ENERGI FÖRETAGEN

Date
2023-09-22

Consequences of proposal for a restriction of PFAS for district heating and cooling

Swedenergy collects and gives voice to around 400 companies that produce, distribute, sell and store energy. Our goal is to develop the energy industry – for the benefit of all, based on knowledge, an overall view of the energy system and in cooperation with our environment.

Summary

Swedenergy

- supports ECHA's and the EU- commission's ambition on ban of PFAS classified substances. Swedenergy agrees that the use of toxic PFAS substances must be minimized and in the long run completely phased out. Only applications that lack viable technical and economical alternatives, and are critical to society, shall be permitted in a transitional period.
- suggests that for essential industrial use of long-life products and solutions the legislation must focus on how to minimize and eliminate the environment and health impacts by avoiding, collecting, and destruction of leakages.
- believes that the capacity of the industry to provide alternatives must be assessed before phase-out of equipment and components in energy sector. To avoid adverse effects on the energy system, a proportionate legislation is needed. Considering technology and market situation there is need of a reassessment of the proposal as well as assessment of derogation needs. Ban on specific components must have a holistic view and the impacts on climate, environment, air pollution, circular economy and use of material must be considered regarding the life cycle of the installations and plants and the alternative solutions. It is not reasonable to demolish substantial investments with long lifetime due to lack of small but essential components. The impact of legislation in relation to the objective of EU's decarbonisation strategy, circular economy, renewable energy, phase-out of fossil energy, etc must be evaluated.
- opposes the timeline for a ban on PFAS classified F-gases that are used in district heating and cooling, as there is currently no technological or economical viable alternative available on the market, able to deliver near

Energiföretagen Sverige
101 53 Stockholm, Besöksadress: Olof Palmes Gata 31
Tel: 08-677 25 00, E-post: info@energiforetagen.se, www.energiforetagen.se
Org. nr: 802000-7590, Säte: Stockholm

100% availability and the temperature ranges needed in Swedish and Nordic district heating networks.

- believes that future large-scale heat pump installations and chillers in district heating and cooling should be built with natural or other sustainable refrigerants, but more research and development are necessary to make this happen.
- suggests, due to the non-existence of technically and economically feasible alternatives, a 12-year derogation followed by an independent review and a possible prolongment, for new heat pump installations, in order not to slow down the transition away from fossil heating and cooling in Europe.
- proposes that derogation permits must be granted and supervised by a competent authority and renewed every five years, on the condition that there is sufficient evidence that drop-in alternative solutions are not available during the derogation period.
- argues for a level playing field in the heating and cooling market. For existing heating and cooling installations, we consider the proposed 12 years derogation for "*Maintenance and refilling of existing HVACR equipment put on the market before [18 months after EiF] and for which no drop-in alternatives exist*" as a minimum derogation period. Most industrial installations have up to 60 years lifetime and replacing them too early will have negative environmental and economic effects for both consumers and society. Instead, we strongly recommend, the derogation period to be extended for the remaining lifetime of existing installations, as long as operators can prove to have a strict customized leakage monitoring systems for refrigerants is in place to avoid PFAS leakages from district heating and cooling installations.

Seen from a socio-economic perspective, Swedenergy believes that measures for the phase out of PFAS should primarily and in the shorter term be aimed at the industries and areas that account for the largest leakage and emissions. For the reasons listed above, the energy sector needs a sufficiently long adjustment period to have the opportunity to reach the climate goals in a sustainable way while harmful substances such as PFAS are being phased out.

Background

The authorities in Sweden, Denmark, Norway, Germany, and the Netherlands have developed a joint and broad restriction proposal for PFAS within the EU/EEA under the European REACH regulations. According to the proposal the use of PFAS substances must be minimized and in the long run completely stopped. Only uses that lack alternatives and are critical to society shall be permitted. A broad restriction of PFAS is expected to enter into force in 2025 at the earliest.

Three proposals are being discussed, partly a full ban after 18 months or an alternative with a phase-out over a longer period (5 or 12 years) with transitional rules. The ban covers PFAS occurring as a single substance, as components of another substance, or as a mixture in a product. As a consequence of the proposal, the presence of PFAS in many applications for electricity grids,

production of electricity as well as common refrigerants in district heating and cooling, with both high and low GWP, would be banned.

