REPORT

GREENHOUSE GAS ASSESSMENT OF PIPE QUALITIES ØKERN PORTAL

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RAP-RIV-01 GREENHOUSE GAS ASSESSMENT OF PIPE QUALITIES

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Abstract

This report highlights the greenhouse gas, GHG, emissions associated with piping systems in the Økern Portal project. Emissions from Aquatherm's polypropylene plastic pipes are compared to conventional metal pipes. Varying quality of available data causes uncertainties and the calculations are only done for the production phase of the pipes. The calculations made in this report are nevertheless the best estimate possible with today's data. The results indicate that there are significantly lower GHG associated with the use of Blue pipe and Green pipe compared to metal pipes.

The project has chosen to use Blue pipe and Green pipe in parts of the piping systems. This gives an estimated total savings of 17%, corresponding to 223 tonnes of CO2 equivalents. If the pipes had been selected in the full extent recommended by Armaturjonsson, the estimated savings would have been a total of 847 tonnes of CO2 equivalents. By far the largest share of GHG emissions is associated with the cooling system and consequently also the greatest potential for emission cuts. This will also apply to other projects where there is comfort cooling in tenant areas and the temperature differences are low.

Clamping is a factor that can cause a reduction in emissions savings, as this is done more frequently for the Blue pipe and the Green pipe, than for the metal alternatives. A longer lifetime of the plastic pipes can have a positive impact on GHG emissions when choosing Blue pipe and Green pipe, but this is not documented in the environmental declaration. For both plastic pipes and metal pipes, there is considerable uncertainty regarding what happens to the pipes at the time of disposal. It is not known what proportion is reused in its original form, recycled, incinerated or landfilled. Results from greenhouse gas calculations should always be included in a greater assessment taking into account other environmental aspects and factors such as fire, installation, quality and price.

COTENTS

1 INTRODUCTION

Greenhouse gas emissions (GHG) for technical installations have been neglected in most of the greenhouse gas assessments carried out to date. Because of this, greenhouse gas mitigation measures have not been considered for technical installations in many of today's construction projects. The GHG emissions from piping systems can, due to the use of products with a high proportion of virgin metals, have a major impact on the total greenhouse gas accounts for a building. Calculations Erichsen and Horgen AS have done for a reference building show that in total, technical installations can account for 20% of GHG emissions in new buildings and 40% for rehabilitation.

The purpose of this report is to assess GHG associated with piping systems where Armaturjonsson's plastic pipe from Aquatherm is selected, or could have been selected, as an environmental measure to reduce emissions.

The report was commissioned by Armaturjonsson and includes systems where their products Blue Pipe, Blue Pipe OT and Green Pipe from the manufacturer Aquatherm are relevant. Therefore, calculations have been made for facilities supplying comfort cooling, heating and consumable water. Emissions associated with the production of the aforementioned plastic pipe qualities are compared to conventional metal pipe qualities.

2 ØKERN PORTAL

The report includes a specific project, Økern Portal, which is a combined hotel, office and commercial building of a total of 81,000 square meters, with planned completion in 2021. The client and project owner is Oslo Pensjonsforsikring. Erichsen & Horgen AS is the consultant engineer for HVAC and building services in the project and therefore has an overview of the technical systems and the BIM model.

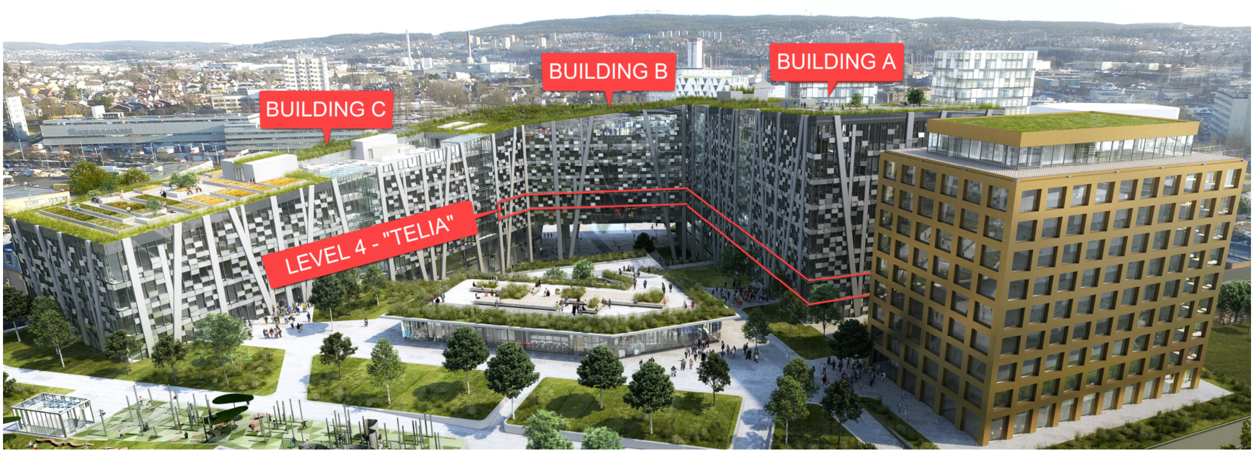


Figure 2-1: Overview picture showing buildings A, B and C included in the report, as well as part of plan 4 which has been completed.

