In the worst case, modern materials and techniques can cause damage to the building. One common problem is that an old building with natural ventilation becomes too sealed after rehabilitation or is damaged as a result of changes to humidity in the basement, the walls or attic.

In order to implement energy-conserving measures it is important to have a good understanding of:

- building structure
- moisture transport and cold bridges
- humidity barriers
- heating
- ventilation
- conservation values

An assessment of the conditions should be carried out before any energy optimisation measures are planned.

OLD BUILDINGS HAVE MANY KINDS OF VALUES

Using a building with great cultural or historical value is sustainable in several different ways. It is good use of resources to continue using an existing building, especially if moderate adaptations can be applied to reduce its impact on the climate and environment.

In addition, this breathes new life into buildings and built environments which hold aesthetic and cultural-historic qualities. Such buildings form part of our cultural environments and have evolved over several generations. They are often of great importance to the identity of their local communities. Buildings also tell us something about the social, financial and cultural history of a particular place.

Most buildings can be made more energy-efficient without damaging their character and history. However, it can be quite challenging to



← **COHESIVE BUILT ENVIRONMENTS**, such as the one pictured here in the town of Skudeneshavn, are of considerable cultural value. The rehabilitation of such built environments must take particular account of these values.

Most buildings can be made more energy-efficient without damaging their character and history.

bring older buildings with historical value up to a standard that is in line with current requirements for energy consumption and emissions. There are several reasons for this. On the one hand, effective measures may compromise the cultural, historic and architectural value of the building; on the other hand, in some cases the actual construction cannot support the kinds of interventions that would be required.

Only a small number of buildings are protected under the Cultural Heritage Act in Norway, but many unlisted buildings may hold considerable historical and cultural value and are thus deemed worthy of conservation. Emissions reduction

measures must be considered on a case-by-case basis and it will be important for the municipalities and local conservation authorities to clearly state what would be permitted and not.

For many buildings with historical value, it may be impossible to add insulation or replace doors and windows, as doing so might impair the heritage value of the property. However, the fact that a building is listed should not be taken as an impediment to doing what can be done. Even modest interventions, such as better temperature regulation, the rehabilitation of windows and the use of sealing strips around doors, can have a major effect.



Good advice for rehabilitation

The Norwegian Directorate for Cultural Heritage has developed a guide with the title *Råd om energisparing i gamle hus* (Energy-Saving Advice for Older Buildings). It is aimed at both owners and users of older buildings as well as architects, consultants, trades people and caseworkers in local municipalities. The Directorate for Cultural Heritage has also produced a standard for how to upgrade energy efficiency in historic buildings.



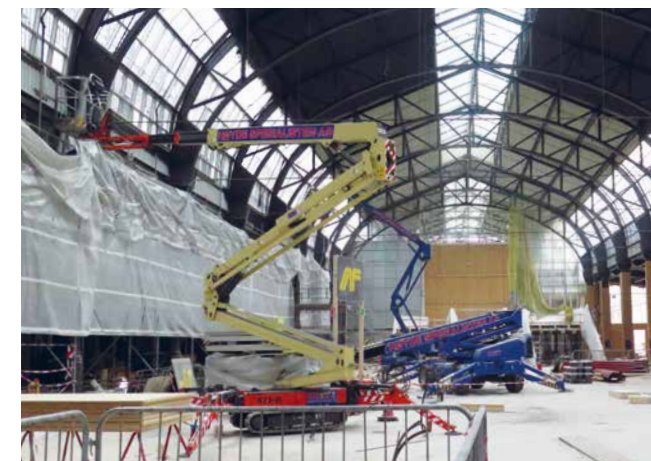
Good principles

- Good maintenance is key
- It is better to repair than to replace old materials
- Do as little as possible
- Use materials and methods which are in line with the distinctive nature of the building in question
- Use high-quality materials



← **TRAINS NO LONGER OPERATE HERE**, but the old Østbanehallen terminal has become a meeting point and a busy commercial centre full of shops, eateries and the Oslo Visitor Centre. It is a pleasant place for the city's residents to meet and socialize, and a nice space for visitors passing through after arriving at Oslo Central Station.