Swedenergy believes that a holistic approach must be adopted to not to risk the objectives of European decarbonisation and circular economy strategy and Swedish security of supply. Below we also highlight the effects of a quick ban on the use of industrial heat pumps and chillers as well as on the electricity grids and the production of electricity.

Differentiate between compounds, applications and impacts

The proposed PFAS restriction must differentiate between unnecessary PFAS use with large emissions (non-essential and short-lived products and applications), versus essential industrial use of long-life products and solutions with low emissions. The restriction should also differentiate between PFAS applications for which alternatives already exist and PFAS applications for which there is currently no alternative available and for which specific derogations are needed. This is in line with the article 68 in REACH regulation, which states that any new restriction "must take into account the socio-economic impact, including the availability of alternative solutions".

For essential industrial use of long-life products and solutions assess and legislate how to minimize and eliminate the environment and health impacts by avoiding, collecting, and destruction of leakages.

Assess the capacity of the industry to provide alternatives

An unrestricted ban on PFAS would mean that the energy transition would come to a standstill for some years, at a time when acceleration is necessary. The entire energy sector In Sweden is aware of its responsibility in dealing with PFAS and is already looking for alternative substances to substitute PFAS. In the short term, however, there is no guarantee that products with the necessary technical and safety requirements will be available at large scale. To avoid adverse effects on the energy system, a proportionate legislation is needed. Considering technology and market situation there is need of a reassessment of the proposal as well as assessment of derogation needs.

Furthermore, for all uses that will be derogated, a mechanism should be established to reassess the derogation period if no substitution meeting equivalent safety or production efficiency properties is available within the specified timeframe. Appropriate and adequate transition period must be defined for PFAS-containing installations.

Consider environmental impacts, minimize material use and emissions

Investments in energy industry are often heavy and have long lifetimes (in average 40-60 years). From environmental and health perspective, it is not wise to demolish large industrial facilities due to a lack of small components on the market. For existing installations and or projects, that are approved for installation before the regulation comes into force, consider and asses if there are efficient

and feasible alternatives on the market. The repair and maintenance of operational equipment should be possible in accordance with circular economy and life cycle assessment principles. This would allow the reduction of waste and climate and environmental impacts until the completion of the entire lifespan of the plant or the equipment. The ban should only take effect after substantial repair or renewal of the existing installations, and if alternatives with equivalent technical properties (especially safety properties) are available on the market.

Assess the impact of the regulation in relation to the objective of EU's decarbonisation strategy

In a decarbonized energy economy, security of supply relies on renewable and low carbon electricity, energy storage systems, hydrogen technologies, energy efficiency and use of waste heat. Key components such as new wind turbines, PV installations, thermal and nuclear power plants, electrolysers, hydrogen compressors, transformers, batteries, cables, switchgears, heat pumps, chillers and ORC power systems among other facilities, are vital for this transformation but could be impacted by the proposed restrictions. To ensure the safe operation of essential pieces of equipment and technologies, certain materials containing PFAS are currently used, while there are no feasible alternatives at a significant scale and technological readiness level. Consequently, derogations for the use of PFAS, as well as the ability to repair and maintain existing installations, become indispensable in achieving climate targets and serve as a crucial pillar for a successful energy transition.

Assess the impact of PFAS restriction for articles or mixtures containing PFAS that contribute to facility safety, energy security and production of circular, renewable and low-carbon electricity, heat and cooling.

District heating and cooling

The inclusion in the potential banned list of single component gases, R134a, R143a and the HFOs R1234yf, R1234ze(E), R407C and R410 A, affects nearly all new and current lower GWP HFC/HFO refrigerant blends.

Generally, and in line with the F-gas regulation there is an understanding in our sector that we must not to exceed 150 in GWP-value for new installations but above all, avoid leakage.

Consequences of the ban

Swedish District heating and cooling grids operates normally with a higher temperature (80-90 degrees) than often found elsewhere. Currently, there are no stable and well-functioning alternatives to PFAS based refrigerant blends working within this temperature range.