3 CALCULATIONS

The report was completed during the design phase of Økern Portal, while the 3D model was being developed. Parts of the building have nevertheless been completed and pipe qualities has been determined. The calculations include office and business premises in building A, B and C, as well as mechanical room and culvert in level 1. Parts of the model are not developed to a great enough extent and are therefore not included in the report. Not included are the hotel, conference room, dining rooms, shopping malls, parking and other ventilation rooms in levels 1 and 2.

Parts of level 4 in building A and B have been completed and shop drawings are available. Therefore, GHG emissions have been calculated for this part, based on material extraction from the shop drawings. The calculations are further scaled up for the remaining offices and commercial premises.

Figure 3-1: Overview of plan 4 showing completed modulated area, marked as "leased local "Telia"".

There are no finished drawings for the mechanical room, culvert and main guides for shafts, but pipelines with the right pipe qualities are largely modelled to the right extent and dimensions. Therefore, material amounts have also been extracted for this section and GHG emissions calculated. Figure 3 2 shows the mentioned parts of the building in level 1, as well as business premises and leased areas for "Telia", which are included in the report. In addition to the markings, some main piping for shafts are also included.

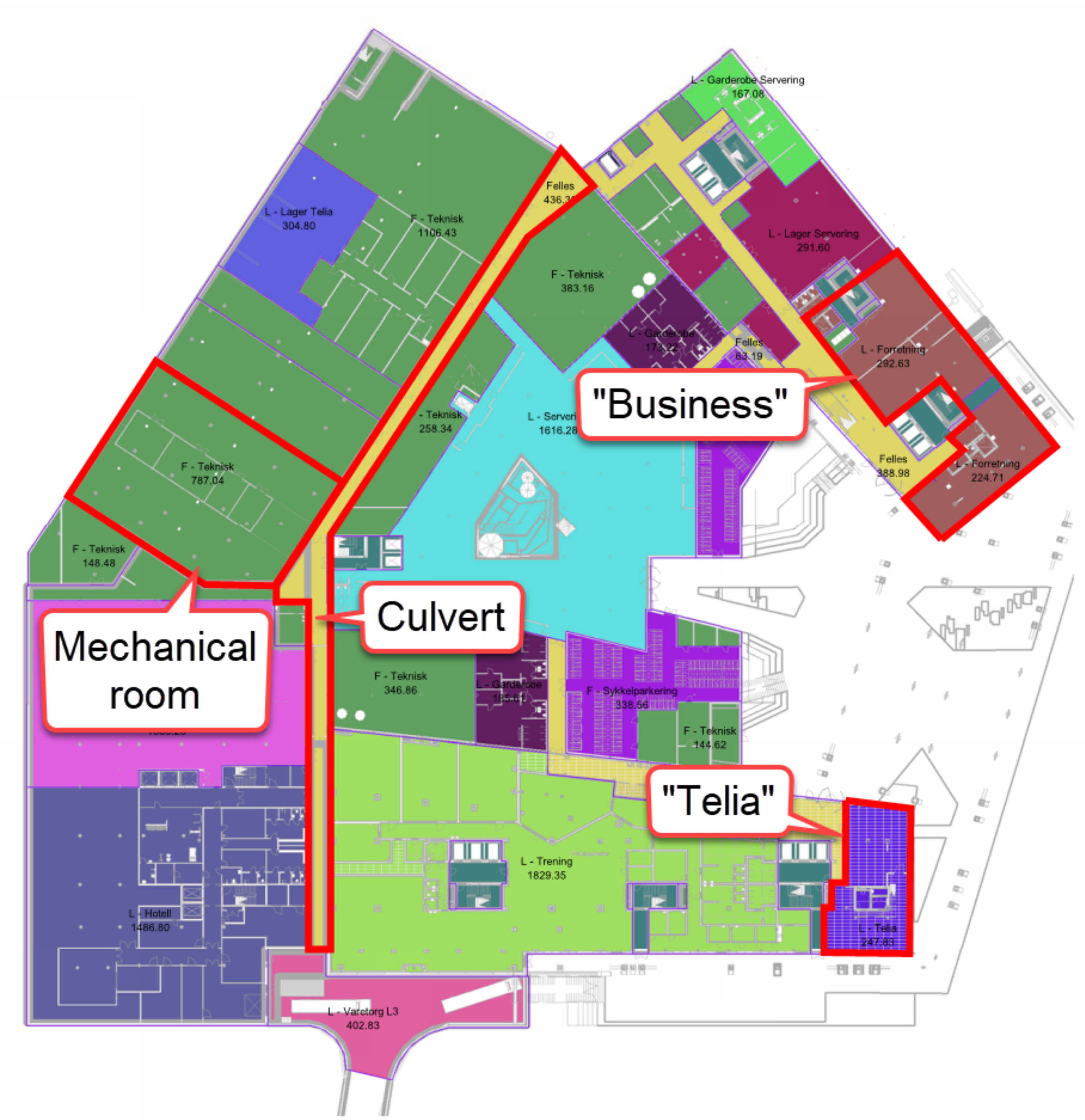


Figure 3-2: Overview of level 1 and areas included in the report..

4 PIPE QUALITIES AND FEATURES

In the following chapters, the various relevant pipe qualities in the project are briefly described.