→ **MORNING COMMUTERS** in Østbanehallen, 1962.



← **IN THE WINTER OF 2015**, Østbanehallen swung open its doors once again after almost two years of renovations.



Upgrade measures vastly reduce emissions

- > The environmental impact of existing buildings is up to half that of new buildings.
- > Continued use of existing building stock is the way to proceed if we want to attain national climate ambitions.
- > The degree of environmental gains from the upgrading of existing buildings will vary depending on the individual conditions.
- > It can take anywhere from 10 to 80 years for a new building to offset the greenhouse gas emissions produced in the initial construction process.
- > Rehabilitation is beneficial in the short and intermediate term (<30 years).
- > The combination of environmentally friendly materials, measures to improve energy efficiency and the use of renewable energy sources is important in order to ensure a cost-effective upgrade of the building stock.



Taking cultural and historical conservation values into account

- > When assessing environmentally friendly rehabilitation measures, cultural and historical conservation values should be taken into consideration.
- > The efficiency potential of the building stock should be drawn out through a holistic and balanced approach.
- > There is a lack of expertise on buildings with historical value.
- > Several factors, including other environmental impacts and social aspects, should be factored into the lifecycle analyses.
- > Decisions should be based on thorough lifecycle analyses rather than superficial or inadequate cost analyses.
- > There is a need for a thorough evaluation of the effects that upgrade measures will have on buildings with historical value.

Our recommendations

Public authorities and developers alike have the potential to facilitate a more climate-friendly approach to construction.

CLARIFY AMBITIONS / It is important to clarify the scope and ambitions of any rehabilitation work prior to commencement. The goal should be to make the greatest level of energy savings possible. Impact must be assessed both on the basis of emissions from construction materials and energy savings from use.

THINK HOLISTICALLY / How extensive the project should be will depend on construction technology, materials and structure as well as the cultural-historical value of the property. A thorough review of planned measures must include an assessment of cultural heritage values.

PERFORM LIFECYCLE ANALYSES / A lifecycle analysis should preferably be undertaken before the planned rehabilitation. What would the consequences be of leaving the building as it is versus the proposed rehabilitation project? If new construction is being considered, demolition of the existing building should be included in the lifecycle analysis for the new property. The analyses should use a standard method for evaluation and reporting. Analyses can also be undertaken on more than just single buildings, such as whole neighbourhoods or districts.

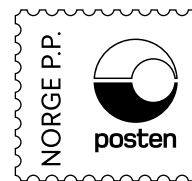
MODEST ACTIONS CAN MAKE A BIG DIFFERENCE / Modest rehabilitation measures can make a big difference without harming the building. Extensive measures to improve energy efficiency may damage the building and increase embodied emissions.

LEARN FROM EXPERIENCE / Collect documentation of best practice from other rehabilitation projects. This experience will yield valuable knowledge that can be put to good use in later projects.

OFFER GRANTS / Financial incentives can help to develop new technologies, materials and solutions for rehabilitation without impairing cultural values. There is a particular need for more knowledge about improving energy efficiency and the integration of new technologies and innovative solutions into buildings with historical value.

USE THE UN'S SUSTAINABLE DEVELOPMENT GOALS AS TOOLS / The construction industry is an important player when it comes to attaining the UN's Sustainable Development Goals (SDG). Conservation values also feature as an integral part of the SDGs and must be factored into any assessment as to whether rehabilitation or new construction makes sense from an environmental standpoint.

PHOTOS Cover – Lene Buskoven, Norwegian Directorate for Cultural Heritage. Page 4 – Øyvind Aase Fluge, Norwegian Directorate for Cultural Heritage. Pages 5, 12, 21, 25, 26, 28 og 29 – Trond Isaksen, Norwegian Directorate for Cultural Heritage. Page 8 – Mads Nygard, Shutterstock. Page 11 – Eder, Shutterstock. Page 15 – Andrey Armyagov, Shutterstock. Page 17 – Sjur Harby, Norwegian Directorate for Cultural Heritage. Pages 30 and 31 – Siri Hagen. Page 31 – Kure Randulf, Oslo Museum.



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