A heat pump for large-scale production of district heating and cooling has high availability, little refrigerant leakage, is well monitored and has a long lifetime, up to 60 years if well maintained. Over the last decades, Sweden has invested in and

developed robust district heating networks dependent on large-scale heat pumps to make use of excess heat sources, such as waste, sewage, and data centres.

As there are currently no viable alternatives, a potential ban on PFAS based refrigerant blends could jeopardise the last decades' work, by moving more of the heat production towards less efficient and climate friendly fossil and electric boilers. Replacing existing equipment will also lead to large additional costs and could endanger the profitability of district heating companies, who operates with low margins and long horizons when making their investment decisions. Furthermore, it creates obstacles for EU's carbon capture and storage (CCS) industry, as projects in the bioenergy and waste-to-energy sector are planning to capture the excess heat and feed it into the district heating system with the help of industrial-scale heat pumps.

This clearly goes against the recent goals and objectives set by the European Union. The EU's REPower Plan encourages frontloading investments in renewables and energy efficiency to reduce import of fossil fuels as well as doubling the current deployment rates of heat pumps in buildings. It also calls for faster deployment of large heat pumps at district heating and cooling. To make this possible, the EU-commission has announced a Heat Pump Action Plan, which aims to accelerate heat pump deployment and markets in the EU.

Swedenergy are ready to contribute to realizing these goals, but strongly believe that existing infrastructure and investments need to be safeguarded, while working towards minimizing and eliminating any potential leakage of PFAS substances.

Competitive conditions on the heating and cooling markets

Swedenergy will emphasize the need for a level playing field in the heating and cooling market. The proposed unlimited time derogation for heating, ventilation, air conditioning, and refrigeration (HVACR) equipment installed in buildings, will create a market distortion in favour of less societal beneficial and decentralised heating and colling solutions. This must be avoided, and the derogation therefore also needs to be valid for industrial district heating and cooling installations placed both in urban areas and industrial complexes.

Small scale heat pumps (chillers) (<100kW) with scroll compressors and hydrocarbons (Propane) are commercially available with as good performance as HFC/HFO alternatives and no security limitations. However, propane is not a good solution for heat pumps with higher heating capacities where more than 5 kg of propane are needed. There is also risk that use of systems charged with natural refrigerants such as propane may be prevented by national or local building authorities.

Heat pumps that are normally used in commercial heating and comfort cooling by property owners at larger properties in the range of 0.5-2 MW have a shorter lifespan, approximately 15-20 years, a higher leakage risk, lower availability, and a lower cost for the unit.

Heat pumps and chillers in district heating and cooling contributes to a stable electricity balance

When heat pumps are installed at co-generation plants, it is possible to optimise the operation after the market's needs of electricity, heat and cooling which means high total efficiency for production of energy. Besides, the production order of heat and cooling in district heating/cooling contributes to balancing the electricity and energy systems. In district heating and cooling, the heat pumps and sometimes cooling by free cold or absorption pumps are started when low price electricity is available on the market while operation of the heat pump and chiller installed at a building is generally a function of outside temperature.

In case of lower delivery of district heating, the Swedish power balance is weakened by larger electricity use in buildings for heating/cooling and less electricity production from cogeneration plants. Fossil fuelled production facilities and electric boilers are already partially phased out in Swedish power and heating plants, and in many cases, it is not possible to restart them. Most of these plants have already reached their technical lifetime which means that it will probably require extensive investments to extend the lifetime. If these plants cannot be restarted, it probably results in a lack of power, in particular in peak-load demand periods.

Consider environmental and economic impacts of alternative solutions

As Sweden is a cold country, during the past decades we have developed district heating and cooling networks in almost all Swedish cities. More than half of all heating comes from district heating and among multi-family houses the share is around 90 percent. The district heating is almost fossil free (2 percent fossil fuels, 2022). During 2021 Swedish energy companies produced 3,6 TWh district heating from large-scale heat pumps (which corresponds to about 7 percent of the total delivery of Swedish district heating) and 1 TWh district cooling. The total capacity of heat pumps is about 1200 MW. According to our knowledge, other Nordic countries have also done long-term investments on large scale heat pumps and chillers in their district heating and cooling networks during the past decades.