4.1 Pipe types

4.1.1 Blue Pipe

The Aquatherm Blue Pipe piping system is made of polypropylene (PP-R) and is used in comfort cooling, industrial cooling and heating. The tubes are fiberglass reinforced, which limits the length extension as a result of temperature changes. The expansion is approximately equal to the that of metal tubes to according Armaturjonsson. Due to wall thickness and thermal conductivity, the insulation requirement is lower than for metal pipes. Blue Pipe is corrosive resistant, which has a positive effect on its lifetime. The service life is stated to be 50-100 years. The pipes also have a lower noise level than metal pipes.

The Blue Pipe piping system is made in two series, with and without oxygen barrier named OT. Blue Pipe OT is used in applications that require oxygen barrier, such as high temperature heating systems. Armaturjonsson states that Blue pipe is well suited for use in heating systems and can be used to any extent where conventional steel pipes and alupex would have been used. For systems with temperatures above 40 degrees, Blue pipe OT must be used.

4.1.2 Green Pipe

The Aquaterm Green Pipe piping system is primarily used for consumable water. The tubes are made of polypropylene (PP-R), which does not react with water. This prevents leakage, corrosion, expansion and erosion. Due to wall thickness and thermal conductivity, the insulation requirement is lower than for metal pipes. Green pipe is corrosive resistant, which has a positive effect on the service life. The service life is stated to be 50-100 years.

4.1.3 Steel pipes

For steel pipes there are several different qualities and designs. Stainless and acid-resistant steel pipes are steel pipes with added alloy to achieve new properties. Joint methods for both are typically press fittings below 54mm and welded joints above 54mm. The list below shows some typical qualities of steel pipes.

- Steel pipes are carbon steel pipes. Typical joining method are so-called weld joints. The pipes are not stainless. Typical applications in buildings are heating systems and sprinklers, as well as cooling systems with temperatures higher than dew point (non-condensing).
- AISI 304 stainless steel pipes are also known as 18/8 due to the addition of 18% chromium and 8% nickel. Such trust-free pipes are not selected in this project.
- AISI 316 acid resistant steel pipes contain chromium and nickel, as well as molybdenum. Its composition makes it more resistant to corrosion than AISI 304, but it is also more expensive. Acid-resistant steel pipes are used in the food industry and are also used on hot

water circulation, hot water above DN50 and in mechanical rooms for technical cooling. For consumable water, welded acid-resistant steel pipes (AISI316) have been selected in the mechanical room.

4.1.4 Copper pipes

Copper pipes are suitable for all freshwater applications. Copper provides versatility and is characterized by good ductility as well as good processing properties. Copper pipes are available in many dimensions, where the typical for building applications today are diameters from 10-12 mm up to 54 mm. Chromed copper pipes are often used for visible piping, but they also come as semi-hard plastic coiled tubes on coils and as full lengths in hard version. The jointing methods vary from pressure fittings and clamping rings, to soft soldering and hard soldering / impact soldering. Copper is a limited resource and its use should be minimized. Priority should be given to recycled copper.

4.1.5 Alupex

Several suppliers offer relatively similar alupex products with a few different properties and internal pipe diameters. The tubes consist of several layers; aluminum (Al), polyethylene (PE) and cross-linked polyethylene (PEX). Each supplier can have their unique plastic mix. The pipes are interconnected with various patent connections and are supplied as system pipes with associated parts. The pipes are malleable up to a certain dimension and have relatively low intrinsic weight compared to metal pipes. Available in coils and as full lengths, pre-insulated and without insulation.

4.2 Clamping of pipes

Armaturson's products generally require more clamping than steel. In this project, a clamping distance of 210 cm for Blue pipe and 500 cm for steel pipe has been chosen for DN100. For long stretches this means a 2.4 times greater need for clamping. Since short stretches and bends have to be clamped anyway, the difference will be somewhat lower overall. In project Økern Portal, iso clamps for steel pipes and kombi/kruge with damping rubber for Blue pipe have been chosen. Increased clamping will result in increased GHG emissions, but due to limited scope of work, this is not included in this report.

4.3 Insulation of pipes

Green Pipe and Blue Pipe are made of plastic and have lower thermal conductivity than metal pipes. This means that the pipes can be insulated with a thinner layer of insulation than metal pipes. But Blue pipe has thicker thicknesses than similar steel pipes, which means that a larger surface must be covered with insulation. An example of this is shown in Table 4 6, which shows that Blue pipe has 10.7 mm larger diameter than corresponding steel pipes in DN100. Therefore, there is no basis for deciding whether Blue pipe causes more or less insulation and GHG emissions than the alternatives, without making a detailed calculation of this. Due to the limited scope of the work, this is not included in this report.

4.4 Mounting

Blue pipe and Green pipe have a significantly lower weight than the conventional alternatives. This makes transport and assembly of pipes easier. One of the reasons why these products are chosen is the advantage of ease of installation. The table below shows an example for steel pipes and Blue pipe in DN 100.