The Swedish large scale heat pumps in district heating upgrade waste heat from sources such as treated wastewater (sewage), data centres, flue gas condensation, geothermal, sea water, and air. Generally, we have more than 100 large scale heat pump installations in the country.

Around 60 percent of the heat pumps were introduced during the 1980s and the rest are mainly installed during 2000-2020. The most common refrigerant used in the heat pumps are R134a, while some installations use R143a, HFOs R1234yf, R1234ze(E), R407C and R410 A. The total use of refrigerants in heat pumps reported to Swedenergy is around 1200 ton.

The Swedish district heating and cooling companies plan to phase out refrigerants with high GWP (Global Warming Potential) in accordance with the F-gas regulation. In accordance with the plan, there has been a transition to refrigerants with lower GWP-value, some of which are also PFAS substances.

A heat pump for large-scale production of district heating and cooling has high availability, little refrigerant leakage, is well monitored and has a long-monitored lifetime, up to 60 years if well maintained. The cost of the unit itself is 0.6-0.8 million euro per MW. If other necessary installations are also included, excluding the building, the cost can be expected to be 1.1-1.2 million euro per MW. A rough estimate is that a replacement of all Swedish heat pumps that today have a PFAS classified refrigerant amounts to 3.0-4.5 billion euro. Replacing these units requires careful analysis before the choice of technology can take place. For instance, one may question if it is better to build a new cogeneration plant and what environmental impacts building of new power plants will have.

A significant part of the industrial heat pumps and chillers is designed with a lifespan over 60 years, given that the same refrigerant could be used. For existing installations and or projects that are approved for installation before the regulation comes into force consider and asses if there are efficient and feasible alternatives on the market. This would allow the reduction of waste, and climate and environmental impacts until the completion of the entire lifespan of the plant or the equipment. Currently, there are no feasible alternatives for high temperature heat pumps.

Not always feasible to replace with natural refrigerants

Most of the solutions for the high temperature markets (supply temperature 80-90°C or higher temperatures) are designed to use a Hydro Fluoro Olefines (HFO) refrigerant which belongs to the PFAS family. Industrial high-temperature heat pumps are crucial for the decarbonisation of industry and district heating, special refrigerants called (HFO) have been developed to replace refrigerants according to the F-Gas Regulation. These HFOs allow high temperature ranges combined with a high efficiency. They are not ozone-depleting, have a very low GWP and a good flammability and explosion protection. Many of these HFO-based heat pumps with a lifetime of 60 years have been recently installed or are in installation.

For heat pumps providing heat at high or very high level (around 80-90°C), alternative commercial refrigerants (natural or other alternatives) to HFO are still non-existent. Because the heat pumps are constructed according to the refrigerants' physical properties, the revamping of the heat pump to use natural refrigerants is not possible. From a holistic point of view when considering environmental impacts and circular economy it is better to operate these heat pumps until the end of their lifetime. It is also very important to ensure that alternative products for this temperature range are available over time on the market.

Prevention of leakage by high performance monitoring system

For the existing district heating and cooling plants, we oppose the timeline for a ban on PFAS classified F-gases, for which there is no alternative available on the market. Instead, we suggest the strictest customized monitoring system to avoid leakage. Both small and large leakages must be quickly identified and stopped.

There are already technical solutions to minimise emissions into the atmosphere. The leakage of F-gases constitutes around 0.5 percent of climate emissions from the Swedish district heating which is around 50g CO_2equivalent per kWh delivered district heating (2022, including emissions from transport and production of fuels and combustion). We agree that these leakages must be minimised and eliminated.

As there is need of research and development to find natural or sustainable substitutes to the PFAS classified F-gases, it is required to ensure future solutions with natural refrigerants while guarantee operation of existing installations corresponding to the remaining technical and economic depreciation periods of the existing installations in district heating and cooling. Therefore, we argue that it is better to guarantee the lifetime of investments that are already commissioned, conditioned that a strict monitoring system must be installed to avoid leakage. That in combination with 24/7 staffing control that can quickly attend, alternatively the system transfers the remaining refrigerant into a separate container. This kind of highly developed monitoring system is already used in some of the Swedish plants that use F-gases.

Swedenergy suggests that it is better to guarantee the lifetime of investments that are already commissioned, conditioned that the strictest monitoring system must be installed to avoid leakage.

For existing installations in district heating and cooling, we suggest a derogation at least 12-years and at maximum the remaining lifetime of the installation conditioned that there is sufficient evidence that alternative feasible solutions are not available during the time for derogation. Swedenergy proposes that derogation permits must be granted and supervised by a competent authority and renewed every five year, on the condition that there is sufficient evidence that drop-in alternative solutions are not available during the derogation period.

Climate impact of early phase-out of PFAS classified F-gases

Sweden has ambitious plans to be not only fossil free but also to become a climate negative nation during the coming 20 years. The energy sector is almost fossil free (less than 2 percent fossil fuels is left) but aim to help other sectors to be fossil free, among others transports and industries. Only the two mentioned sectors, together, constitute around 65 percent of Swedish climate emissions. For that reason, electricity production and use will increase rapidly in Sweden. According to different scenarios electricity production has to be doubled during the coming 20 years. In practice, phasing out a significant part of the heat production and replacing it with other production is difficult to implement. Besides need of new investments, there are other obstacles such as decline of COP due to change of the refrigerant (if there are any alternatives).

The use of heat pumps and chillers in Swedish district heating and cooling is significant to meet net zero emissions of greenhouse gases as it reduces demand on fossil fuels. A premature phase out of PFAS classified F-gases in district heat and cooling will not only decrease the potential use of waste heat but in short

term the district heating companies might use more fossil fuels which thereby will increase the climate emissions from the energy sector. In longer term, it´s most likely that district heating and cooling companies will try to store the refrigerants to get by for a few years and thereafter drive more with electric boilers or more bio-oil, if it is possible to get hold of, which could be better used for other applications. Right now, there is no alternative refrigerant for high temperature heat pumps on the market, which is an important prerequisite for the cold climate in the Sweden and other Nordic countries.

In the energy sector, intensive work is underway to change energy production for reduced climate impact, where existing phase-out requirements according to the F-gas regulation for refrigerants are considered. Seen from a socio-economic perspective, Swedenergy therefore believes that measures for the phase out of PFAS should primarily and in the shorter term be aimed at the industries and areas of the use that account for the largest refrigerant leakage and emissions. For the reasons listed above, the energy sector needs a sufficiently long adjustment period to have the opportunity to reach the climate goals in a sustainable way while harmful substances such as PFAS are being phased out.

National and local environmental and health requirements

As DHC is an energy solution particularly for urban areas, production sites are in many cases very close to where people live and work. Therefore, safety is one of the key priorities alongside sustainability for district heating companies.

National and local requirements will follow EU directives. What is unclear is how the fire protection authority and others will deal with having large amounts of flammable and sometimes explosive refrigerants near housing and premises. It is currently unclear what measures will be required to prevent fire and explosions from spreading to surrounding buildings and what this may cost.

Market impact of a rapid phase out for district heating and cooling

The energy customers that apply different environmental certifications that have refrigerants as rating criteria (such as LEED, BREEAM, etc.) will follow the legislation, which means that the energy companies risk losing commercial customers provided that the customer can themselves install heat pumps with renewable refrigerants.

If no equivalent alternative substances are known or if they are not technically proven and/or not available on the market at a relevant scale, a transition period of 12 years must be set in accordance with the ECHA regulations.

Further information on impact of different phase-out scenarios is available under Appendix 1.

Electricity grids and production of electricity

Electricity networks DSOs, TSOs, industry and power stations need long testing periods before the introduction of new products into the network operation. These testing and piloting periods, that are part of the certification process of new

products, are necessary to ensure a reliable and secure system and in some cases are expected to exceed the transition period proposed by the regulation.