Table 4-1: Pipe data for Blue pipe and steel pipes in DN100

	Dim.	Outer diameter [mm]	Density [kg/m]	Thickness [mm]	Type
Blue pipe	DN100	125	4,13	11,4	SDR 11
Seamless steel pipe	DN100	114,3	12,1	4,5	Pressure class 4

The example in Table 4-6 shows that the weight of the Blue pipe in DN 100 constitutes only 34% of the corresponding steel pipes. Acid-resistant steel pipes are somewhat lighter than Blue pipe and for DN 100 these are about 4 kg per meter, but these are also expensive and will therefore only be used where acid-resistant pipes are needed.

Green and Blue pipe in dimensions from 20 mm to 125 mm can be joined with fusion welding. The pipe system can also be welded with electrical sleeves in dimensions up to and including 250 mm for Blue pipe and 125 mm for Blue pipe OT. Dimensions from 160 mm onwards can be welded with a welding machine.

Becaouse the Aquatherm pipes are delivered in shorter lengths than metal pipes, which results in an extra amount of cut. It is assumed that increased cutting constitutes a small proportion of the total amount compared to metal pipes. The differences in the amount of races are therefore chosen to be neglected.

4.5 Selected pipe types

In the project Økern Portal, it has been decided to use Blue pipe in parts of the cooling system, which consists of comfort cooling piping with chilled beams and technical cooling piping with fan coil units. Green pipe is used in large parts of the consumable water system. The pipe types are used up to and including dimension Ø125.

Potentially, Blue pipe and Green pipe could have been used in larger parts of the cooling and consumable water system. Blue pipe could also have been used in the heating system, which consists of radiator piping, piping for hot air outlet, floor heating and heating batteries in ventilation units.

Table 4-2 to Table 4-6 below shows which pipe types are selected for comfort cooling, technical cooling, consumable water, floor heating and other heating respectively. The tables also show any conventional alternatives in metal and plastic from Aquatherm. For comfort cooling and technical cooling, the distribution network at each floor is defined as piping from shafts, up to the last branch before any equipment. Connection to chilled beams are made in PEX. For consumable water, the distribution network at each floor is defined as piping from shaft to solenoid valve before manifold cabinet.

Some of the pipe choices are made due to different supply and return temperatures for the different systems. For high temperatures, the material must be heat resistant and plastic tubes must have an oxygen barrier. Low temperatures cause condensation problems that must be considered, both in the choice of pipe quality and the associated insulation. Technical cooling and ventilation rate have a supply/return temperature of 10/17 °C, which is lower than for comfort cooling with 15/18 °C for chilled beams. Floor heating has a supply/return temperature of 35/30 °C. Ventilation heating, air outlets and radiators all have a supply temperature of 50 °C and a return temperature of 30 or 40 °C. In the heat exchanger, it is assumed that the temperature will not exceed 55 °C.

Table 4-2: Comfort cooling (chilled beam) – current pipe types.

System part	Current pipe types	Conventional alternatives	Aquatherm alternative
Distribution network	Blue pipe	Steel pipes or stainless steel and acid resistant steel	
Main piping and risers	Steel tube for chilled beam piping Acid resistant for ventilation piping		Blue pipe
Mechanical room	Acid resistant steel		Blue pipe

Table 4-3: Technical cooling (fan coil units) – current pipe types

System part	Current pipe types	Conventional alt.	Aquatherm alt.
Distribution network	Blue pipe	Acid resistant steel	
Main piping and risers	Blue pipe	Acid resistant steel	
Mechanical room	Syrefast stål		Blue pipe

Table 4-4: Consumable water (hot, cold and circulation) – current types

System part	Current pipe types	Conventional alt.	Aquatherm alt.
Distribution network	Green pipe	Copper pipes	
Visible piping	Copper pipes		Green pipe
Main piping and risers	Green pipe	Copper pipes	
Mechanical room	Acid resistant steel		Green pipe

Table 4-5: Heating (floor heating) – current pipe types

System part	Current pipe types	Conventional alt.	Aquatherm alt.
Distribution network	Alupex		Blue pipe
Main piping and risers	seamless steel pipes		Blue pipe
Mechanical room	seamless steel pipes		Blue pipe

Table 4-6: Heating (radiators, hot air outlet, ventilation and mechanical room) – current pipe types

System part	Current pipe types	Conventional alt.	Aquatherm alt.
Distribution network	Alupex		Blue pipe OT
Main piping and risers	seamless steel pipes		Blue pipe OT
Mechanical room	seamless steel pipes		Blue pipe OT

5 METHOD OF CALCULATIONS

Lifecycle analysis (LCA) is a methodology for systematically assessing all processes that follow a product from extraction of raw materials to final disposal of waste. This is also commonly referred to as cradle-to-grave. Such an analysis can assess different types of environmental impact but is typically used to assess GHG emissions for a product/material related to the entire material's life cycle.

NS 3720 Method for calculating greenhouse gas from buildings specifies the guidelines for the preparation of greenhouse gas calculations from buildings and parts of buildings. GHG emissions throughout the life cycle are linearly organized into modules from A to D (Figure 5-1). The greenhouse gas calculation system boundaries define which modules (parts of the life cycle) are included in the individual calculation, and are related to the purpose of the calculation. Where the purpose is to form the basis for assessment for different choice of materials, modules A1-A5, B1-B5 and C1-C4 and possibly D is included.