A significant part of the electrical equipment in networks is designed with a lifespan over 40 years, given that proper maintenance and repairs are carried out regularly. Very often, spare parts needed must be of the same properties as originally designed, otherwise the technical performance of the whole installation might change. For the security of supply and the continuous expansion of electricity networks, essential for the integration of renewable energy sources, the possibility to repair existing and future installations is of utmost importance. This would also allow the reduction of waste and climate and environmental impacts until the completion of the entire lifespan of the plant or the equipment.

Need of consistent approach with the EU F-GAS Regulation

Fluorinated gases serve as insulating and switching agents in switchgears. While some PFAS-free alternatives exist for gas-insulated electrical switchgear under 145 kV, there are no ready-to-market PFAS-free products available for equipment above 145 kV, particularly for circuit breakers, and development in this voltage range seems limited with physical constraints making market maturity in the next 10-15 years unlikely.

At present, only one manufacturer can supply F-gas-free products to meet European switchgear requirements for the next decade or more regarding high voltage. Competitors have not shown any development strategy for non-PFAS, gas-insulated high-voltage switchgear in the European market.

With the ongoing energy transition to renewable energy and the necessity for substantial grid expansion, it would be an economic and political concern to have just one manufacturer dominate the switchgear market across Europe. There is a risk that this single manufacturer may not be able to meet the demand from all switchgear users in Europe, potentially leading to monopolistic conditions.

It is crucial to adopt a consistent approach with the EU F-GAS Regulation. Banning both SF6 and PFAS would require using solutions that demand physical space often unavailable in electricity distribution substations, especially in urban areas, offshore substations, and offshore converter stations. Derogations are necessary to allow the use of alternative F-gases to replace SF6 in these scenarios.

Set an adequate transition period for PFAS when an adequate alternative exists

PFAS is currently used in production of among others insulation materials, gaskets and coating, circuit breakers, wind turbine generators, nuclear power plants, fuel cells, electrolysers, and manufacturing of semiconductors. In some cases, there are alternative solutions while in many cases there are no alternative solutions on the market. It urges the experts and legislators to investigate extensively the compounds and equipment before deciding the regulatory regime and transitory delays to apply. There is need of an adequate transition period for PFAS when an adequate alternative exists.

Assess impacts on transition of energy production to renewables and EU's decarbonisation strategy

Both lithium-ion and Redox batteries use components with PFAS for their operation. The current PFAS proposal might severely impact the batteries' availability, which are necessary for the ecological transition and the decarbonisation processes of electricity production. At present, no alternative is foreseen to substitute these elements. A transitional period of at least 12 years will allow battery technology to be adapted and is necessary to achieve the ambitious objectives set up by the EU to deploy storage systems especially for production of electricity from renewable sources.

Impact of the proposed PFAS regulation for Organic Rankine Cycle Power systems

Organic Rankine Cycle (ORC) power systems are an emission-free technology suitable for the conversion of thermal energy into electricity, in particular used in the district heating sector. ORC units typically operate locally, utilising heat from waste and combustion of biomass, industrial waste heat and other sources offering low temperature heat in the range of 80-200^{o}C. ORC installations are often in the range 100-1500 kW electricity output. In Europe, industrial waste heat alone has the potential to generate as much as 150 TWh/year of emission-free electricity, saving 46 Mtonnes/year of CO_2-emissions (data from Eurostat 2019 and KCORC, www.kcorc.org). For waste heat below 200^{o}C the potential is 40 TWh/year and 12 Mtonnes/year CO_2 savings.

The ORC technology contributes to a dispatchable and distributed base load electricity production that complements the intermittent nature of other renewable energy sources such as solar and wind power. ORC is often the only option to make use of waste heat. Thus, the technology is important when considering the EU Energy Efficiency Directive as well as climate, air pollution and energy objectives. As electric power from ORC has the potential to directly replace electricity from fossil fuel.

ORC systems in the range 50-2000 kW electricity predominately utilise refrigerants as working fluids. The main reason is safety. Hydrocarbons can sometimes work as replacements from a technical perspective. However, their extreme flammability most often disqualifies them for safety and/or regulation reasons in many applications such as industrial waste heat, marine, and district heating. CO_2 is not an option for ORC due to the high temperatures. Ammonia might be technically possible for low temperatures but is toxic.