Product Stage			Construction stage		Use stage					End-of-Life Stage				Next Product System
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
Raw materials supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction	Transport	Waste processing	Disposal	Reuse, recovery or recycling potential

Figure 5-1: Life cycle stages for building life as modules

Greenhouse gas calculations for materials are made on the basis of the materials' third-party certified environmental declarations (EPDs), or if they are not available - using generic data, average data or otherwise representative data.

All calculations have been prepared as CO_2 equivalents (GWP) per meter of pipe. Due to limited data for technical systems, the greenhouse gas calculation is limited to the production phase for the pipe types included in the report, known as "cradle-to-port" (A1-A3).

Pipe systems include more than the pipes themselves, such as bends, tees, transitions, clamps, seals and adhesives. Therefore, an EPD should include supplements that will be required for a complete piping system. These parts are included to varying degrees for all environmental declarations included in this data base, see section **Feil! Fant ikke referansekilden.**.

As the environmental declarations only specify pipe stretches, bends and other parts are converted into longitudinal meters in accordance with Norwegian measurement rules. It is assumed that energy consumption and GHG emissions associated with making bends and other parts are greater than what the mass-equivalent pipe length it corresponds to. This conversion causes some uncertainty, but this will apply to all pipe types compared in this report.

5.1 Emission calculation software

The greenhouse gas calculations have been carried out with *Erichsen & Horgen's* internally developed calculation tools for greenhouse gases associated with HVAC and building services. Input in the tool is material extraction from Revit. Based on Environmental Declarations and other available emission figures, GHG emissions are calculated for the various system parts. The tool uses GWP values per meter of pipe. The value is adapted to different pipe dimensions, so that it gives the correct calculations for different thicknesses of piping.

6 DATA

6.1 Area

The Table 6-1 below shows areas for all buildings divided according to their respective levels. GHG emissions for the office and business premises in building A, B and C are calculated based on a scaling of emissions per gross area in Telia's premises in level 4. For all areas other than Telia's areas, a third of Blue pipe 25mm pipes is deducted. This is because it is prepared for several cooling beams in Telia's premises, which entails more piping of this dimension.
For levels 1 and 2, areas under the name "L - Business" are included under "not leased area".
For rented areas in level 6, the area "Telia option" is included.

Table 6-1: Gross area for office and commercial premises

Level	Not leased area [m2]	Leased area (Telia) [m2]
01	518	248
02	784	1113
03	2019	3998
04	1710	4007
05	1751	3997
06	2002	3997
07	4937	-
08	3651	-
09	2250	-
10	687	-

6.2 Environmental data

There are varying degrees of environmental declarations (EPDs) for the pipe grades included in this report. The following sections describe the data base used in the calculations for the various pipe grades.

All environmental documentation, except Aquatherm, includes major parts of the product life cycle. Because Aquatherm's EPD is limited to A1-A3, this is set as a system boundary for the metal pipes as well.

EPDs for steel pipes and copper are obtained from EPD-Norway and IBU-EPD, respectively, which are both certified and recognized system operators. The other environmental declarations have been received at the request of the respective owner.

Plastic piping Aquatherm
For Aquatherm, a joint collection EPD has been used for five different pipe grades. This includes the products Green, Blue, Lilac, Red and Black Pipe. These are all made of PP-R plastic, but with different composition and dimensions to achieve desired properties. The greenhouse gas data in this EPD is thus an average for all grades. The declaration includes

modules A1-A3 (cradle to port) and therefore these three modules have been selected as system boundaries for this entire analysis.

Steel pipes
For metal pipes in general, environmental documentation is basically marginal. Therefore, for reasons of data quality, it has been chosen to use FeRROMETALL's EPD for untreated steel pipes as a starting point. It is important to point out that since this EPD is not specific to building pipes, it will not include additional materials and parts needed in a building pipe system. The values for GHG emissions are quality assured against figures for stainless steel pipes in the Oneclick LCA tool. The numbers correlate in magnitude and indicate that they are based on a representative data base.

Copper pipes
For copper pipes, Weiland Werke AG's EPD for copper pipes is used. This is a product specific EPD for copper pipes for building purposes and includes additional materials and clamps.

Alupex
For multi-layered polymer and aluminium (alupex) pipe systems, Teppfa's generic LCA declaration has been chosen as a starting point. This compares the environmental impact of alupex and copper.

7 RESULTS

This chapter presents calculated GHG emissions for pipes in the Økern Portal project. The three sub-chapters 7.1, 7.2 and 7.3 contain results for plan 4, for mechanical room and culvert respectively, and in total for a larger part of the building.

For all three sections, GHG emissions are calculated for three scenarios:

- **"Conventional":** GHG emissions if the projected Blue pipe and Green pipe pipes are replaced with conventional metal pipe qualities.
- **"Selected":** GHG emissions for pipe types selected in the project and projected in the model.
- **"Extended":** GHG emissions if Blue pipe and Green pipe are used in all system parts where Armaturjonsson states that they are suitable

7.1 Office areas level 4

In this subchapter, GHG emissions for pipes are presented in the completed projected part of level 4. The results are presented in subsequent tables and figures.

Table 7-1: GHG emissions for level 4, building A and B, by building part and scenario.

Greenhouse gas [tonn CO_2-ekv.]					
Building part	**Conventional**	**Selected**		**Extended**	
	Emissions	Emissions	Reduction	Emissions	Reduction
31 Sanitary	1,9	1,9	2 %	1,8	4 %
32 Heating	2,7	2,7	0 %	1,5	44 %
37 Comfort cooling	25,6	10,7	58 %	7,7	70 %
Total	**30,3**	**15,3**	**49 %**	**11,0**	**64 %**

GHG emissions related to comfort cooling are significantly higher than for sanitary and heating, accounting for 70% of the total emissions for level 4. The main reason for this is that the pipe dimensions for consumable water and heat are substantially smaller than for the chilled beam piping. This is because the liquid in the chilled beam piping has a low temperature difference both for supply and return temperature and compared to room temperature, which means that it needs a relatively large amount of liquid to achieve the desired cooling effect.

Figure 7-1 shows a graphical representation of the results for the office premises in plan 4.

Table 7-2 below shows GHG emissions as a ratio per area. These figures are intended for possible future comparison with other projects and other choices of pipe grades.

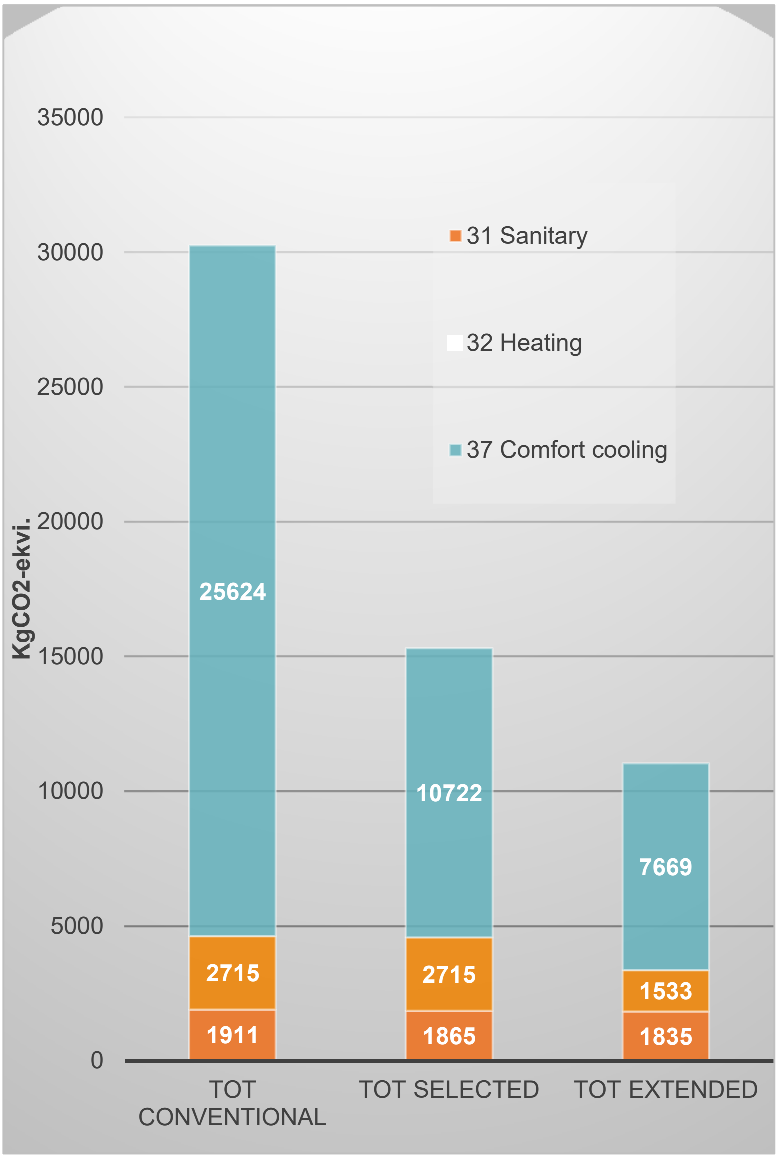


Figure 7-1: GHG emissions for plan 4, building A and B, by building part and scenario.

Table 7-2: GHG emissions per area for conventional, selected and potential pipe types.

Greenhous gas [kg CO_2-ekv./m^2]		
Conventional	**Selected**	**Extended**
5,3	2,7	1,9

Mechanical room and culvertFeil! Fant ikke referansekilden.This section presents GHG emissions for pipes in the mechanical room and culverts, based on material extraction from the Revit model.

Table 7-3: GHG emissions for mechanical room and culverts, by building part and scenario.

Greenhouse gas [tonn CO_2-ekv.]					
Building part	**Conventional**	**Selected**		**Extended**	
	Emissions	Emissions	Reduction	Emissions	Emissions
31 Sanitary	3,2	2,6	19 %	2,6	19 %
32 Heating	9,2	9,2	0 %	2,5	73 %
37 Comfort cooling	96,8	88,4	9 %	32,9	66 %
Total	**109.1**	**100,1**	**8 %**	**38,0**	**65 %**