Very small ORC systems up to about 1 kW in very low temperature applications, thus containing very small amounts of working fluids, might be able to use hydrocarbons in the future, pending development of regulations, standards, and technologies. Very large ORC systems (>3 MW electricity) can use hydrocarbons and is doing so already for high temperature applications as such large installations are often built outdoors and in remote areas, for example in geothermal and gas turbine power plants.

An ORC system is a closed and sealed system with no emissions to the environment during normal operation and system filling. After use, the fluid can be disposed of in such a way that the substance is destroyed and no longer poses a threat to the environment. A leakage is of course possible. However, online and automatic leakage detection systems are frequently used already today and can easily detect leakages at the order of single grams per day which facilitates prompt service/repair. Major leakages in industrial ORC systems are very rare. If, against all odds, there should be a leakage, the monitoring system will detect this, causing the machine to shut down and the refrigerant to end up in an internal tank. It is also possible to automatically shut off the refrigerant in the tank.

As a summary, a derogation for using fluorinated greenhouse gases as working fluids in waste heat recovery applications using ORC technology for both new and existing installations is suggested. A ban of fluorinated refrigerants would totally stop the excellent opportunity ORC constitutes along with the companies working in the field. In light of the PFAS issue, some additional demands and regulations is justified after investigation to decrease the risk for emissions even further. It is highly recommended that such regulations are handled within the already existing F-gas regulation. There is need of research and development to find natural or sustainable substitutes to the PFAS classified F-gases for ORC applications.

Appendix 1

Below you can find analysis of phase out scenarios and consequences on Swedish energy system.

1. Scenario phase out immediately

An immediate ban on use of PFAS classified F-gases is not manageable for energy companies in Sweden and would have major consequences for Swedish energy security. A production capacity of 1200 MW of heat would be at risk of disappearing, which currently cannot be replaced in the short term, nor achieved by the expected date which according to current proposal is scheduled by 2025. The entire market in Europe will lack capacity when plant owners decide to switch to another form of heating or change the refrigerants in heat pumps and cooling systems.

Our analysis shows that is not technically possible in almost any of Swedish installations to replace the PFAS-classified refrigerants in the existing installations with other refrigerants. The loss of capacity of 1200 MW in Swedish district heating (which means a production of 3,6 TWh, 2020) and cooling (660 GWh, 2020) must be compensated by new heat pumps and chillers or other production capacity. Currently, that means we are referred to "natural" refrigerants, where the most common solutions are ammonia, carbon dioxide and propane.

Energy companies have started asking their suppliers of heat pumps and chillers if there are any refrigerants (natural refrigerants or F-gases with low GWP-value which are not classified as PFAS) for substitution and initially received essentially

negative answers. This means that their production of heating and cooling must be stopped if there will be an immediate ban on PFAS classified F-gases.

Amongst others, safety precautions are required as ammonia is moderately flammable and toxic. Carbon dioxide is also a suitable alternative, although high pressures are required, making it less suitable for systems larger than 1–2 MW. Right now, it seems that there are no practical refrigerants on the market for district heating at high temperature. Ammonia for large scale heat pumps, is often mentioned as alternative but it is not validated that it could be an option at high temperature applications.

A transformation period of 1 ½ years is, not realistic, as it is not feasible to have time to procure, install and commission larger heat pump systems or other solutions in such a short time.

R152a falls outside the PFAS definition. It has potential for certain applications and is being used in blends but has previously been rejected as a single component refrigerant due to its A2 flammability.

As a summary, if district heating companies do not get a derogation, they will not be able to replace the heating capacity in such a short time and will have to switch to fossil or biooil operation or stop delivery of the heat and cooling to the customer. As none of these are conceivable for the district heating companies in Sweden, the most likely is that district heating and cooling companies will try to store the refrigerants to get by for a few years and thereafter drive more with an electric boiler or more bio-oil, if it is possible to get hold of, which could be better used for other applications.