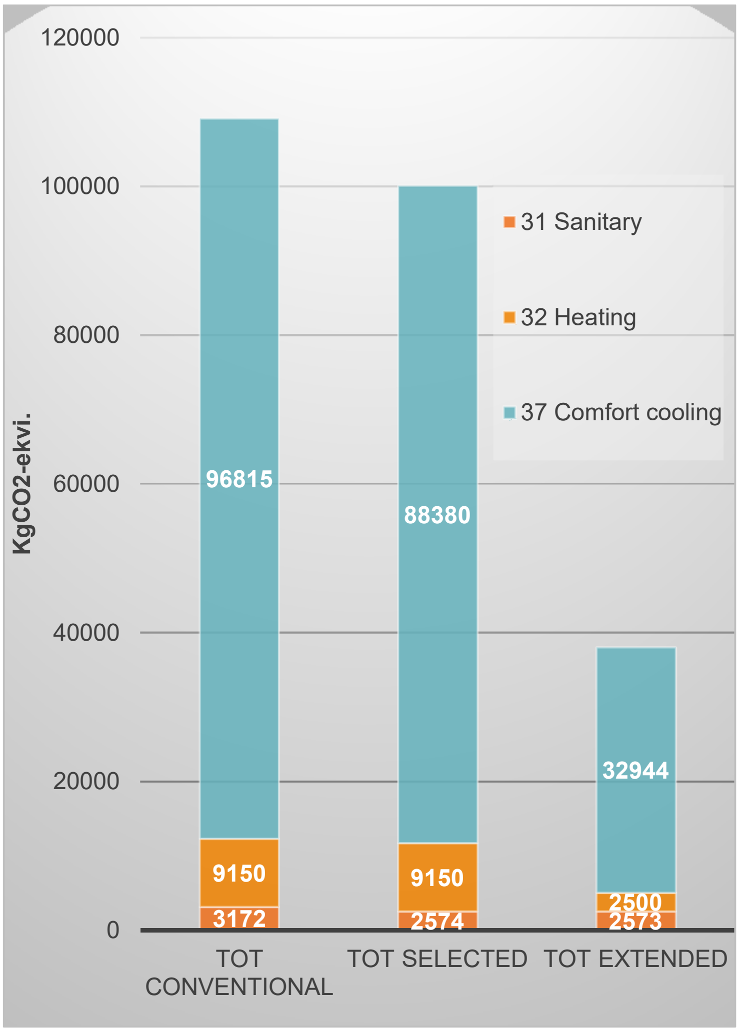


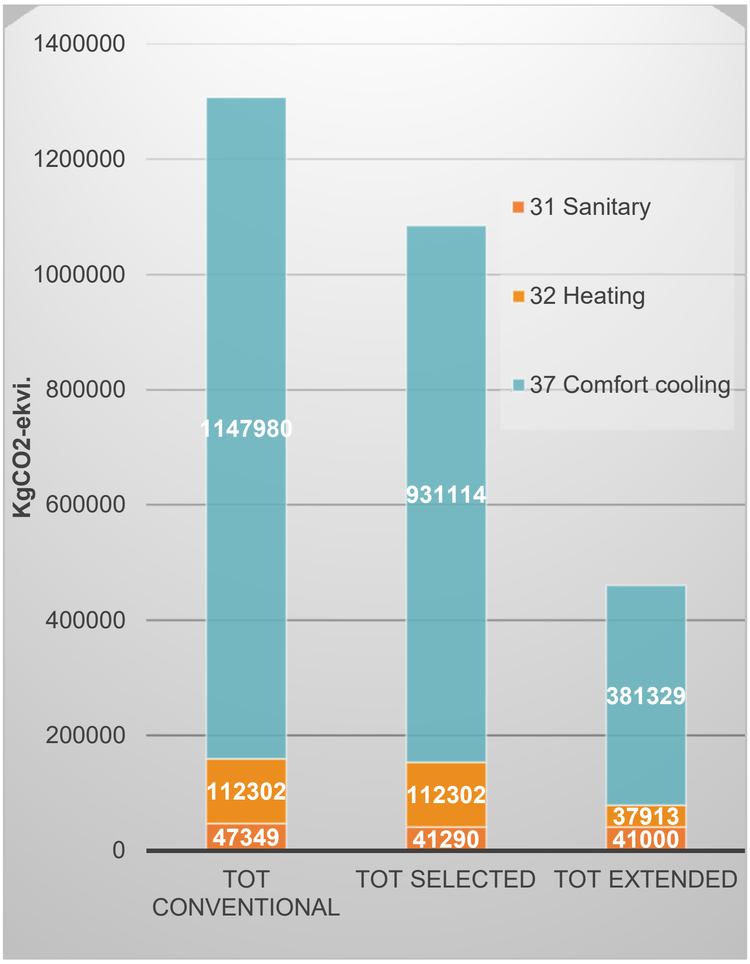
Figure 7-1: GHG emissions for mechanical room and culverts, by building part and scenario

7.2 Building A, B, C, mechanical room and culvert

In this sub-chapter, total GHG emissions for all included areas are presented. The emissions for level 4 are scaled up for building A-C, and summed with emissions for mechanical room and culverts.

Table 7-4: GHG emissions for building A, B, C, mechanical room and culvert, by building part and scenario.

Greenhouse gas [tonn CO_2-ekv.]					
Building part	**Conventional**	**Selected**		**Extended**	
	Emissions	Emissions	Reduction	Emissions	Emissions
31 Sanitary	47,3	41,3	13 %	41,0	13 %
32 Heating	112,3	112,3	0 %	37,9	66 %
37 Comfort cooling	1148,0	931,1	19 %	381,3	67 %
Total	**1307,6**	**1084,7**	**17 %**	**460,2**	**65 %**



Figur 7-2: GHG emissions for building A, B, C, mechanical room and culvert, by building part and scenario.

8 DISCUSION

The greenhouse gas calculations are limited to the production phase A1-A3. This is done because Aquatherm's environmental documentation is limited to the mentioned modules. This means that factors such as service life, recycling rate and mounting extra such as clamps are not included. In general, environmental declarations for different types of pipes show that GHG emissions from the production phase constitute by far the largest proportion of emissions during the life cycle of the products. This is due to energy-intensive raw material extraction and processing. Therefore, it is reasonable to argue that the result of the greenhouse gas calculations and the size ratios of the emissions from the various pipe types are also representative of the entire life cycle. If the calculations had been extended, it is reasonable to assume that GHG emissions will increase to varying degrees, but that this will not have a major impact on the total.

Armatujonsson states that Blue Pipe and Green Pipe have a long life due to low corrosivity. This report does not assess the extent to which the stated lifetime is correct, but there are grounds for assuming a longer life for the plastic pipes than for metal pipes in general. Lifetime is therefore a factor that may have a positive impact on GHG emissions for Blue pipe and Green pipe, but this is not documented in the current environmental declaration from Aquatherm and therefore cannot be included.

There is a great deal of uncertainty about what happens when disposing of both plastic and metal pipes. It is not known how much is reused in other projects, recycled, incinerated or landfilled. The biggest challenge seems to be related to a lack of return schemes and opportunities for material recycling in Norway. For environmental reasons, a greater focus should be placed on the industry and the authorities for reuse and recycling.

Clamps are installed more frequently for Blue pipe and Green Pipe, than is done for the alternatives in metal. This is a factor that will cause an increase in GHG emissions through the use of plastic pipes and reduce the difference to metal alternatives. It is assumed that the excess weight and GHG emissions associated with more frequent clamping are smaller than what the pipes themselves constitute and that this does therefor not affect the conclusion about lower emissions for the plastic pipes.

Varying quality of environmental declarations and greenhouse gas documentation leads to uncertainty. Generally, it is observed that generic emission figures are often higher than stated in product specific EPDs. This may mean that the difference in emissions between plastic pipes and steel pipes may be smaller, but until better documentation from the industry is available, the results in this report must be used.

9 PROPOSAL FOR FURTHER WORK

- Greenhouse gas estimation for pipes throughout the whole building when it is completed.
- Overall assessment of GHG emissions, which includes insulation, clinging and cutting.
- Extended calculation of GHG emissions to include the stated lifetime.
- Assessment of the extent to which pipes are recycled, material recycled, sent to incineration plants or landfilled, and what opportunities and potentials exist.
- Utilization of the cuttings.

10 CONCLUSION

Documentation of GHG emissions is relatively new for the HVAC and building service industry. The quality of available environmental declarations and emission data varies widely. The calculations in this report are made only for the production phase for the pipes, but this is also the phase where emissions are generally the greatest. It is therefore reasonable to assume that the magnitude of differences in emissions is transferable to a full life cycle. The calculations made in this report are the best estimates possible with today's data, until better documentation is obtained.

The GHG calculations indicate that there are significantly lower GHG emissions for Blue Pipe and Green Pipe, compared to conventional metal pipe types. For the project Økern Portal, Blue and Green Pipe are chosen for parts of the piping systems, which gives an estimated total savings of 17%, corresponding to 223 tonnes of CO_2 equivalents. The difference is greatest for offices and commercial premises, where the reduction is 49%, compared to conventional pipe types in metal. For the mechanical room and culverts, the saving is 8%. The main reason for this is that Blue and Green pipe are largely chosen for small dimensions at other floors.

Potentially, the project could have saved 847 tonnes of CO2 equivalents, compared with the use of conventional pipe types. The saving corresponds to an emission cut of 65% and assumes that Blue Pipe and Green Pipe are chosen for all system parts where the supplier states that they are suitable. The potential for savings is roughly the same for the office and business sector and for the mechanical room and culvert.

GHG emissions for cooling pipes represent by far the largest proportion of the total, and consequently also the greatest potential for savings in GHG emissions. For conventional pipe grades, cooling accounts for 88% of emissions. The main reasons for this are that local cooling has been chosen in the tenant areas and that low temperature difference results in large pipe dimensions. For Økern Portal and other projects with similar cooling solutions, it will therefore be an especially effective environmental measure to choose pipe types with low GHG emissions for comfort cooling.

Clamps are used with smaller gaps for Blue Pipe and Green Pipe, than what is done for the alternatives in metal. This factor will increase GHG emissions associated to use of the plastic pipes and reduce the difference to metal alternatives. Lifetime is a factor that can have a positive impact on the GHG emissions for Blue Pipe and Green Pipe, but this is not documented in Aquatherm's environmental declaration.

It is important to point out that the results of the greenhouse gas calculations should be included as part of an overall assessment with other environmental considerations and factors such as fire, installation, quality and price. There is a great deal of uncertainty about what happens to the pipes at disposal, both for plastic pipes and metal pipes. It is not known how much reused in other projects, recycled, incinerated or landfilled.