According to our information, a total ban is not in question, but rather that it is no longer allowed to manufacture, sell, or import the refrigerants into the EU. One solution for these companies will be to store large amounts of the refrigerants for a longer period (the remaining lifetime) but it will be a risk both for the utilities and the environment to store large amounts of the PFAS classified refrigerants under a long period of time. It is also against the ambitions that are announced in the ECHA's proposal.

In case of a rapid phase out, besides all technical and market issues, the system cost for production of district heating and cooling will be increased during the coming 20-year period.

2. Scenario phase out after 5 years

Also, a ban after 5 years is not manageable for the most district heating companies in Sweden as there is no alternative on the market. There are many reasons:

- Immense uncertainty about which alternative refrigerants are available on the market.
- Increased risks with natural refrigerants - challenge in urban areas

- New refrigerant requires space for new equipment. That is not always available at an existing plant.
- There is risk that no permit will be issued by the local authorities, as natural refrigerants may cause major risks in an urban environment. Natural refrigerants such as ammonia, can pose new risks, among others strong odours even in the case of minor leaks, which can cause public concern. Higher flammability in urban areas is another risk in some cases, even if it has sometimes proven to be manageable in specific cases.
- Ammonia is not an option in certain applications in the cities where our district heating and cooling utilities are placed. New refrigerants may require more bulky equipment, which can be a challenge to retrofit in existing buildings and restrictive urban environments.
- If district heating companies do not get a derogation, they will not be able to replace the heating capacity and will have to switch to other production such as electrical boilers or more bio-oil. Right now, if the plants get a bigger leak and can't top up with R134a, the heat production in the short term can be replaced by boilers combusted with bio-oils. In a situation where there are limitations for many installations, there will not be enough bio-oil for all utilities.
- Uncertainty around COP of the new refrigerants affects not only efficiency of the plant but also profitability. It is estimated that drop of efficiency will be around 15-20% in case of rapid conversion to new refrigerants.
- There is a risk of insufficient delivery of cooling to customers, i.e. industrial processes and socially important operations such as hospitals, offices, computer halls, hotels, and shopping malls.
- There will not be enough temporary cooling/heating rental installations if there is no time to get a permanent solution in place.

3. Scenario phase out after 12 years or more

A transition period would provide a prerequisite for planning and projecting sustainable and long-term alternatives. For existing plants in district heating and cooling, Swedenergy suggests a derogation at least 12-years and at maximum the remaining lifetime of the facility conditioned that there is sufficient evidence that alternative solutions are not available during the derogation period. There is need of research and development to find natural or sustainable substitutes to the PFAS classified F-gases for district heating installations that operate at higher temperature range. It is required to ensure future solutions with natural refrigerants and to ensure continued operation of existing installations corresponding to the remaining technical and economic depreciation periods of most of the existing district heating and cooling installations in Sweden. It is better to guarantee the lifetime of investment that are already commissioned, conditioned that a strict monitoring system must be installed to avoid leakage.

There is need of time to develop natural and other sustainable refrigerants and technologies that could be used in large scale industrial heating and cooling plants. The refrigerants must be technically and economically feasible, result in high COP and at the same time impose no other health and environmental risks for the environment and people. There is time needed for change of other legislations that harmonize to allow natural refrigerants for example fire and explosion risk as well as environmental and health risk. The skills required for the changeover must be adapted to the needs and can thus constitute a limitation in case of a rapid phase out. A rapid phase out of PFAS classified F-gases will probably imply a shortage of natural refrigerants on the market which will cause increased price for alternative solutions before the market is stabilised.

There will probably be a shortage of units with the "right" refrigerants. Already today, there is limited production of units with natural refrigerants. A transition period is also needed to avoid hasty decisions about alternatives that may later turn out to be worse and must be phased out later on.

Right now, there are rules on handling of all refrigerants. All installation companies have a responsibility in the destruction of refrigerants. Only certified/accredited companies have the right to manage refrigerants. The refrigerant industry has a requirement to take care of refrigerants that is no longer in use. In case of discharge, the waste classified refrigerant is destroyed by incineration which is a controlled process. Swedenergy proposes a strict monitoring and control for heating and cooling installations that are derogated.